

ASIA PACIFIC Glaucoma Guidelines



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ASIA PACIFIC Glaucoma Guidelines



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ABOUT APGS

The Asia-Pacific Glaucoma Society (APGS) was established to facilitate interaction between glaucoma specialists in the region, to encourage collaborative research and service projects, to increase the opportunities for exchange of skills and knowledge in this rapidly advancing field, and to assist our comprehensive ophthalmological colleagues and other eye care workers (whether medically trained or not) to be up to date with advances in all aspects of glaucoma diagnosis and management.

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INTRODUCTION

The **Asia Pacific Glaucoma Guidelines** originated in 2003 and have been distributed widely across the region in both print and CD-ROM format. These guidelines were created to raise awareness and update clinical knowledge about glaucoma and to provide a rational basis for glaucoma diagnosis and cost effective management that is appropriate for the Asia-Pacific Region.

Devising best-practice methodologies for the Asia Pacific region continues to represent a unique challenge, given the diverse health care service systems and the wide range of available resources. The working groups have tried to be sensitive to the wide variations in human, structural, and equipment resources available throughout the Asia Pacific region, as well as the ethnic diversity of the local communities. We appreciate that while a guideline may be suitable in one country or location, it may not be ideal in another. Wherever possible we have strived to define an optimal standard of care that is deserved by all our patients and communities.

Glaucoma subspecialists in the APGG Working Party and Review Group have collaborated closely and widely to compile the information and recommendations within the guidelines. These will assist comprehensive ophthalmologists, general health care and eye care professionals, and health care policy makers to deliver effective glaucoma management to their communities. We have relied on published evidence, wherever possible, and on expert consensus when definitive evidence was not available to ensure that the 3rd Edition of the Guidelines are as up-to-date as possible.

We have also benefitted from generous educational grants from industry: see Acknowledgements on page v. This sponsorship permitted the Working Party to meet face-to-face and cover costs of publication and distribution of the 3rd Edition of the APGG. The easy-to-read format of the 1st Edition of the APGG has been retained; each section answers questions of '**Why?**', '**What?**', '**When?**', and '**How?**'. As with all treatment guidelines, this publication is not a prescription for automated care.

By adapting the Guidelines to the patient before you, bearing in mind individual needs, and the socio-economic environment and medical facilities available, plus your own experience, we hope the 3rd Edition of the APGG helps you to achieve the hallmark of excellent care.



Tin Aung and Jonathan Crowston

Co-chairs Asia Pacific Glaucoma Guidelines 3rd Edition Working Party

EPIDEMIOLOGY OF GLAUCOMA IN ASIA^{1,2}

Glaucoma is a group of optic nerve diseases characterised by selective and progressive loss of retinal ganglion cells. It is manifest clinically by thinning and loss of the neuroretinal rim and retinal nerve fibre layer with corresponding visual field loss. Glaucoma is the leading cause of irreversible blindness worldwide.

The age-specific prevalence of glaucomatous optic neuropathy (GON) is the highest among people of West African origin, and is probably the lowest among Caucasians of European origin. Asian populations have rates of GON that are intermediate between these two groups. European- and African-derived individuals predominantly have primary open-angle glaucoma (POAG), whereas rates of primary angle-closure glaucoma (PACG) are higher amongst East Asians. Although a direct and exact comparison of POAG rates is difficult, it is likely that POAG has a similar prevalence in Asian people to that seen in European populations (Table 1). Asians account for over half of those with POAG worldwide and more than three quarters of those with PACG. The higher rate of GON in Asians is probably attributable to the excess of PACG.

Up to 36% of those with POAG and 70% of those with PACG were blind at the time of examination in population-based studies (Table 1). Blindness rates in developed countries were significantly lower than in less developed regions. PACG on average produced three times as much blindness as POAG. Cautious extrapolation of these data suggests that glaucoma probably causes blindness in approximately 1.7 million people in China. PACG is responsible for the vast majority (91%) of these cases.³⁻⁵ Glaucoma is the leading cause of registered, permanent blindness in many countries in the region (including Hong Kong, Japan and India).⁶⁻⁸

Incidence rates of symptomatic acute angle closure (given as cases/100,000 persons/year for the population aged 30 years and older) range from 4.7 in Europe (Finland)⁹ to 15.5 in Chinese Singaporeans.¹⁰ Malay and Indian people in Singapore have lower rates than do Chinese Singaporeans (6.0 and 6.3, respectively).¹⁰ Over the past few decades, reduced rates of acute angle closure in Taiwan have been attributed to increasing cataract surgical rates.¹¹

Increasing IOP and advancing age are the most consistent risk factors for glaucoma, whether it is POAG, PACG, or secondary glaucoma.^{3,6-8,10,12-15} Female gender is recognised as a major predisposing factor for the development of PACG.^{4,16,17} There appears to be no gender difference for POAG. Chinese ethnic origin confers a higher risk of angle closure compared with Malay and South Indian people.^{10,12} Studies in urban centres generally find POAG prevalence exceeds PACG,^{3,4,18} whereas in rural areas, the reverse is true.^{8,17} Population-based studies in Japan and Korea have found a high proportion of normal tension glaucoma amongst those with POAG. In India, the prevalence of POAG in urban populations is almost twice that in rural populations as reported by both the Chennai Glaucoma Study and The Andhra Pradesh Eye Diseases Study.^{19,20} Due to lack of healthcare, blindness rates are higher in rural than urban centres. Most glaucoma is undetected in less developed countries with more than 85% of those being detected to have glaucoma in population-based studies unaware of their disease state. In addition to poor access to healthcare, two-thirds of those with PACG who had been detected to have glaucoma from the Chennai Glaucoma Study and The Andhra Pradesh Eye Diseases Study were being treated as open-angle glaucoma.^{19,20}

PACG is most commonly associated with a hypermetropic refractive state, but it can also occur in people with myopia. A shallow anterior chamber predisposes to angle closure.¹⁷ The depth of the anterior chamber reduces with age, tends to be shallower in women than in men, and is highly heritable.²¹⁻²³ There is an association between myopia and POAG.²⁴ From population-based studies, about 65% to 92% of POAG occurs in people with 'normal' population range of intraocular pressure (IOP <21 mm Hg).^{25,26}

Table 1. Prevalence of primary glaucoma and reported blindness rates from different population based studies in the region.

Study Location	Age range	POAG (%)	PACG (%)	N	Setting	Ethnicity	% age POAG blind	% PACG blind
Hovsgol, Mongolia ³	40-87	0.53	1.49	942	Rural	Asians	20.0	21.4
Andhra Pradesh, India ²⁷	30-70+	1.93	NA	1399	Urban	Asians	18.5	NA
Tanjong Pagar, Singapore ⁴	40-79	1.79	1.14	1232	Urban	Asians	27.3	50.0
Rom Klao, Thailand ²⁸	50-80+	2.28	0.86	701	Urban	Asians	25.0	33.3
Aravind, India ²⁹	40-70+	1.24	NA	5150	Rural	Asians	9.4	NA
West Bengal, India ³⁰	50-80+	2.99	0.24	1269	Rural	Asians	5.3	0.0
Tajimi, Japan ^{17,25}	40-80+	3.94	0.63	3021	Urban	Asians	1.7	5.3
Chennai-Rural, India ^{31,32}	40-89	1.63	0.87	3924	Rural	Asians	3.1	2.9
Liwan, China ¹⁶	50-93	2.11	1.53	1372	Urban	Asians	17.2	42.9
Meiktila, Myanmar ³³	40-70+	1.88	2.50	2076	Rural	Asians	7.7	61.5
Chennai-Urban, India ^{20,34}	40-80+	3.51	0.88	3850	Urban	Asians	1.5	14.7
Singapore Malay Eye Study ³⁵	40-80+	3.17	0.24	3280	Urban	Asians	9.6	12.5
Kandy, Sri Lanka ^{36,37}	40-70+	2.41	0.56	1244	Rural	Asians	3.3	28.6
Andhra Pradesh, India ¹⁹	40-70+	NA	0.94	3724	Mixed	Asians	NA	42.9
Beijing, China ³⁸	40-70+	2.57	1.02	4315	Mixed	Asians	0.0	6.8
Bin, China ^{39,40}	40-70+	0.71	1.57	4956	Rural	Asians	2.9	14.1
Handan, China ^{41,42}	40-80+	1.86	0.76	6716	Rural	Asians	2.4	41.2
Kailu, China ⁴³	40-70+	1.42	1.74	5158	Rural	Asians	8.2	6.7
Yunnan, China ⁴⁴	50-80+	1.03	0.94	2133	Rural	Asians	36.4	70.0
Namil, South Korea ^{45,46}	40-80+	3.59	0.65	1532	Rural	Asians	5.5	0.0
Bhaktapur, Nepal ⁴⁷	40-80+	1.28	0.43	3991	Rural	Asians	2.0	5.9
Blue Mountains, Australia ¹⁵	49-80+	2.38	0.27	3654	Rural	European ancestry	0.0	0.0
Melbourne-Urban, Australia ⁴⁸	40-90+	1.72	0.06	3264	Urban	European ancestry	0.0	0.0
Melbourne-Rural, Australia ⁴⁸	40-90+	1.97	0.07	1469	Rural	European ancestry	0.0	0.0
Kumejima, Japan ^{49,50}	40-90+	4.0	3.7	3762	Rural	Asian	0.7	3.7
							Mean % age blind: 8.6	Mean % age blind: 20.1

FREQUENTLY ASKED QUESTIONS

Is PACG more common than POAG in Asian countries?

PACG is not more common than POAG in South and East Asian countries. Population-based studies have reported that the prevalence of PACG varies from 0.5% to 2.5% in South East Asian countries. Population based studies of Caucasian and African populations have reported a prevalence of PACG of 0.4% to 0.7%, mostly among people older than 40 years.

Does PACG cause more blindness than POAG?

Population based studies show that PACG causes three to ten times proportionately more blindness than POAG.

Does the clinical presentation of angle closure vary in different parts of Asia?

Yes, acute angle closure is more common in China than in India, even more common in northern China compared to southern China. However, chronic angle closure is still more common than acute angle closure overall. Compared with CAC, acute angle closure is rare in the Indian subcontinent.

What is the natural history of PAC?

There is little information available: a population-based study from South India reported 22% progression of PACS to PAC and 29% of PAC to PACG over five years. Recently, a study in a high-risk Mongolian population, with a central anterior chamber depth of <2.53 mm, reported a 20.4% incidence of PACS over six years. A study in Eskimos reported a 35% progression rate for PACS after ten years.

Please refer to figure 1.1 on page 15 for definitions.

1.1 PATIENT ASSESSMENT

The purpose of this section is to describe the initial assessment of a patient in whom glaucoma is suspected, from the perspective of clinicians in both developed and developing countries. Inevitably, some sections will have more relevance to one or other setting. The initial consultation lays the foundation for successful management of the patient.

Assessment of a child with suspected glaucoma raises specific and distinct questions. Such a child should be referred urgently to a specialised centre (Appendix 1).

Why?

The aims during the initial assessment of a patient are:

- To determine whether or not glaucoma is present
- To assess risk factors for glaucoma to determine the likelihood of glaucoma developing or glaucoma progressing
- To exclude or confirm alternative diagnoses
- To identify the underlying mechanism(s) of damage to guide appropriate management
- To plan a management strategy
- To determine whether treatment is appropriate based on risk factors
- To identify suitable forms of treatment, and to exclude those that are inappropriate

What?

The initial assessment can be divided into three phases:

- History
- Examination
- Investigations

HISTORY

Key Points

- Most glaucomas are asymptomatic until advanced
- Assess medical and social factors that will affect treatment decisions
- Assess the risk factors for glaucoma (family history of glaucoma/visual problems)
- Younger age means a longer exposure to glaucoma and its treatment

Past Ophthalmic History

Consider

- Previous medications (especially glaucoma medications, steroids)
- Previous trauma, or previous eye surgery or laser treatment
- Allergies/adverse reactions to medications
- Refractive state

SYMPTOMS OF ACUTE INTRAOCULAR PRESSURE ELEVATION

- Intermittent/episodic blurring,
- glare and coloured rings around lights,
- eye pain,
- frontal headache with nausea and malaise.

Acute IOP elevation can occur in the presence of acute primary angle closure, Posner-Schlossman Syndrome, hypertensive uveitis, pigment dispersion, ectopia lentis, or pseudoexfoliation syndromes and secondary angle closure or angle recession

Acute IOP elevation has been misdiagnosed as migraine, tension headaches, meningitis, acute abdomen, psychosomatic disorders

Past Medical History

Consider

- Factors that will affect life expectancy and adherence with treatment
- Exclude past history of systemic conditions that may mimic glaucoma but are not progressive, such as haemodynamic crises (postpartum haemorrhage, blood transfusions, severe trauma), anterior ischaemic optic neuropathy that may cause optic disc pallor and cupping, or intracranial pathology⁴⁹⁻⁵²
- A past need for blood transfusions
- Systemic conditions relevant to glaucoma history taking (Table 1.1)

Table 1.1 Factors to consider when taking a medical history from a patient with suspected or established glaucoma.

System	Condition
Respiratory	Asthma and COPD associated with hyper-responsive airways and/or Reduced lung capacity will limit the use of topical β -blockers Obstructive sleep apnoea associated with POAG and glaucoma progression
Cardiovascular	Cardiac arrhythmias (heart block) may preclude the use of topical β -blockers or α -agonists Systemic hypotension Systemic hypertension – over-treatment (causing hypotension, particularly at night) may worsen glaucoma risk and progression; systemic β -blockers may mask elevated IOP Vasospastic tendency (migraine, Raynaud's phenomenon) may be associated with an increased incidence and severity of glaucoma, especially normal tension glaucoma (NTG) Previous episodes of low blood pressure, haemodynamic shock, or significant blood loss requiring blood transfusion Possible interaction between systemic and topical medications
Endocrine	Diabetes – increasingly prevalent and associated with increasing rates of neovascular glaucoma. Risk with POAG not consistent in population and cohort studies Thyroid eye disease Pituitary tumours
CNS	Previous CVA/head injury/pituitary lesions (cause visual field loss) Early dementia – affects adherence, understanding, and insight into the disease. RNFL loss can occur in advanced Alzheimer's disease
Musculoskeletal	Arthritis (osteo-, rheumatoid) may severely affect the ability to administer eye drops
Urogenital	Renal stones may limit use of systemic CAIs
Pregnancy and lactation	Present or possible, renders all interventions potentially hazardous (Appendix 2)

MEDICATION

Use of any current medication needs to be considered, along with certain specific past medications, including:

- Steroids – any route of administration is associated with ocular hypertension (OHT) and POAG; sometimes found in traditional medicines
- Glaucoma eye drops (prolonged use may increase the likelihood of trabeculectomy failure or increased postoperative subconjunctival fibrosis)
- Anticholinergics/tricyclic antidepressants – can cause angle closure
- Anticonvulsants:
 - topiramate: can cause acute angle closure
 - vigabatrin: linked to nasal peripheral VF loss without disc changes
- Systemic β -blockers/CCBs – may interact with topical β -blockers
- α -Agonists are contraindicated for:
 - patients taking MAOIs (prescribed for depression, migraine prophylaxis, or Parkinson's disease)
 - infants and children
- Check for sulphur allergy prior to using CAIs

Note: See Appendix 3 for systemic medications that may induce angle closure.

Socioeconomic Factors

Consider

- How regularly can the patient attend?
- Can the patient afford and adhere to topical glaucoma treatment?
- How will having glaucoma affect the patient's life/work/family (disease and treatment)?

Family History of Glaucoma

Consider

- What is the glaucoma type and course in the family? (See Epidemiology).

EXAMINATION/INVESTIGATIONS

Examination requires appropriate equipment, sufficient training in examination techniques, and accurate and reliable recording of findings. While resources vary widely across the region, there is a minimal acceptable standard of equipment and training.

NECESSARY RESOURCES FOR EXAMINATION

- A slit lamp with indirect lens (60-90 D) and/or direct ophthalmoscope
- An automated perimeter
- A gonioscope that allows indentation gonioscopy
- A Goldmann-style applanation tonometer (Schiötz or Maklakov tonometers are not generally acceptable)

WHEN THE PATIENT CANNOT GET TO A SLIT LAMP

- A portable hand-held slit lamp may be very useful
- In the absence of a portable slit lamp, a jeweller's loop or an operating loop with a torchlight will allow a reasonable anterior segment examination
- A direct ophthalmoscope set at +10 to +12 D will allow anterior segment examination. Perkins, Tonopen, Rebound tonometer and airpuff tonometer are acceptable.

SLIT-LAMP EXAMINATION – GOLDMANN APPLANATION TONOMETRY

Why?

- IOP is currently the only modifiable risk factor for glaucoma that has been shown to arrest disease progression

What?

- Applanation tonometry (using a Goldmann tonometer)

When?

- Every visit

How?

- Check calibration of tonometer (Appendix 4)
- Disinfect prism tip and remove disinfectant. Disposable tonometers may also be available
- Anaesthetise the cornea
- Instil fluorescein
- Keep eyelashes out of the way (avoid pressure on eye)
- Gently touch the tip to the central cornea with the observer looking through the slit-lamp eyepiece just prior to the tip making contact
- Adjust the gauge until the split tear meniscus just touches on the inside
- Instruct the patient to loosen the tie and not to hold breath during IOP measurement

Note: Look for the white split ring that fluoresces when the tip touches the cornea.

Factors Associated with Intraocular Pressure

(Tables 1.2 and 1.3, and Appendix 5)

Table 1.2 Factors affecting measured intraocular pressure.

Factor	Mechanism
Circadian cycle	IOP follows a circadian cycle, varies with posture and is often highest when the patient is horizontal at night Diurnal (day time) IOP fluctuation is variable between individuals. The normal diurnal variation is 3-6 mmHg
Corneal parameters	Generally thicker corneas are associated with artificially elevated IOP measurements, and thinner corneas with artificially depressed IOP measurements While correction nomograms based solely on corneal thickness are neither valid nor useful in individual patients, ⁵³ the clinician needs to put the measured IOP into context Corneal hysteresis: Lower corneal hysteresis values are associated with greater risk of visual field progression ^{54,55} Corneal/refractive surgery may under-estimate IOP and this effect may be substantial ⁵⁶
Blood pressure	IOP is positively associated with systemic blood pressure ⁵⁷⁻⁵⁹ , however, reducing blood pressure has little impact on IOP in an individual patient. May increase the risk of a retinal vessel occlusion
Intra-abdominal pressure	Increased intra-abdominal pressure by playing wind instruments or Valsalva manoeuvre increases episcleral venous pressure and IOP
Age	Overall, IOP is only slightly correlated by advancing age
Exercise	Exercise can decrease IOP by 3 or more mmHg for 1-2 hours (by dehydration and/or acidosis), while certain postures may increase IOP acutely (e.g., head-down yoga positions) ⁶²
Lifestyle	Large-volume rapid fluid intake increases IOP, while alcohol and marijuana transiently decrease IOP. There is currently little evidence to demonstrate whether alcohol or marijuana influences the natural history of glaucoma
Posture	Head-down position can double IOP levels ⁶² Supine or prone position increases IOP

Table 1.3 Measurement errors associated with Goldmann-style applanation tonometry.⁶³

Error	Possible cause
IOP reading artificially low	Insufficient fluorescein in tear film Microcystic epithelial corneal oedema
IOP reading artificially high	Excessive fluorescein in tear film Eyelid pressure on globe from blepharospasm Digital pressure on globe to hold lids apart (the lid should be held against the orbit and not on the globe) Obese patient Patient straining to reach chin/forehead rest Patient breath-holding Patient wearing constricting clothing around neck (tight shirt collar and tie for men) Hair lying across cornea distorting mires Lens-corneal (and IOL-cornea) apposition
Technical difficulties (interpret results with caution)	Corneal abnormalities (scars, graft, oedema, keratoconus) Marked corneal astigmatism Small palpebral aperture Nystagmus Tremor

Anterior Segment

When examining the anterior segment, pay attention to the following areas:

Globe surface

- Episcleral blood vessels
- Conjunctival injection (papillae or follicles)

Cornea and anterior chamber

- Pigment on corneal endothelium (pigment dispersion)
- Peripheral anterior chamber depth (Van Herick technique)
- Central anterior chamber depth
- Evidence of inflammation (keratic precipitates, anterior chamber flare and cells)
- Descemet's membrane rupture (Haab's striae)
- Corneal diameter and curvature
- Evidence of ocular surface disease
- Pseudoexfoliation (PXF) material on the endothelium
- Signs of previous refractive surgery

Iris

- Mid-dilated poorly reactive (post-angle closure attack)
- Isolated zones of patch atrophy or spiralling
- Rubeosis iridis
- Synechiae
- Ectropion uvea

- Configuration in relation to lens
 - PXF material on pupil edge
 - Pigment deposits on anterior surface (PXF or pigment dispersion)
 - Transillumination defect (PXF – peripupillary; pigment dispersion – mid-peripheral), loss of pupillary ruff (early sign of PXF)
- Displaced pupil with iris atrophy and/or hole(s) [ICE syndrome, Axenfeld-Rieger syndrome]
- Pigmented iris nodule (ICE syndrome, Cogan-Reese type), Lisch nodules
- Sphincter ruptures pointing to previous ocular trauma
- Presence of a iridotomy/iridectomy

Lens

- PXF material
- Lens opacity
- Phacodonesis
- Glaukomflecken (past acute high IOP)
- Early PXF changes on lens after pupillary dilatation
- Lens positioning

GNIOSCOPY

(See also Appendix 6)

Why?

- Detect angle closure and secondary glaucomas

What?

- Angle width and characteristics (see below)

When?

- Initially for all
- Repeated more frequently for patients with angle closure

How?

Gonioscopy should be performed to look for iridotrabecular contact. Gonioscopy needs to be performed in a dark room with a small slit-lamp beam minimizing light falling on the pupil.⁶⁵

- Minimal room illumination
- Good anaesthesia
- Shortest slit practicable
- High magnification
- Dim slit illumination
- Set slit lamp on upper cornea, beam off-centre 30°-45° nasally
- If necessary, elevate upper lid
- Place lens gently on eye while looking through slit lamp (as if you are doing tonometry)
 - no gel needed with Zeiss-type lenses
- Look through the upper mirror (inferior angle) as you place lens on eye, stop pushing when you can see the iris
- Move slit-lamp beam inferiorly (avoid pupil) to examine superior angle
- Turn beam 90° and move on axis
- Move to nasal side (temporal angle), then to temporal side (nasal angle)
- Record findings on gonioscopy
- In the presence of appositional closure, indentation should be performed to look for peripheral anterior synechiae (PAS)
- It may be necessary to alter the position of the mirror or the position of gaze to look over a convex iris to visualise the angle

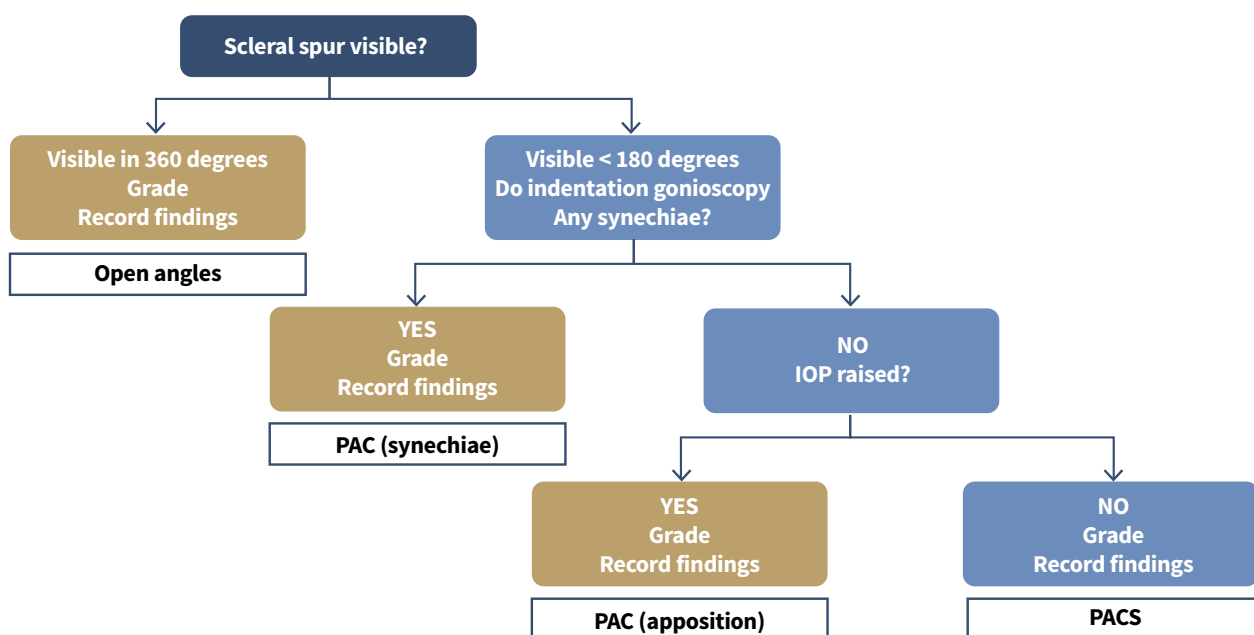
(Figure 1.1 and Appendix 6)



Tip: If you cannot find the angle structures, use a bright wide slit (parallel to the mirror) at low magnification. Once you have found the angle structures, turn the illumination down, shorten and narrow the slit, and look for the change in iris/angle configuration. Avoid light entering the pupil. You may need to wait a minute or so. If suspicion of angle closure is high then, in some cases, you may need to wait for two to three minutes after reducing the illumination.

Additional resources: www.gonioscopy.org

Figure 1.1 Gonioscopy flow diagram.



Angle Closure Signs

- PAS
- Pigment patches over trabecular meshwork (TM) (evidence of irido-trabecular contact)
- Iris insertion above scleral spur

Abnormal Open Angles

- TM with pigment, PXF material, new vessels, precipitates, or abnormal iris processes
- Wide ciliary body band or sclera (angle recession, cyclodialysis cleft)
- Schlemm's canal with blood reflux

OPTIC NERVE HEAD AND RETINAL NERVE FIBRE LAYER

Why?

- Defines presence of glaucoma

What?⁶⁴

- Disc size
- Disc shape
- Disc tilt
- Peri-papillary atrophy
- Vertical cup-disc ratio
- Cup shape
- Cup depth
- Neuroretinal: rim, ISNT rule
- NFL defect
- Disc haemorrhage

When?

- Every visit

How?

Consider non-glaucomatous optic neuropathies. Differentiate compressive optic neuropathy and anterior ischaemic optic neuropathy from glaucoma, especially giant cell arteritis;^{65,66} both can cause pale cupped disc and field loss.

- Slit lamp
- Very thin, bright beam for disc measurement
- Dimmer beam for clearer lenses or pseudophakics
- Indirect slit-lamp lens (60-90 D)
- It is important to gain a stereoscopic view (best when dilated – recommended if safe)
- Red-free (green) illumination may help assessment of RNFL

(See table 1.4 and 1.5)

Table 1.4 Normal vertical cup-disc ratios for vertical disc diameter (European ancestry).⁶⁷

Disc diameter (mm)	Mean VCDR	95% CI
≤1.0	0.26	0.20-0.32
1.2	0.33	0.32-0.34
1.4	0.39	0.39-0.39
1.6	0.45	0.45-0.45
1.8	0.50	0.50-0.50
≥2.0	0.55	0.53-0.57

Table 1.5 Normal vertical cup-disc ratios for disc size (Indians).⁶⁸

Disc size (mm)	Mean VCDR	95% CI
1.50–2.00	0.19	0.09-0.28
2.01–2.50	0.27	0.18-0.35
2.51–3.00	0.36	0.34-0.38
3.01–3.50	0.45	0.43-0.47
3.51–4.00	0.48	0.45-0.51
4.01 and above	0.54	0.48-0.6

Disc Recording

- Draw optic disc (large), rim, key vessels that define rim, and peripapillary signs
- Document disc size, *i.e.*, whether large, average, or small
- Draw notches, shelving, loss to rim-clock hours
- Record whether RNFL is visible and assess for wedge(s) or slit defects
- Record VCDR in the narrowest part of the rim – consider recording the rim-disc ratio at key parts of the rim
- Record splinter haemorrhages, PPA (β -zone), barring of circumlinear blood vessels, blood vessels bayoneting



Tip: Disc margin is *INSIDE* the peripapillary scleral ring of Elschnig. Appropriate lens magnification correction for Volk lenses: Superfield 1.5x, 90 D 1.3x, 78 D 1.1x, Super 66 D 1.0x.

DISC SIZE

- Disc size is variable (Table 1.6) – large discs have large VCDRs, although the neuroretinal rim area is normal; while a large VCDR may not be pathological, pathological rim loss can be missed in a small disc, especially if generalised
- VCDR is related to optic disc size and is not important for diagnosis of glaucoma; asymmetry of VCDR of >0.2 between two eyes is suspicious unless disc size is similarly asymmetrical
- Disc size can be measured by:
 - adjusting the vertical beam of a slit lamp to the diameter of the optic disc
 - using optic nerve imaging devices
 - using the small size spot (5°) of a direct ophthalmoscope, which approximates the average disc size, to estimate whether a disc is large or small

Table 1.6. Percentiles for vertical cup-disc ratios in non-glaucomatous eyes.*

Percentile	Disc size		
	Small	Medium	Large
50 th	0.35	0.44	0.55
95 th	0.56	0.65	0.71
97.5 th	0.59	0.68	0.74
99 th	0.62	0.72	0.80

*The data were derived by planimetric measurement of disc size and VCDR.

NEURORETINAL RIM

The rim is more important than the cup. The rim width is defined clinically by the area that extends from the inner border of the scleral ring to where the rim falls just below the level of the scleral ring.

The cardinal feature of GON is a loss of tissue from the inner edge of the rim.

Features that should raise suspicion that glaucomatous damage has already occurred include:⁶⁹

- Diffuse loss or notching of the rim (especially to the disc margin)
- Haemorrhage crossing the rim
- Undercutting of the rim (also found in many physiological large cups)
- Asymmetry of rim width between the eyes in the absence of asymmetry of disc size
- A rim to disc ratio of 0.1 or less in the superior or inferior is suspicious
- Significant asymmetry of rim width between superior and inferior sector of the optic disc

Check the ISNT rule.

Tip: An approximate rule is that a vertical CDR of >0.7 (note importance of disc size) or loss of rim to the disc margin anywhere outside the temporal sector strongly suggests glaucoma. This rule may not apply if the disc is extremely large or very tilted.

ISNT RULE – A GUIDE

Normally, the thickest to thinnest parts of the neuroretinal rim of the optic disc are Inferior > Superior > Nasal > Temporal (ISNT). Any variation from this may help to detect glaucomatous damage. The ISNT rule may not be followed in up to 50% of normal discs in certain populations.⁷⁰ The essence of the ISNT rule is the 'T': in almost all normal eyes, independent of ethnicity, the narrowest part of the rim is in the temporal 60°.

DISC HAEMORRHAGE

- Important risk factor for glaucoma progression
- Suggests ongoing damage to the optic nerve head
- Independent risk factor for development of glaucoma⁷¹
- Presence of disc haemorrhage in OHT increases the risk of conversion to POAG by six times (univariate analysis) and four times (multivariate analysis)
- Recurrent disc haemorrhages increase the risk of optic nerve damage by three to four times compared with single haemorrhage^{72,73}

Additional resources: www.gone-project.com

OPTIC DISC PHOTOGRAPHY AND IMAGING

Optic disc monitoring should include detailed documentation of optic disc architecture. This is best done with serial optic nerve head and retinal nerve fibre layer photographs or imaging technologies (Table 1.7).

Optic disc photography (preferably stereoscopic) is optimal if a fundus camera is available, for all glaucoma suspects and patients with glaucoma at the time of diagnosis.

These images should be used as an aid in follow-up examinations.

Table 1.7. Optic disc/retinal nerve fibre layer assessment.

Qualitative	Quantitative
Direct ophthalmoscopy	Disc photography with digitalisation
Slit-lamp indirect ophthalmoscopy	Stereo disc photography with optic disc analysis
Disc photography	OCT/HRT
RNFL photography (red-free fundus photography)	GDx/OCT

Optic Disc and Retinal Nerve Fibre Layer Imaging Technologies

Currently, sensitivity and specificity for glaucoma diagnosis for three technologies (HRT, OCT, and GDx with variable corneal compensation) is approximately 80%. Agreement between all three technologies is approximately 25% to 40%.

The 2016 WGA consensus on glaucoma diagnosis (structure) 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.”

VISUAL FIELD EXAMINATION

Why?

- Defines state of optic nerve function and if glaucoma is progressing or not
- Defines visual impairment

What?

- Automated perimetry with machines having appropriate normative database
- Ideally, the same programme is preferred at follow-up visits

When?

- When glaucoma is suspected at examination. Tests should be performed more frequently early in disease to ascertain rates of progression.⁷⁴

How?

- It is very important to understand the correct procedure for performing visual field testing
- Users should read and be familiar with the perimetry manual

TIPS FOR BETTER VISUAL FIELDS

- A careful explanation of technique and goal of the test before examination can improve test quality
- During and at the end of the test, the patient should be told how well they have performed and feedback should be given to them about the results of their test so that, in future, they can improve on their test performance
- The technician makes the best assessment of performance
- Visual field test performance usually improves over the first two to three tests
- Check pupil size and note any change
- Use appropriate correction for near vision
- If defects involve the points within ten degrees of fixation, specific testing of the central ten degrees is required
- Tests, if repeated on the same day, should be after the patient has had an adequate rest (more than 30 minutes)

Note: See Appendix 7.

CHARACTERISTICS OF GLAUCOMATOUS VISUAL FIELD DEFECTS

- Follow pattern of the retinal nerve fibre layer
- Rarely cross the horizontal midline/rarely extend across the horizontal midline
- Located in mid-periphery* (5°-25° from fixation)
- Reproducible
- Not attributable to other pathology
- Clustered in neighbouring test points (localised)
- Defect(s) should correlate with the appearance of the optic disc and the neighbouring retinal nerve fibre layer

**Early/moderate cases.*

FREQUENTLY ASKED QUESTIONS

Is it necessary to take a full medical history as part of the glaucoma evaluation?

It is essential; various systemic diseases and treatments can affect IOP and glaucoma. For example, a β -blocker may be contraindicated for a patient with heart block or asthma. If the patient is taking a systemic β -blocker, a topical β -blocker will be less effective for lowering IOP and may cause systemic side effects. Some anti-glaucoma medications may be contraindicated with certain systemic drugs, for example, monoamine oxidase inhibitors contraindicated with α 2-agonists.

Why is a family history of glaucoma important?

Risk for glaucoma increases 5- to 8-fold for a patient with a positive family history. First-degree blood relatives are at highest risk.

Can steroid ointment used for skin lesions increase IOP?

Steroids in any form can increase IOP. A detailed drug history is necessary, especially if the response to treatment changes, for example, loss of IOP control in a previously stable patient.

Is migraine associated with glaucoma? Are there other clinically important associations to look for?

Some population- and clinic-based studies have found migraine to be a risk factor for primary open angle glaucoma (normal tension glaucoma). A patient with migraines may be approximately two and a half times more likely to progress than a patient without migraine. All glaucoma patients and suspects should be asked about a history of systemic vasospastic diseases (Raynaud's phenomenon), blood loss, severe hypotension (haemodynamic crisis), and stroke.

Do we need to check CCT for all glaucoma patients and suspects?

Ideally, yes. IOP measurement is not precise, and there is no 'correction' factor to make it accurate. CCT should be checked in suspected OH and NTG before diagnosis, and especially before a patient undergoes expensive or invasive investigations such as imaging or angiography.

What is the effect of corneal oedema on IOP measurement?

Corneal oedema can cause the tonometer to read falsely low. With mild corneal oedema secondary to contact lens wear, the IOP measurement is falsely high.

Is the type of musical instrument a patient plays important for the management of glaucoma?

Playing wind instruments increases IOP considerably by the Valsalva manoeuvre which increases episcleral venous pressure.

What is the current role of the Schiottz tonometer?

The Schiottz tonometer has no role to play in modern glaucoma diagnosis and management.

As the air puff non-contact tonometer works on the applanation principle, can it be used instead of the GAT?

The air puff tonometer has reasonable agreement with GAT in the physiological range of IOP. However, its variability is higher and GAT remains the gold standard.

What is the role of the diurnal variation test? Do all patients require it?

IOP fluctuates over 24 hours – the magnitude of the fluctuations is different for each patient. Knowing the baseline before starting medication is important, as is knowing the effect of the medication during the day. As a full 24-hour diurnal variation test is logistically difficult for patients and practitioners, it is best to obtain several IOP readings during the day, or at different times for clinic visits. A '24-hour' or full diurnal variation test may be helpful before subjecting a patient with 'NTG' to invasive or expensive investigations, and for patients who progress despite acceptable IOP readings during office hours.

How is applanation IOP performed for a patient with high astigmatism (>4 D)?

In this scenario, the usual method gives an inaccurate IOP reading. The Goldmann or Holladay methods can provide an accurate IOP measurement, but alterations to the standard method are required. Clinically, the Holladay method is easier: measure the IOP with the tonometer prism at 90° and 180°, then take the mean of these two readings to derive the IOP. For the Goldmann method, the red line on the applanation prism (set at 43°) is adjusted to the flat axis of the corneal curvature and the measurement is taken as usual.

Can the Van Herick method be used instead of gonioscopy for angle assessment in the clinic?

No, all clinic patients need gonioscopy. If it is impossible to do gonioscopy due to patient factors, as long as the Van Herick test result is at least one-quarter corneal thickness and the torchlight test is negative, it is almost 98% certain that the angle is not closed.

What is the ideal gonioscope? Can the Goldmann 3-mirror lens be used for gonioscopy?

It would be ideal to have an indentation gonioscope (Susmann, Zeiss, or Posner 4-mirror) as well as a Goldmann single or 2-mirror lens. The indentation gonioscope uses the patient's tear film as coupling fluid, and allows easier indentation to look for anatomical landmarks and to distinguish appositional from synechial closure, and to perform routine gonioscopy. However, it is easier to put pressure on the eye and artificially open the angle with this type of lens. The disadvantages of the 3-mirror gonioscope are that it does not have the right optics (mirror height and distance from the centre of the lens) for gonioscopy, it is harder to use for indentation gonioscopy, it is bulky, and it needs coupling fluid. The latter disadvantage also applies to the single and 2-mirror lenses, making routine gonioscopy difficult.

How often should patients with glaucoma undergo gonioscopy? What if the patient is known to have POAG?

Gonioscopy is mandatory at the initial evaluation to assess whether the angle is closed or open and, in the presence of angle closure, to distinguish the amount of synechial versus appositional closure. How much the angle opens at indentation predicts how much it will open after LPI. In an open angle, gonioscopy identifies other findings in the angle, for example, PXF material or irregular pigmentation. After LPI, repeat gonioscopy identifies the response to the procedure (when the effect of pilocarpine has worn off). Subsequently, gonioscopy can be performed if there is a suspicion that something has changed. Patients with POAG can develop angle narrowing and require regular gonioscopy, especially if anything changes. Changes in angle configuration and other findings (pigment, new vessels) provide information about secondary risk factors within the eye.

What is the best clinical method of optic disc assessment? Can a direct ophthalmoscope be used?

Ideally, dilated stereo-biomicroscopic disc evaluation with a contact or non-contact lens is best.

Should the optic disc size always be measured?

VCDR depends on disc size. While it is unnecessary to measure accurately the size of every disc, it is important to know whether the disc is 'small', 'medium', or 'large'. A small cup may be abnormal for a small disc. A large cup may be normal for a large disc. The disc can be measured using the slit lamp and a correction made for the lens being used. Charts are available for this correction.

How can the RNFL be assessed clinically?

By using dilated stereo-biomicroscopic evaluation with a contact or non-contact lens with the red-free filter (green light). An indirect ophthalmoscope can also reveal defects. However, these techniques need experience, and the RNFL cannot be visualised in all patients, for example, those with lens opacities or very light-coloured fundi in those with diffuse RNFL loss.

Is it necessary to examine the anterior segment again after dilatation?

Post-dilatation flare and pigment release can help diagnosis. Look for early signs of PXF.

Is it necessary to dilate the eye for routine optic disc assessment?

Dilated optic disc examination is ideal. In addition to glaucoma evaluation, the rest of the fundus should be examined for related and unrelated pathology, as several retinal disorders can produce glaucoma-like field defects.

Can HRT, GDx, OCT or other imaging technologies be used in isolation to diagnose glaucoma?

Abnormal HRT, GDx, or OCT results alone are not adequate to diagnose glaucoma. Clinical diagnosis of glaucoma is predicated on the detection of thinning of the retinal nerve fiber layer, narrowing of the neuroretinal rim, and deformation/cupping of the optic nerve head.

What is the role of imaging technologies for optic disc evaluation in the clinic?

According to the 2016 WGA consensus statement, “Although optic disc photography is effective to detect glaucomatous optic disc damage, imaging technologies including optical coherence tomography, confocal scanning laser ophthalmoscopy and scanning laser polarimetry have afforded a more objective and quantitative approach to detect and monitor glaucoma.”

How do you estimate optic disc size using a high plus lens at the slit lamp?

Focus a co-axial thin vertical slit beam on the optic disc. Shorten the length of the slit until it covers the longest vertical extent of the optic nerve head. The scale measurements of the slit lamp are recorded and multiplied by the appropriate correction factor for the lens used; multiplication factors depend on lens power and the manufacturer. This technique gives the vertical diameter of the optic disc.

Can POAG and ACG coexist?

A patient with POAG can develop anatomically narrow angles, which needs to be recognised and managed appropriately. This is likely to be related to enlargement of the anteroposterior diameter and a more anterior position of the lens, which occurs over time.

Do all PAC eyes with open angles need to be followed up post-LPI?

PAC is a multi-mechanism disease. An LPI only treats one of the components (pupillary block); non-pupillary blockage PAC may remain closed, PAS extension occurs in more than 15% of PAC patients after LPI, further increases in IOP can develop. A patent LPI is not a cure, these patients must be followed up. Eyes with PAC that have undergone LPI need to be monitored in the usual manner (and have gonioscopy repeated).

Is unilateral POAG common? How should such a patient be assessed?

Although POAG may be very asymmetric with minimal damage in one eye and advanced loss in the other, true unilateral POAG is uncommon. Carefully assess such eyes to rule out angle closure or a secondary glaucoma, for example, PXF, pigment dispersion, angle recession, or uveitis.

How should glaucomatous disc changes be differentiated from non-glaucomatous disc changes?

If disc pallor is out of proportion with cupping, then it is more likely to be non-glaucomatous. Rim pallor is 94% specific for a non-glaucomatous disc.

What is the significance of optic disc (peripapillary nerve fibre layer) haemorrhage?

This finding is very specific for glaucoma, and suggests an active disease process. Disc haemorrhage in OH increases the risk of conversion to POAG 4- to 6-fold; in POAG, disc haemorrhage increases the risk for progression of VF loss by 4- to 5-fold. NTG has a higher incidence of optic disc haemorrhage. Disc haemorrhages may also be seen in posterior vitreous detachment, and diabetic retinopathy; these should be distinguished from disc haemorrhages related to glaucoma.

What is the current role of short-wave automated perimetry or blue-on-yellow perimetry in glaucoma management?

Short-wave automated perimetry was thought to demonstrate VF loss up to five years earlier than standard automated white-on-white perimetry in glaucoma suspects. However, it has now been found to detect damage at the same rate as white on white perimetry and is therefore not recommended for early detection.

What is the relationship of blood pressure to glaucoma?

Raised blood pressure has been associated with increased IOP, but it is not a simple 1:1 relationship. Systemic hypertension has been associated with glaucoma in hospital-based studies, and some population-based studies show a link. Low perfusion is a risk factor for glaucoma (and overtreatment of hypertension may contribute to this).

What is the value of provocative testing for glaucoma diagnosis?

Provocative tests (dark-room and dark-room prone tests for PAC) may have value in some situations. A simpler manoeuvre involves checking IOP and gonioscopy in the mid-dilated position in PACS: elevated IOP and angle narrowing may change the management plan. In patients with POAG, water drinking tests might help to detect IOP spikes and identify peak IOP levels during the circadian rhythm.

How should the applanation tonometer tip be sterilised?

The head should be cleaned with wipes soaked in 70% isopropyl alcohol or 3% hydrogen peroxide. Time should be allowed for the alcohol to evaporate, and sterile saline should be used to wash off the hydrogen peroxide before the next patient to prevent iatrogenic corneal ulcers.

What is the effect of laser refractive surgery on IOP measurement?

Refractive surgery, including LASIK, LASEK, and PRK, causes a falsely low IOP measurement. A similar depth of ablation will result in a greater decline in IOP measurement following LASIK than following surface ablation. Pascal dynamic contour tonometry and ocular response analyser are less sensitive to changes in corneal biomechanics.

1.2 RISK CATEGORIES AND TREATMENT TARGETS

Why?

- Tailor treatment to likelihood of future visual disability, depending on disease stage, risk factors for progression, and patient's overall health status and life expectancy

What?

Glaucoma with High 5-year Risk for Progressive Visual Loss or High 5-year Risk for Visual Disability

Moderate to advanced GON with correlating VF loss and:

- Demonstrated progression over a short time
- Higher IOPs
- Bilateral VF loss⁷⁵
- Pigmentary and PXF glaucoma⁷⁵
- Very advanced VF loss, fixation threat, or glaucoma-related visual disability
- Young age with advanced disease
- Secondary glaucoma
- ACG

Glaucoma with Moderate 5-year Risk for Visual Loss or Glaucoma Suspect with High Risk for Visual Loss

- Mild GON with correlating early VF loss and higher IOP
- Mild-to-moderate glaucoma with low IOP⁷⁶
- PAC with high IOP and PAS
- Younger age

Glaucoma Suspect at Moderate Risk for Visual Loss

- Fellow of eye with established GON (excluding secondary unilateral glaucomas)⁷⁷
- OH with multiple risk factors (thin CCT, high IOP, suspicious disc)⁷⁸
- GLC gene mutations associated with severe glaucoma
- Recurrent optic disc haemorrhages
- PXF syndrome
- Younger age

Glaucoma Suspect or Other Condition with Low Risk for Glaucomatous Visual Loss

More important

- Ocular hypertension^{77,78}
- Older age^{77,78}
- PACS (anatomically narrow angle with no PAC signs or raised IOP)
- Pigment dispersion syndrome with normal IOP
- Glaucoma suspect disc, including disc asymmetry
- Family history of glaucoma

Less important

- Steroid responder, steroid user
- Myopia
- β -Zone PPA
- Diabetes mellitus
- Uveitis
- Systemic hypertension

Table 1.8 How to identify risk of progression and lifetime visual disability^{79,80}

Factors associated with high risk of progression within 5-years	Disease stage	Factors associated with High risk for lifetime visual disability
Demonstrated progression over a short time Higher IOP Pigment dispersion and Pseudoexfoliation glaucoma Secondary glaucoma Recurrent disc haemorrhages	I. Open angle glaucoma	Advanced disease at time of presentation Bilateral visual field disability Visual field loss threatening fixation Younger age at diagnosis
Demonstrated progression over a short time Higher IOP Greater extent of PAS	I. Primary angle closure glaucoma	Advanced disease at time of presentation Bilateral visual field disability Visual field loss threatening fixation Younger age at diagnosis
High IOP and PAS	Primary angle closure	Younger age
OHTS risk factors ⁷⁸ -Low CCT -High IOP -suspicious discs -Older age African origin Recurrent optic disc haemorrhages Pseudoexfoliation syndrome	III. Ocular hypertensives	Young age Multiple risk factors for progression Fellow eye of established GON (excluding unilateral secondary glaucoma)

The presence of multiple risk factors proportionally increases glaucoma risk and may elevate a patient into a higher risk category.

When?

- At initial consultation and reassess change in risk status at each review

OBJECTIVE

To maintain functional vision throughout the patient's lifetime with minimal effect on QOL.

SETTING GOALS

Goal of Intervention Is Risk Factor Reduction

- IOP
- Angle control; elimination of angle closure
- Treatment of predisposing disease/factors (diabetes mellitus, uveitis, steroids)

CONSIDER RATE OF GLAUCOMA PROGRESSION AND LIFE EXPECTANCY

- Treatment: set goals to preserve sight and maintain visual abilities
- This should be a balance of disease stage, progression rate, and life expectancy of the patient (the time course over which the disease is expected to run)
- A slow disease process in an elderly patient results in little progression during his/her life expectancy; a fast disease process in a younger patient tends to result in blindness
- This is the balance that has to be assessed by the clinician before determination of target pressure and all glaucoma treatments

Stage of Disease

Use the four risk categories above.

Estimate Rate of Retinal Ganglion Cell Loss

Higher → more aggressive risk factor reduction.

Severity of Risk Factors

Higher or greater number → more aggressive risk factor reduction.

Modifiers of Goals

- Life expectancy
- Ability to attend follow-up
- Diseases that prevent accurate disc or field assessment
- Treatment morbidity

INTRAOCULAR PRESSURE CONTROL

Intraocular Pressure Landmarks

- Presenting (untreated) IOP
- IOP in fellow normal eye in unilateral secondary glaucoma
- Population mean and SD IOP for normal eyes

TARGET INTRAOCULAR PRESSURE

- Target IOP is the pressure range estimated to slow or halt disease progression
- Target IOP range is determined from the baseline IOP, stage of disease, estimated progression rate, and life expectancy
- When the target is achieved, the patient needs continued monitoring for structural and functional changes
- Target IOP range should be individualised
- The benefits of further IOP reduction need to be weighed against the risks
- Target IOP is dynamic: changing with life expectancy and risks of intervention weighed against risk of visual disability from disease process

EXAMPLES OF HOW TO SET TARGET IOP RANGE

Glaucoma with High Risk for Progressive Visual Loss or Visual Disability

Target pressure reduction of $\geq 40\%$ ^{77,78,81} or 1-2 SD below the population mean (9-12 mmHg), if achievable safely.^{77,82-84}

Glaucoma with Moderate Risk for Visual Loss or Glaucoma Suspect with High Risk for Visual Loss

Target pressure reduction of $>30\%$ ^{77,82-84} or population mean, whichever is lower.

Glaucoma Suspect at Moderate Risk for Visual Loss

- Monitor closely for change or treat depending on risk and patient preferences
- Treat if risk(s) increase(s) with target pressure reduction of $\geq 20\%$ ^{77,82-84} or 1 SD above the population mean, whichever is lower
- 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.

CENTRAL CORNEAL THICKNESS IN RELATION TO TREATMENT TARGETS

Knowledge of CCT is useful in defining treatment IOP targets. As well as CCT being an independent risk factor for progression, it can be used to modify how we interpret the IOP (Table 1.9)

Table 1.9 CCT ranges for different patient populations.

	mean	SD
Europeans and Chinese Singaporeans	≈ 540 μm	≈ 35 μm
Japanese* and Indians (urban)	≈ 520 μm	≈ 30 μm
Indians (rural) and Mongolians*	≈ 505 μm	≈ 30 μm

*CTT was measured using optical pachymetry. Ultrasound pachymetry was used in all other cases.

ANGLE CONTROL

The goal is to deepen the anterior chamber and open the anterior chamber angle by:

- Iridotomy to eliminate pupil block
- Peripheral iridoplasty (ALPI) to flatten the peripheral iris
- Lens extraction to reduce pupil block and/or displace the iris posteriorly

TREATING PREDISPOSING DISEASES IN SECONDARY GLAUCOMAS

The goal is to prevent onset of GON by appropriate management of underlying primary disease eg uveitis or proliferative diabetic retinopathy.

FREQUENTLY ASKED QUESTIONS

Should the target IOP be calculated for every patient?

While many specialists keep target IOP in mind while managing patients, recording the actual value in the notes is helpful. IOP-lowering should be individualised for each patient: an individualised (target) IOP tends to prevent over- or under-treatment and minimises treatment effects on QOL. There is no definitive evidence for the concept or the methods used to determine a target IOP.

There are various tables and formulae available to calculate target IOP? Which one should be used in clinical practice?

Most formulae and tables provide similar values. A general rule is to reduce the IOP by the following:

Mild glaucoma – $\geq 20\%$

Moderate glaucoma – 30%

Severe glaucoma – $\geq 40\%$

For acute glaucoma, the literature provides limited data to set a target IOP. Ideally, the target IOP should be set below the pre-onset level or that of the other eye when it is normal.

Does the target IOP need to be calculated only at the beginning of management?

Target IOP is not a static or magic number, but a range that should change depending on the results of long-term monitoring. If a patient progresses at the target IOP, lower it further. If a patient is stable at the target IOP, perhaps the target could be reset to a higher level (with ongoing careful monitoring), allowing withdrawal of some treatment.

A healthy 75-year-old Indian patient has moderate glaucoma. However, in India, the average life expectancy is 66 years. How should this patient be treated?

The average life expectancy is calculated from birth. A person who has reached the age of 75 years is a survivor and, if healthy, could live for many more years, so should be treated accordingly. Calculators on the Internet facilitate determination of a patient's life expectancy. This might enable a more specific management plan.

Do all patients with NTG require systemic evaluation such as brain scan or carotid Doppler test before diagnosing them with NTG?

No. A small proportion of patients with NTG, especially those who are younger, have unilateral disease, disc pallor out of proportion with cupping, atypical VF defects, and colour deficiency, require appropriate cardiovascular and/or neurological investigation.

What is the goal of glaucoma management? Is it IOP reduction, prevention of VF progression, or prevention of progression of optic disc damage?

Glaucoma management aims to preserve visual function and QOL for individual patients for their lifetime. The aim is not to treat only the IOP, optic disc, or VF, but to treat the patient as a whole to provide maximum benefit with minimal side effects.

Should target IOP be similar for POAG and PACG?

Target IOP calculation depends on structural and functional damage, baseline IOP at which the damage occurred, age, and presence of additional risk factors. Even though PACG causes more blindness than POAG, this has not been incorporated into current target IOP calculations.

What is the importance of knowing a patient's age and presence of systemic diseases while deciding the management options?

These factors are important. For a 90-year-old patient with ischaemic heart disease, history of myocardial infarction, diabetes, hypertension, COPD, and early glaucoma in both eyes, the treatment should not be too aggressive.

If a patient who is a glaucoma suspect has an IOP of 24-28 mmHg, CCT of 540 μm in both eyes, optic disc showing inferior wedge-shaped RNFL defects, and normal white-on-white perimetry, and short-wave automated perimetry shows defects, how should the target IOP be decided?

RNFL defects with a suspicious disc suggest a diagnosis of pre-perimetric glaucoma. Treatment depends on other factors such as age, general health, and family history.

SECTION 2 TREATMENT

2.1 INITIATION OF TREATMENT

Why?

Glaucoma is a progressive optic neuropathy; treatment aims to delay disease progression and maintain quality of life.

What?

Assess the patient as a whole and individualise treatment. Aim to preserve visual function. IOP is the only known risk factor whose manipulation has been shown to alter glaucoma progression.^{75,77,81-86}

Mechanisms that elevate IOP:

- IOP elevation is most commonly due to reduced aqueous humor outflow due to functional or structural abnormalities.

When?

In the presence or increased likelihood of developing visual field damage that will interfere with QOL during the patient's lifetime.

How?

Treat the Mechanism(s)

- Remove precipitating factors
 - any drug that may elevate IOP (steroids; Appendix 3)
- IOP reduction
 - medication(s)
 - laser
 - surgery
- Correct the abnormal anatomy (angle closure),⁸⁷ if present
 - Laser
 - Trabecular surgery
- For secondary glaucoma, treat the underlying pathology (Appendix 8)
- Collaborate with colleague(s) to treat systemic problems

FREQUENTLY ASKED QUESTIONS

With so many drugs available, which one should be used as first-line treatment?

The ideal drug should be effective, easy to use, affordable, with no systemic side effects, and minimal or no ocular side effects. PGAs are popular as first-line agents. β -Blockers and α 2-agonists might be appropriate, especially in countries where costs prohibit expensive drugs.

The AGIS suggested that a mean IOP of 12 mm Hg minimises glaucoma progression. Should every patient's IOP be reduced to this level?

The IOP level of 12 mm Hg arose from a post-hoc analysis of AGIS data when it was noted that those who did not progress had a mean IOP of 12mm Hg, which should be interpreted with care. Lowering IOP is beneficial and, overall, the lower the better. Aiming for an IOP of 12 mm Hg is not necessary for all patients, and could provoke needless side effects. One should set a target pressure for each individual patient aiming to maximize drug effectiveness and quality of life but minimize side effects and cost.

The EMGT, AGIS, and OHTS studies show that if IOP is lowered by 1 mm Hg then the risk for progression is lowered by 10%. How should these data be used in clinical practice?

Such statements are based on statistical manipulation of the data, an explanation of which is beyond the scope of FAQs. The statement does not necessarily reflect real life and should not lead to needless aggressive treatment. Use information from trials but treat patients as individuals, not as study populations.

A patient is using a topical β -blocker, but needs better IOP control. Should another aqueous suppressant such as an α 2-agonist be added, or is it better to add a PGA?

β -Blockers act by suppressing aqueous, while PGAs act on the uveoscleral outflow pathway, which might be more effective. A unilateral trial of a PGA would be appropriate. As the aim is to switch medications where possible, rather than add, if IOP-lowering with a PGA is sufficient, withdrawal of the β -blocker could be attempted.

The OHTS shows that IOP reduction by 20% reduces risk for progression by 50%. Should all patients with OH be treated?

The OHTS reported reduction of progression by 50% for the treatment group. Not all patients with OHTS will progress. As 9.5% of patients in the control group progressed, 90.5% did NOT; this figure was reduced to 4.4% in the treatment group over 5 years. Most of the endpoints were disc related, not functional. Accordingly, not all patients with OH require treatment. Using OHTS data and other literature, if patients with high IOP (>26 mm Hg), thin corneas (<550 μ m), large vertical CDR, and high PSD on VF tests are treated, the maximum benefit could be obtained. Other risk factors such as family history of glaucoma need to be considered.

If a patient with PAC has an IOP in the mid-twenties several weeks after LPI, how should he be treated?

Management depends on the gonioscopy post-LPI and the state of the discs/fields. The main objective of LPI is to open the angle, to prevent anterior segment damage (PAS) and subsequent IOP elevation. If the angle still shows a PACS configuration, determine the underlying mechanism of residual AC and treat accordingly. Plateau iris syndrome may need ALPI (or long-term low-dose miotic, if tolerated). Once the angle is open, management is similar to POAG; some patients may need an IOP-lowering agent.

If a patient with pigment dispersion syndrome without disc and VF changes has an IOP between 22 mm Hg and 24 mm Hg, should LPI be performed or is observation sufficient?

There is good evidence that a laser PI does not prevent onset of pigmentary glaucoma in pigment dispersion syndrom.

Most studies have reported that topical CAIs reduce IOP by approximately 20%. However, whenever this has been started as a third-line agent after a β -blocker and PGA in the clinic, a 20% IOP reduction is never obtained. Why is this?

IOP cannot be lowered below episcleral venous pressure medically. IOP reduction achieved by first-, second-, and third-line drugs becomes progressively less. IOP reduction of 20% is more likely if the CAI is used first.

Several glaucoma specialists advocate a unilateral drug trial, but the recent literature shows this is ineffective. Should a unilateral drug trial still be used to prove that a drug is working?

A recent retrospective study concluded that unilateral drug trials might not be helpful. Like any technique, a unilateral trial does not always work. Another study showed that a unilateral drug trial was effective approximately 80% of the time. If a patient is asked to use a medication that is expensive and may have side effects indefinitely, there should be little doubt that it works. Despite its weaknesses, the unilateral drug trial is probably the best way to demonstrate effectiveness.

A patient has moderate glaucoma and the IOP is 28 mm Hg in both eyes. If a unilateral drug trial is used, 1 eye will remain unprotected for a period of 4 to 6 weeks. Is this safe?

Glaucoma is a chronic progressive disease, so has usually been present for a long time. Nothing significant is likely to happen during the short period of a unilateral trial. Care should be taken in eyes with critical visual field defect.

Can a relatively selective β_1 -blocker (Betaxolol) be prescribed to a patient with asthma?

Even though they are selective and have fewer respiratory side effects, relatively selective β -blockers can worsen asthma; they should be used with caution, if at all. The 'double-DOT' instillation technique should always be used to minimise systemic absorption.

What should be remembered when starting a unilateral trial with a β -blocker?

Used unilaterally, β -blockers have a contralateral effect of approximately 1.5 mm Hg; this correlates with the IOP fall in the treated eye and with the baseline IOP in the contralateral eye. Take this into account when assessing the response to the unilateral trial.

2.2 MEDICAL TREATMENT

Why?

- Effective for the majority of patients
 - Generally acceptable therapeutic index
 - Widely available
 - Requires good compliance (adherence and persistence) to the prescribed medication
- The choice depends on the mechanism of glaucoma, comorbidities such as dry eye disease, as well as other risk factors (Section 1).^{83,88,89}

What?

- For angle closure, medical treatment is suitable in conjunction with laser peripheral iridotomy or cataract extraction for patients after PI. See Tables 2.1 and 2.2 for the drug classes and their mechanisms of action

Table 2.1. Efficacy and dosing frequency of various drug classes.⁸⁹⁻⁹⁷

Drug class	Daily dosage	Efficacy
PGAs	1x	25-35%
β-Blockers†	1x to 2x	20-25%
α_1-Blockers	2x	15-20%
α_2-Agonists‡	2x to 3x	18-25%
$\alpha_1\beta$-Blockers	2x	20%
CAIs		
Topical	2x to 3x	20%
Systemic	2x to 4x	30-40%
ROCK (Rho-kinase) inhibitor	2x	20%
Cholinergics	3x to 4x	20-25%
Hyperosmotic agents	Stat dose(s)	15-30%
Proprietary fixed combinations		
β -Blocker + CAI	2x	25-30%
β -Blocker + PGA	1x	25-35%
β -Blocker + pilocarpine	2x	25-30%
β -Blocker + α_2 -agonist†‡	2x	25-35%
CAI + α_2 -agonist	2x to 3x	25-35%

† If a patient is taking systemic β -blockers, the decrease in IOP with topical β -blockers is likely to be reduced, and the potential for systemic side effects increased: consider other drug classes first.

‡ α_2 -Agonists are absolutely contraindicated for patients taking MAOIs and for children <2 years.

Table 2.2. Mechanism of action of different drug classes.⁸⁹⁻⁹⁶

Mechanism of action	Drug class	Preparations
Increase in aqueous outflow	PGAs Increase in uveoscleral outflow	Latanoprost Travoprost Bimatoprost Tafluprost Unoprostone
	α_1 -Adrenergic antagonists Increase in uveoscleral outflow	Bunazosin
	α_2 -Adrenergic agonists	Brimonidine Apraclonidine
	$\alpha_1\beta$ -Adrenergic antagonists Increase in uveoscleral outflow	Nipradiol
	Cholinergics Increase in trabecular outflow	Pilocarpine Carbachol
	ROCK (Rho-kinase) inhibitor Increase trabecular outflow	Ripasudil
Decrease in aqueous inflow	β -Adrenergic antagonists	β 1-Non-selective Timolol Levobunolol Carteolol β 1-Selective Betaxolol
	α_2 -Adrenergic agonists	Brimonidine Apraclonidine
	$\alpha_1\beta$ -Adrenergic antagonists	Nipradiol
	CAIs	Systemic Acetazolamide Methazolamide Dichlorphenamide Topical Dorzolamide Brinzolamide

How?

Choose the Most Appropriate Medication

- Greatest chance of reaching target IOP
- Best safety and tolerability profiles
- Minimal inconvenience
- Affordable
- Maximal likelihood of adherence

Start Low and Slow

- Minimal concentration
- Minimal frequency

One-eyed Therapeutic Trial

- May be helpful in some situations
- Start treatment in the worse eye
- Check the IOP response after two to four weeks
- Assess side effects
- If acceptable and effective, make treatment bilateral

Inadequate initial response

If the response is inadequate to achieve the target pressure, switch before adding:

- Switch to a different class of medication (switching within the PGA class may be useful, but adherence and regression to the mean need to be considered)
- If a drug fails to reduce IOP from baseline or produces significant side effects, one should switch to a second drug

Use more than one agent only if each has demonstrated efficacy but is insufficient to reach target pressure:

- Apply this principle also to the fixed combinations
- Do not combine two drugs with the same pharmacological action
- Do not use two fixed combinations containing overlapping categories.
- In rare cases where a very large IOP reduction is needed it may be necessary to start with more than one active agent

See Figure 2.1 for the medical treatment algorithm.

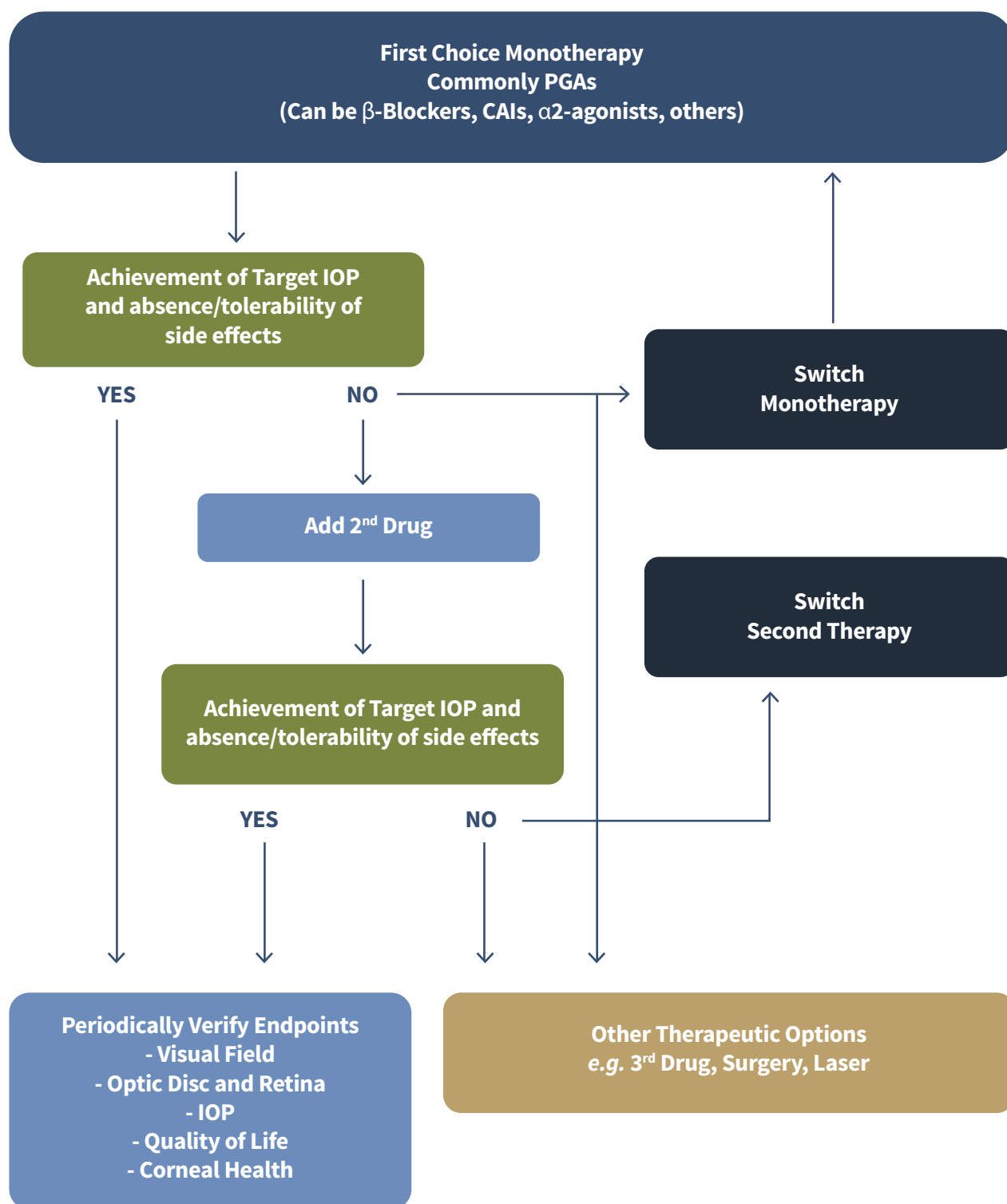
See Appendix 10 for the side effects of glaucoma medications.

Maximise the Likelihood of Adherence⁹⁷

- Establish a therapeutic alliance with the patient and their family – they need to view the doctor as an ally against the disease
- Patient and family education
- Least complex regimen
- Least disruption of lifestyle
- Reminder systems (such as cellphone based alarms) significantly improve adherence

Teach the Technique for Eye Drop Instillation⁹⁸

- Demonstrate the preferred method, including punctal occlusion and eyelid closure for at least three minutes (double DOT technique – ‘don’t open the eyelid’ and ‘digital occlusion of the tear duct’)
- Ensure the patient can do it
- If ≥ 2 drops are to be instilled, wait at least five minutes between drops
- Provide educational material
- Efficacy of additional medications diminishes as number of drugs increases
- Laser trabeculoplasty may be used in place of or as an adjunct to medical therapy
- Surgery may be an appropriate alternative in certain situations

Figure 2.1 Medical treatment algorithm.

FREQUENTLY ASKED QUESTIONS

If a patient has an IOP that is always maintained in the low teens, but non-adherence is suspected, with the drops used only before visiting the clinic, how is adherence checked?

Non-adherence (non-compliance) is serious, and there is no foolproof method to check. Filling of prescriptions and the amount that remains can be monitored. Patients can be asked whether ANY medication has been missed since the last consultation. The specificity of a “Yes” answer is very high — if a patient admits to missing a single dose, there is likely to be significant non-adherence. However, if a patient’s glaucoma is stable, should adherence be increased, which may be over-treating? This can be a difficult area and one that potentially leads to conflict in the doctor-patient relationship. The best method of ensuring adherence (or concordance) is to build a trusting relationship with the patient so that they understand the need for treatment.

What is maximal tolerable medical therapy? If a patient who is a business executive and travels a lot can instil only 1 drop per day (he is using a combination of a PGA and a β -blocker), can this be considered as maximal tolerable therapy for him?

Theoretically, maximal tolerable medical therapy is the minimum number and concentration of drugs (within the combination of different classes of medications) that provides maximum IOP-lowering for that patient. Practically, it is the greatest burden of drop instillation and side effects a patient can manage, and is very different for different individuals. If a patient cannot use medications reliably more than once per day then, for this patient, such a regimen might be considered maximal tolerable therapy. The patient must be helped to understand the options and risks, and participate in planning realistic treatment strategies.

Should topical CAIs be avoided for patients with poor corneal endothelial function? What are the guidelines?

In a compromised cornea with poor endothelial function, topical CAIs can precipitate corneal oedema. Topical CAI use should be minimised for patients with poor corneal endothelial function (Fuchs’ dystrophy, post-surgical corneal oedema).

A patient developed choroidal effusion and angle closure (AC) shallowing after starting a systemic CAI. He has used this before with no side effects. How does this happen?

Choroidal effusion and secondary angle closure shallowing is a rare idiosyncratic complication of systemic CAIs and other drugs. Angle closure shallowing follows forward rotation of the ciliary body, pushing the iridolenticular diaphragm forwards. This mechanism requires a sensitising dose and an inciting dose. The effusion is typically not seen at first use.

What is the current role of neuroprotection in glaucoma?

Currently, there is no clinical evidence for neuroprotection as an isolated strategy. CCBs might help in the presence of marked vasospastic disease (migraine and/or Raynaud’s phenomenon). α 2-Agonists are prescribed primarily for their IOP-lowering effects. Phase III trials of the NMDA receptor blocker memantine yielded mixed results.

For a patient with hypertension, should the physician change the antihypertensive treatment to a CCB?

If a glaucoma patient with progressive damage and marked vasospastic disease is also taking antihypertensive agents, systemic CCBs could be considered (although there is no firm evidence of their efficacy for glaucoma). Systemic CCBs can have significant side effects and, given with topical β -blockers, can potentiate negative inotropic and chronotropic cardiac effects. Ensure a patient taking systemic antihypertensive agents is not being over-treated. For a patient with hypertension it may be advisable to take their anti-hypertensives in the morning if they are on a once a day regime, to avoid nocturnal dipping. Where feasible, check 24-hour blood pressure and pulse measurements to detect and rectify nocturnal blood pressure dipping.

There are numerous generic PGAs available locally. Are they as good as the original molecule?

Most generic PGAs have not been compared with the original molecules. When one latanoprost generic was compared with Xalatan™, the IOP reduction was less than for the original drug.

Do fixed combination therapies reduce IOP equally to the individual components?

Medications used individually tend to lower IOP more than if used in fixed combinations. However, fixed combinations are more convenient, encourage adherence, reduce preservative load to the eye, and may be cost-effective.

Which antiglaucoma medications can be used during pregnancy?

Direct research into the use of antiglaucoma medications during pregnancy is lacking, limiting the safety evidence. The USA FDA has classified drugs for use during pregnancy based on animal or human studies. Brimonidine is classified as a class B medication (presumed safety based on animal studies). All other topical glaucoma medications are classified as class C (uncertain safety; no human or animal studies show an adverse effect). SLT and ALT can be considered to try to reduce drug use. For advanced glaucoma, cyclophotocoagulation is an option. Use of MMC is contraindicated and surgery is also associated with a high risk after the first trimester. IOP can spontaneously drop later in the pregnancy, so sometimes watching and waiting may be the best strategy. Alpha agonists are contraindicated in neonates and infants. Beta-blockers also have the potential to reduce foetal respiration in late pregnancy.

If a patient does not respond to one PGA, should other PGAs be used?

Switching between PGAs might be effective, so consider this before switching to another group of medications.

2.3 LASER TREATMENT

TYPES OF LASER TREATMENT

Open-Angle Glaucoma

- Outflow enhancement: laser trabeculoplasty
- Inflow reduction: cyclophotocoagulation (usually for end-stage disease)

Angle Closure (± Glaucoma)

- Pupillary block relief: laser iridotomy
- Modification of iris contour: laser peripheral iridoplasty
- Inflow reduction: cyclophotocoagulation (usually for end-stage disease)

Post-Filtering Surgery

- Outflow enhancement: laser suture lysis

LASER TRABECULOPLASTY

Why?

- Relatively effective
- Relatively non-invasive
- Avoid medical non-adherence
- Easy to perform

What?

- Laser treatment to TM to increase outflow

When?

- Medical therapy failure or inappropriate
- Adjunct to medical therapy
- Primary treatment if appropriate

How?

Prelaser Management

- Explain the procedure
- To reduce post-treatment IOP spike or inflammation, consider 1%⁹⁹ apraclonidine^{100,101} or 0.15-0.2% brimonidine¹⁰² and/or 2-4% pilocarpine¹⁰¹ (pilocarpine may decrease the blood-aqueous barrier, which may increase inflammation), and/or β -blocker and/or steroid drops before the procedure
- Topical anaesthesia

Laser

- Argon green or blue-green¹⁰³
- Frequency-doubled Nd:YAG (532 green) or Diode laser – SLT¹⁰⁴⁻¹⁰⁷
- Diode laser trabeculoplasty (DLT)

*Lens**

- Latina SLT Gonio laser lens
- Goldmann gonioscopy lens
- Ritch trabeculoplasty lens
- CGA© LASAG/Meridien CH
- Magna View Gonio argon/diode laser lens

* Should be coated to minimise reflection and hazard to observers.

PLACEMENT OF LASER SPOTS

Between pigmented and non-pigmented TM (Table 2.3. and Appendix 11).

LASER PARAMETERS	Spot size:	50 μm (for ALT), 400 μm (for SLT)
	Exposure time:	0.1 sec (for ALT and DLT), 3 nsec for SLT
	Power:	300-1200 mW depending on the reaction
	Number of spots:	30-50 spots evenly spaced over 180° Treat the remaining 180° sequentially or at the same time, as required

Table 2.3. Selective laser trabeculoplasty versus argon laser trabeculoplasty.

	SLT	ALT
Number of spots	30-50	50
Exposure time (nsec)	3	100,000,000
Fluence (mJ/mm²)	6	40,000
Power	0.4-1.4 mJ	300-600 mW
Laser requirements	Ultrashort pulse duration Low laser energy	

Effectiveness

- ALT and SLT have similar efficacy
- Laser trabeculoplasty is initially effective in 80-85% of treated eyes with a mean IOP reduction of 20 to 25% (of 6-9 mmHg). The effect wears off over time for both ALT and SLT¹⁰⁸
- In the Glaucoma Laser Trial, after 7 years follow up, patients with ALT had lower IOP (1-2 mmHg) than patients on medical treatment and no difference in progression of glaucoma.¹⁰⁹ SLT has shown to decrease IOP to a degree similar to that of prostaglandin analogues after 9-12 months follow-up¹¹⁰ and appears to be repeatable¹¹¹
- Currently studies evaluating SLT as a primary treatment are being undertaken

Predictors of Efficacy

- Higher baseline IOP is associated with greater IOP reduction after SLT and ALT^{112,113}
- The effectiveness of ALT is influenced by the treating surgeon and success is better when surgeons have more experience in ALT^{113,114}
- Pigmentation of the TM is important for ALT. ALT is less successful in eyes with no pigmentation of the TM. Younger subjects (less than 40 years old) usually respond less to ALT¹¹⁵

Complications

- Temporary blurred vision
- IOP spike with possible visual field loss
- Transient iritis
- PAS if placement of burns is too posterior or post-laser inflammation control is not effective (for ALT)
- Endothelial burns if treatment is too anterior (for ALT)
- Chronic increase in IOP
- Corneo-refractive changes
- Suprachoroidal effusion¹¹⁶

Post-Laser Management

- Continue any current medical treatment
- Recheck IOP, especially if IOP spike prevention treatment is not available
- Topical steroid qid for 4-14 days is recommended for ALT^{117,118}
- NSAIDS may be given for SLT for 4-7 days
- Consider omitting topical steroids or NSAID following SLT as they may decrease post-operative inflammation but decrease efficacy as creating inflammation and its subsequent effect on the trabecular meshwork is postulated as its mechanism of action

Closer monitoring is suggested for certain patients:

- Advanced glaucoma with severe visual field loss
- One eyed
- High pre-laser IOP
- Previous laser trabeculoplasty
- Pigmentary glaucoma

Repeat Treatment

Initial treatment may not be long-lasting. Laser trabeculoplasty can be repeated, especially in eyes that have shown a prolonged response to previous treatment.¹¹⁹

There is evidence that SLT is relatively safe to repeat.¹²⁰

LASER IRIDOTOMY

Why?

- Effective in relieving pupillary block
- Relatively non-invasive
- Preferable to surgical iridectomy in certain situations

What?

- Laser Parameters for argon Laser

When?

- Laser treatment to connect the anterior and posterior chambers to relieve pupillary block
- PAC – pupil block significant
- PACG – pupil block significant
- PACS (absolute):
 - PAC in the fellow eye
- PACS (relative):
 - need for repeated dilated examinations
 - poor access to regular ophthalmic care
 - confirmed family history of PACG
- Secondary angle closure with pupil block
- LPI may not be helpful in angle closure where pupil block is not the dominant mechanism eg uveitis, iris cysts or uveal effusions

How?**Pre-Laser Management**

- Explain the procedure
- Instil 1-4% pilocarpine
- To reduce post-treatment IOP spike/inflammation, consider 1% apraclonidine or 0.15-0.2% brimonidine, and/or β -blocker, and/or oral CAI, and/or steroid drops before the procedure
- Topical anaesthesia
- Topical glycerine, if the cornea is oedematous
- Lenses used are: Abraham (+66 diopters), Wise (+103 diopters) or CGI©LASAG CH lens (procedure)
- Iridotomy site is usually chosen in the superior quadrants of the iris well covered by the upper eyelid, in a thin looking area or an iris crypt
- A recent publication suggest that a temporally placed iridotomy may lead to reduced visual symptoms¹²¹
- Care should be taken to perform iridotomies peripherally
- Patients should be warned of the low risk of visual symptoms which can occur regardless of the site of the iridotomy

Laser

- Nd:YAG¹²²
- Argon¹²²
- 'Sequential' laser: Argon followed by Nd:YAG
- Sequential PI is useful in eyes with thick irides and also in patients receiving systemic anticoagulation or anti platelet medication to reduce the risk of hyphema

**LASER
PARAMETERS FOR
CONTINUOUS-
WAVE ARGON
LASER**

Preparatory stretch burns

Spot size:	200-500 μ m
Exposure time:	0.2-0.5 sec
Power:	200-600 mW

Penetration laser burns

For penetration burns by Argon

Spot size:	50 μ m
Exposure time:	0.05-0.1 sec
Power:	700-1000 mW

For pale blue or hazel iris

First step, to obtain a gas bubble:

Spot size:	50 μ m
Exposure time:	0.5 sec
Power:	1500 mW

Second step, penetration through the gas bubble:

Spot size:	50 μ m
Exposure time:	0.05 sec
Power:	1000 mW

For thick dark brown iris (chipping technique)

In case of thick, dark brown irides spot size is 50 μ m, duration 0.02 sec, and power of 1500 mW.

Spot size:	50 μ m
Exposure time:	0.05-0.1 sec
Power:	600-1000 mW

Choose and modify parameters depending on individual response

LASER PARAMETERS FOR ND:YAG LASER

Energy: 1-6 mJ; use minimum energy, 1-3 pulses per burst, once penetration has occurred and gush of pigments and aqueous seen it is best to reduce power to continue enlarging the iridotomy horizontally and penetrating as lens damage and zonule weakness is possible above 2 mJ per pulse once the iris has been penetrated.

Tip: Defocus to zero, focus the beam within the iris stroma rather than on the surface, avoid any apparent iris vessels, use the least effective amount of energy¹²³ lens capsule damage is possible above 2 mJ energy.

- Focus the beam within the iris stroma rather than on the surface of the iris
- Choose an iris crypt or an area of thin iris
- Can be effectively combined with argon laser
- To facilitate penetration of a uniformly thick iris, argon laser pretreatment can:
 - coagulate
 - stretch
 - thin the target area

LASER PARAMETERS FOR 'SEQUENTIAL' LASER – ARGON FOLLOWED BY ND:YAG LASER

Preparatory burns — Argon laser (chipping technique)

Spot size: 50 µm
Exposure time: 0.02-0.05 sec
Power: 500-900 mW (depends on iris pigmentation. Lower power for darker irides)

Apply preparatory burns through the iris stroma, until iris pigment epithelium reached (pigment puff)

Penetration laser burns – Nd:YAG laser

Power: 3-8 mJ
Number of spots: As required, until hole of adequate size created¹²³ (usually 2-5 shots)

- Pretreatment with argon laser to minimize bleeding by coagulating iris vessels is optional (spot size 400 µm, duration 0.2 sec, energy approximately 200-300 Mw)
- In case of thick dark iris, to reduce total Nd:YAG energy, pretreatment with argon laser in two stages may be considered.¹²⁴ In the first stage, low power argon of 90-250 mW, duration 0.05 sec, spot size 50 µm is applied, followed by the higher power argon 700 mW, duration 0.1 sec, spot size 50 µm to create a punched out crater appearance. Laser Iridotomy is completed with Nd: YAG laser.

Complications

Complications are rare and can often can be avoided with careful and proper technique.

- Temporary blurring of vision
- Corneal epithelial and/or endothelial burns with argon (especially with bubble formation and proximity to endothelium)¹²⁵
- IOP spikes
- Postoperative inflammation
- Posterior synechiae

- Intraoperative bleeding
- Iridotomy closure¹²⁶
- Failure to penetrate
- Localised lens opacities or cataract progression¹²⁷
- Rarely: retinal damage, retinal and subhyaloid haemorrhage,¹²⁸ cystoid macular oedema, ciliary block glaucoma,¹²⁹ endothelial decompensation,¹³⁰⁻¹³² decompression retinopathy,¹³³ Descemet's membrane detachment¹³⁴
- Visual disturbances occur in 6-12% and less likely to occur when the iridotomy is completely covered by the eyelid^{135,136}
- Elevation of IOP at one hour after iridotomy occurs in approximately 10% of primary angle closure suspect eyes¹³⁷

Post-laser Management

- Particularly if IOP spike prevention treatment is not available:
 - re-check IOP 1 hour after laser
 - systemic acetazolamide or mannitol may be indicated if IOP rises rapidly
 - discharge patient only when IOP stable at a safe level
- Topical steroid (or NSAIDs) at least 4-6 times/day for 4-14 days depending on inflammation, it reduces post laser inflammation
- Stop topical pilocarpine, and taper any other topical IOP-lowering drugs as indicated
- Verify the patency of the PI by transillumination. However, it is best to actually look at the PI under magnification in the slitlamp. It is possible that following PI, synechiae may occur in the iris or anterior lens capsule at a later stage.
- **Repeat gonioscopy when effect of pilocarpine has worn off** – if appositional closure remains and IOP high, may consider laser peripheral iridoplasty or early cataract extraction¹³⁸ if lens mechanism is identified
- Pupillary dilatation to break posterior synechiae when suspected
- Surgical iridectomy may have a role in certain conditions such as inflamed eye with acute primary angle closure, iris bombe in anterior uveitis, as well as when the cornea visibility is very poor

PERIPHERAL IRIDOPLASTY¹³⁹

Why?

- Non-invasive

What?

- Laser treatment to contract the peripheral iris:
- To flatten the peripheral iris
 - To widen the anterior chamber angle inlet
 - To re-open appositionally closed segments of drainage angle

When?

- Help to break an attack of acute angle closure as initial treatment,¹⁴⁰⁻¹⁴⁶ or as adjunctive measure when systemic medications fail to control IOP
- Angle remains occludable following PI, e.g., plateau iris^{147,148}
- To break attack of secondary forms of acute angle closure (phacomorphic glaucoma)¹⁴⁹⁻¹⁵¹
- Facilitate access to TM for laser trabeculoplasty¹⁴⁰
- As an adjunct to goniosynechialysis^{152,153}
- Plateau iris syndrome
- Contraindicated in area with PAS; will not break PAS, may cause more inflammation

How?

Pre-Laser Management

- Explain the procedure
- Instil 2% or 4% pilocarpine
- To reduce post-treatment IOP spike/inflammation, use 1% apraclonidine or 0.15-0.2% brimonidine, and/or β -blocker, and/or oral CAI, and/or steroid drops before the procedure
- Topical anaesthesia

Lens

- Any laser iridotomy contact lens
- Lenses used are: Abraham (+66 diopters), Wise (+103 diopters), CGI©LASAG CH lens or the central non-mirrored part of the Goldmann lens

Procedure

- Different types of continuous wave lasers can be used: argon laser, diode laser (810 nm) and the frequency doubled Nd:YAG laser (532 nm)
- Argon green or blue-green
- Diode laser¹⁴⁴
- Placement of laser spot
 - aim at the most peripheral location
 - aiming beam may have to straddle limbus
- If peripheral anterior chamber too shallow, a mid-peripheral laser spot could be placed first to deepen the anterior chamber, before a more peripheral laser spot is applied
- Charring of iris or ‘pop’ sound or bubble signifies too much power – reduce power accordingly

LASER PARAMETERS

Power:	150–240 mW depending on the reaction — the smaller the spot size, the lower the power setting
Spot size:	500 μ m — both small-spot and big-spot pattern can be used with appropriate adjustment of power setting
Exposure time:	0.5 sec
Number of spots:	10–40 applications over 360°, leaving at least 1- to 2-spot diameters between spots; 180° treatment may also be effective ¹²¹ Do not overtreat

Endpoint

Iris contraction with peripheral anterior chamber deepening.

Complications^{139,144,146}

- Mild iritis
- Iris atrophy
- Mydriasis
- Corneal endothelial burns
- IOP spikes
- PAS(rarely) and/or posterior synechia (PS)
- Rarely: decompression retinopathy¹⁵⁴
- Rarely: Urrets-Zavalía syndrome¹⁵⁵ (Iris ischaemia causing a dilated and irregular fixed pupil)
- Iris atrophy and non-dilatable pupil are established complications

Postoperative Treatment

- If treatment for prevention of IOP spike is not available, check IOP within 1 hour and at 24- 48 hours depending on the status of the patient
- Topical corticosteroids 4-6 times/day for 7 days or more depending on the post-laser inflammation
- Repeat gonioscopy to evaluate the anterior chamber angle and identify any other mechanism(s) of angle closure that might necessitate further intervention
- Pupillary dilatation to break posterior synechiae when suspected
- According to the WGA Consensus Series 3¹⁵⁶, two additional situations should be noted:
 - First, when iridoplasty needs to be repeated because of recurrence of appositional closure at some point after the angle has been initially opened, it is possible to place the contraction burns further peripherally than had been initially possible. The reason for this is evident if one conceptualizes the geometry of the peripheral iris. When the angle is closed, burns placed just inside the point of apposition pull open the angle and expose iris stroma further peripherally. This area can be treated on a subsequent occasion, if necessary
 - Secondly, a few angles have a very sharply defined plateau, which on indentation forms almost a right angle and takes firm pressure to indent open. This type of plateau iris often does not respond well to contraction burns placed with the Abraham lens but require burns placed through one of the angled mirrors with magnification buttons directly into the peripheral angle. A 200 µm spot size should be used in this circumstance

CYCLOPHOTOCOAGULATION

Why?

- Reasonably effective
- Preferable to cyclocryotherapy because less collateral damage and inflammation
- Can be repeated if IOP-lowering effect wears off

What?

- Reduces aqueous production by coagulative destruction of ciliary epithelium

When?

- Painful blind eyes or eyes with poor vision
- CPC can be used in sighted eyes where the benefits and risks of cyclodiode are believed outweigh those for incisional surgery
- Failed multiple filtering surgeries
- Primary procedure to alleviate pain in secondary glaucomas with poor visual potential
- Surgery not appropriate

How?

Pre-Laser Management

- Explain procedure
- For trans-scleral technique, careful slit-lamp examination to identify suitable/unsuitable sites for laser application
- Topical and sub-Tenon's anaesthesia, or retro-/peribulbar anaesthesia
- General anaesthesia when indicated

Techniques

- Transpupillary
- Trans-scleral
- Endolaser
- Conservative, incremental applications avoiding 3- and 9-o'clock positions

Contact Transscleral Diode Laser

Diode laser with transscleral contact probe (Appendix 11).

LASER PARAMETERS

Exposure time:	0.5-2.0 sec
Power:	1.0-2.5 W
Number of burns:	20-40 over 180-360°
Location:	1.0-2.0 mm from limbus

Endolaser

- Diode endoscopic laser
- Argon laser

LASER PARAMETERS

Depends on laser system used – consult the instruction manual and clinical updates

Ultrasonic cyclodestruction

- Ultrasonic circular cyclocoagulation using high-intensity focused ultrasound delivered by a circular miniaturized device has also been reported to reduce IOP in patients with refractory glaucoma^{157,158}

Complications

- Pain
- Persistent inflammation
- Loss of visual acuity^{159,160}
- Hypotony¹⁶¹ and Phthisis¹⁶²
- Scleral *thinning*^{163,164} or rupture¹⁶⁵
- Pupillary distortion¹⁶⁶
- Macular oedema
- Retinal detachment¹⁶⁷
- Aqueous misdirection syndrome¹⁶²
- Sympathetic ophthalmia¹⁶⁸
- Failure to control IOP – multiple procedures may be needed
- Rates of complications are higher in neovascular glaucoma and with treatment protocols using more than 80 J per session¹⁶⁹

Postoperative Management

- Analgesia
- Continue any current treatment as the effect of cyclophotocoagulation is not immediate
- Check IOP after 24-48 hours if concerned over the potential effect of an IOP spike
- Topical corticosteroids 4-6 times/day for 14 days or more depending on post-laser inflammation
- Cycloplegia 2-4 times/day for 7-14 days
- Continue any current IOP-lowering treatment; taper as indicated

LASER SUTURE LYSIS

Why?

- Effective
- Non-invasive
- Avoid early bleb failure
- Staged postoperative IOP control

What?

- Laser treatment to selectively lyse the subconjunctival scleral flap suture(s), without disturbing the overlying tissues, allows postoperative titration of IOP by increasing outflow¹⁷⁰

When?

- Commonly within 28 days of glaucoma filtering surgery

How?**Pre-Laser Management**

- Explain the procedure
- Topical anaesthesia

Laser

- Argon green or blue-green
- Diode
- Frequency-doubled Nd:YAG

Lens

- Ritch
- Hoskins
- Mandelkorn
- Zeiss 4-mirror
- Glass rod

Uses of Lens

- Blanch the conjunctival vessels
- Focus on the suture
- Fix the globe
- Open the lids

Placement of Laser Spots

- Subconjunctival scleral flap sutures (nylon)

Complications

- Conjunctival burn, leak
- Hypotony
- Shallow anterior chamber
- Bleeding from ostium
- Hyphaema

Note: in presence of subconjunctival haemorrhage, one must be cautious, since lasering this area may cause charring of the conjunctiva and sometimes a button hole in the conjunctiva, leading to a leak.

**LASER
PARAMETERS**

Spot size:	50 µm
Exposure time:	≤0.1 sec
Power:	300-800 mW
Number of spots:	1 or more, as needed
Technique:	Cut one suture per session to fully evaluate the response If blood present under the conjunctiva, choose different suture to cut, or use a longer wavelength laser, or use a short exposure time Cut suture close to one end or the other

Post-Laser Management

- Continue current postoperative regimen
- If bleb does not form spontaneously, apply pressure, eg, around trapdoor
- Recheck IOP and outflow 1 hour after laser and within 1 week
- Examine the bleb and if not formed do some controlled massage. If a bleb is formed one may check the IOP and then wait for an hour and recheck the iOP to see if the IOP remains lower than before the Laser suturelysis. This often gives an indication of the efficacy of the procedure

FREQUENTLY ASKED QUESTIONS

Which is more effective: ALT or SLT?

Most reports suggest that they have similar IOP-lowering effects.

Does ALT/SLT alter the success rates of future glaucoma filtering surgery?

Eyes that have undergone ALT have been reported to have poorer success rates for trabeculectomy. This information is not yet available for SLT.

Is there a significant risk of cataract progression following LPI?

There are a few reports of cataract progression following LPI. However, there are no definite figures for the increased risk.

Is it possible for a patent LPI to become blocked with time? Should gonioscopy be performed at regular intervals, even with a patent iridotomy?

Blockage of a patent iridotomy is uncommon with the YAG laser. Blockage of the LPI or changes in lens thickness can alter angle anatomy. Regular gonioscopy is important.

What is the role of iridoplasty in plateau iris?

Iridoplasty can open the angle in patients with plateau iris and should be considered. Pilocarpine does the same, and can be used instead, in some instances. Iridoplasty seems to have a role in acute ACG resistant to conventional treatment.

Can SLT be used as primary therapy?

SLT can be used as primary therapy, or to decrease the number of medications required for patients whose IOPs are well controlled but for whom the drug regimen is a burden.

2.4 SURGERY

TYPES OF SURGERY

Open-Angle Glaucoma

- Outflow enhancement: penetrating and non-penetrating filtering surgery
- Glaucoma drainage devices
- Minimally invasive glaucoma surgery (MIGS): subconjunctival, suprachoroidal, trabecular bypass

Angle-Closure Glaucoma

- Pupillary block relief: iridectomy
- Outflow enhancement: trabeculectomy
- Widening of anterior chamber angle: lens extraction
- Plateau iris syndrome: laser peripheral iridoplasty (or lens extraction)
- Angle surgery: goniosynechialysis
- Glaucoma drainage devices

Childhood Glaucoma

- Angle surgery: goniotomy and trabeculotomy
- Outflow enhancement: trabeculectomy ± trabeculotomy
- Glaucoma drainage devices

GLAUCOMA SURGERY

Why?

- Effective in lowering IOP in eyes where topical medication and or laser have failed to do so or are deemed unlikely to provide satisfactory IOP control^{171,172}

How?

- Penetrating filtering surgery:
 - trabeculectomy
 - trabeculectomy with antimetabolites
- Non-penetrating surgery (with or without implant):
 - deep sclerectomy
 - viscocanalostomy/ canaloplasty
- Glaucoma drainage devices
- Surgical iridectomy: largely replaced by laser iridotomy (Section 2.3)
- Lens extraction for lens-induced angle closure
- Goniosynechialysis
- Vitrectomy for ciliary block
- Minimally invasive glaucoma surgery (MIGS)

How?

- Failed medical and/or laser treatment¹⁷¹
- Anticipated failure of medical and/or laser treatment (very high IOP)^{89,172}
- Patient preference
- Other forms of therapy are inappropriate: poor adherence, side effects, socioeconomic problems

How?

Preoperative Assessment

Identify risk factors for failure and treat where applicable¹⁷³

- Asian, African, Hispanic ethnicity
- Previous ocular surgery
- Young age
- Aphakia
- Pseudophakia

- Active ocular inflammation
- Prolonged use of topical antiglaucoma medications¹⁷⁴
- Tendency to form keloid scars
- Neovascular glaucoma and other secondary glaucomas

SURGICAL TECHNIQUE: TRABECULECTOMY

- Select appropriate technique and decide whether or not to use antimetabolites
- Fornix-based or limbus-based conjunctival flaps
- A corneal traction suture to rotate the globe inferiorly
- If antimetabolites are used, these should be applied to a large surface area of conjunctiva to reduce the risks of bleb infections and cystic blebs¹⁷⁵
- The scleral flap architecture should encourage posterior flow
- Pre-placing scleral sutures, viscoelastic and/or inserting an infusion cannula can reduce periods of hypotony during surgery
- Meticulous Tenon's and conjunctival closure to prevent leaks and their sequelae
- The EX-Press implant inserted under a trabeculectomy flap has shown equivalent rates of success to trabeculectomy but similar rates of other complications¹⁷⁶

ENHANCEMENT OF SURGERY

- Use of antifibrotic agents:
 - intraoperative¹⁷³
 - postoperative^{173,175,177,178}
- Use of anti-inflammatory agents such as topical or systemic corticosteroids^{179,180}
- Use of laser suture lysis or releasable sutures¹⁸¹
 - adjustable or releasable sutures add an extra dimension of flexibility towards a gradual and titratable postoperative modulation of flow¹⁸²

Postoperative Management

- First 12 postoperative weeks critical for results
- Examine first postoperative day and thereafter as clinically indicated
- Topical steroids for 6-12 weeks and may be continued further for patients at persistent risk of scar formation.
- Topical antibiotics for ≥ 14 days
- Cycloplegics for 2-6 weeks, especially for those at risk for ciliary block (short axial length)
- Analgesics
- Intensive individualised postoperative care (globe indentation, suture lysis or release, subconjunctival 5-FU)

USE OF ADJUNCTIVE AGENTS IN GLAUCOMA SURGERY

Why?

- Scarring is the major cause of failure following filtration surgery. Antifibrotics agents have been shown to inhibit scarring and to increase the success rate^{183,184}

What?

- Intraoperative MMC: Used widely in trabeculectomy surgery
- Intraoperative 5-FU: Though still utilised, has been largely superseded by MMC due to less impressive efficacy^{185,186}
- Adjunctive Anti-VEGF therapy to augment trabeculectomy needs more evidence to support its efficacy at present¹⁸⁷

When?

- When there is high risk of failure following standard filtering surgery (including repeat surgery, neovascular glaucoma, glaucoma in uveitis, glaucoma in aphakia, younger age, African-derived populations)
 - In primary surgery, especially when a lower target pressure is required^{188,189}
 - With glaucoma drainage devices but with limited evidence
 - With needling of a failed filter
 - Antimetabolites should be avoided in pregnancy and lactation
 - In high risk patients, post-operative 5-FU injection can be an alternative
 - MMC and 5-FU are cytotoxic agents, one must take care with handling and disposal
- In these instances, the enhanced success rates with antimetabolites may mitigate against the complications associated with their use (especially hypotony, bleb-related infections)

How?

INTRAOPERATIVE APPLICATION

Dose

- Sponge soaked in MMC (varying doses of 0.2-0.5 mg/mL) applied for 1–3 minutes
- Sponge soaked in 5-FU (50 mg/mL) for 1–5 minutes

Mode of application

- Minimise exposure of the conjunctival edge and cornea to antimetabolites
- Sponge placed under the conjunctiva
 - a little extra subconjunctival blunt dissection allows multiple sponges or a large single sponge to be placed¹⁸³
 - count sponges to avoid leaving in pocket
- Apply to a large surface area of conjunctiva to reduce the risks of bleb infections and cystic blebs.¹⁷⁵ This is followed by copious irrigation of the treated area with balanced salt solution, normal saline, or Ringer's lactate solution

Postoperative Application

5-FU is also used as postoperative injections of 5 mg in 0.1 mL for up to 4 weeks. The injection may be given alongside or behind the bleb, or sometimes 90°-180° away, preferably using a 30-G needle. The number of injections is titrated according to the appearance of the bleb. Care is taken to avoid spillage on the cornea and the resulting epitheliopathy. The conjunctiva over the area of injection may be tamponaded with a cotton bud for about one minute after the injection. Discontinue injections in the presence of corneal epithelial defects.

Note: The use of antimetabolites can be associated with sight-threatening complications and they must be used with caution.¹⁹⁰

Complications of Trabeculectomy Surgery

- Failure to control IOP
- Hypotony
- PAS
- Pupillary distortion
- Cataract
- Sclerostomy blocked by iris, blood, vitreous, or fibrin
- Bleb related complications eg blebitis, leak
- Bleb related endophthalmitis
- Aqueous Misdirection
- Suprachoroidal haemorrhage

SURGICAL TECHNIQUE: NON-PENETRATING SURGERY

Why?

Non-penetrating surgery reduces IOP less effectively than penetrating surgery, but with lower complication rates (postoperative hypotony, bleb-related infections) compared with trabeculectomy with antimetabolites.

When?

Failed medical and/or laser treatment, when there is less need for lower target IOP.

How?

In deep sclerectomy, Schlemm's canal is de-roofed underneath a scleral flap and a deep lamella of corneo-sclera removed to leave a scleral lake. Aqueous percolates through the remaining TM into this area. A very shallow filtration bleb can be seen with imaging. A collagen implant can be used as a spacer to keep the lake patent.¹⁹¹

Viscocanalostomy modifies the above procedure by injecting hyaluronic acid into Schlemm's canal. This may increase outflow by widening and/or microrupturing the walls of Schlemm's canal and collector channels.

Non-penetrating surgery requires a steep learning curve.¹⁹¹ The deep sclerectomy may be performed manually or assisted with CO2 laser. Further management with Nd:YAG goniotomy may be required in up to 40% of surgeries to further lower the IOP in the longer term.

Canaloplasty is a form of non-perforating blebless surgery for open-angle glaucoma, in which a microcatheter is threaded into Schlemm's canal. A 10-0 prolene suture, is tied to the distal tip of the microcatheter, pulled back through to replace the catheter in the canal and left tensioned in Schlemm's canal, thus aiding aqueous outflow through natural pathways.

SURGICAL TECHNIQUE: GLAUCOMA DRAINAGE DEVICES

Why?

A glaucoma drainage device allows aqueous to flow from the anterior chamber into a bleb that forms around the plate of these devices. Aqueous diffuses through the capsule and is collected by blood vessels in the surrounding capsule.

Tube versus trabeculectomy: Five-year results comparing Baerveldt drainage devices with trabeculectomy + MMC in patients who had previous trabeculectomy and/or cataract extraction with IOL

- Both procedures were associated with similar IOP reduction and use of supplemental medical therapy at 5 years
- Additional glaucoma surgery was needed more frequently after trabeculectomy with MMC than tube shunt placement¹⁹²

What?

Glaucoma drainage devices¹⁹³

- Valved
 - Ahmed
- Non-valved
 - Molteno
 - Baerveldt
 - AADI (Aravind Aqueous Drainage Implant)

When?

Where there is a very high risk of failure of trabeculectomy with antimetabolites

- Previously failed trabeculectomies with antimetabolites
- Prior multiple ocular surgeries with conjunctival scarring
- Traumatic, inflammatory, or chemically induced surface scarring
- Intraocular membrane formation likely to occlude a non-implant drainage procedure (ICE syndrome, neovascular glaucoma)

How?

Glaucoma drainage device surgery and the postoperative management of such patients can be complicated.

Depending on the surgeon's preference, one of the glaucoma drainage devices is positioned on the scleral surface, usually in the superior temporal or superior nasal quadrant (or both for a 2-plate glaucoma drainage device) and connected to the anterior chamber by a tube. Insertion beneath a scleral flap and/or use of a corneal or scleral patch or Tutoplast over the tube reduces risk of tube extrusion, and is recommended. There is minimal evidence for the use of antimetabolites with glaucoma drainage devices.

A tube-occluding suture may be used to avoid immediate postoperative hypotony with a non-valved tube; venting slits may be needed to avoid high IOP until the suture is removed or dissolves. Valved tubes may have a lower rate of immediate hypotony, but postoperative hypotony can occur via leak around the tube. A post-operative hypertensive phase is common with any shunt and may require medical therapy to reduce IOP.¹⁹⁴⁻¹⁹⁷

Similar rates of surgical success were observed with both the Ahmed and Baerveldt implants at five years. The Baerveldt implant produced greater IOP reduction and a lower rate of glaucoma reoperation than the Ahmed valve, but the Baerveldt was associated with twice as many failures because of persistent hypotony or explantation.¹⁹⁸

Complications of Glaucoma Drainage Devices

- Failure to control IOP
- Hypotony and choroidal effusions
- Corneal decompensation (long-term complication with anterior chamber tube – reduced with pars plana tube). Under the iris implantation in pseudophakes is becoming more popular¹⁹⁹
- PAS
- Pupillary distortion
- Cataract
- Tube blocked by blood, vitreous, or fibrin
- Erosion of the tube and/or plate(s)
- Globe malposition and/or motility disturbance
- Endophthalmitis (rare)
- Aqueous Misdirection
- Suprachoroidal haemorrhage

CATARACT AND GLAUCOMA SURGERY

Cataract and glaucoma are both common conditions, which often coexist. A recent review has assessed current surgical management and highlights the limited evidence in the literature about the effectiveness of combined cataract and glaucoma surgery compared with separate.²⁰⁰

Cataract surgery after trabeculectomy significantly increases the rates of bleb failure. However, performing cataract surgery after 6 or even 12 months seems to lower rates of bleb failure.^{201,202}

BLEB MONITORING AND MANAGEMENT

Bleb Morphology²⁰³

- Bleb morphology is an important determinant of the long-term success of trabeculectomy.
- It is important to assess bleb morphology and function on every follow-up to recognise any undesirable patterns of healing in bleb tissues to enable early postoperative interventions, and consequently, achieve better surgical outcomes.

If the IOP is high and the bleb is low:²⁰³

- Check for patency of the sclerostomy and for any obstructions to the internal ostium or fistula, such as plugged iris tissue
- The scleral flap may be sutured too tightly. This may cause high IOP and a poorly functioning bleb in the immediate postoperative period. The sutures may be adjusted or removed (either manually if sutures are releasable, or by laser suture lysis) to re-establish flow and expand the bleb
- Assess bleb morphology and function

Bleb Assessment Criteria

- **Vascularity**
 - A general assessment of the vascularity of the entire bleb area must be done, but specific attention should be made to hypervascularity of the tissues surrounding the central bleb area, which may be associated with a six-fold increased risk of bleb failure six weeks after trabeculectomy²⁰⁴
- **Corkscrew vessels**
 - Corkscrew vessels probably represent migration of fibroblasts to the bleb, ongoing wound healing, and contraction of the bleb space, all of which may lead to bleb failure^{203,205,206}
- **Dragged vessels and conjunctival suture line contraction**
 - Dragging or straightening of conjunctival vessels represents contraction of Tenon's capsule and scarring, and an increased risk of bleb failure.²⁰⁵
 - Inflammation and contraction of the suture line indicates shrinkage of the bleb²⁰³
- **Elevation**
 - A low, large surface area bleb without focal thinning or demarcation by fibrotic tissue tends to give excellent IOP control with better long-term outcomes²⁰³
- **Bleb area/extent**
 - In general, large bleb areas are desirable and associated with good IOP control and a lower risk of long-term complications
- **Wall thickness**
 - Wall thickness is inferred from the degree of translucency or transparency
- **Avascular areas ('cystic blebs')**
 - Thin-walled, avascular, or 'cystic' blebs may predispose to long-term complications, such as bleb leaks, hypotony, dysesthesia, and bleb-related endophthalmitis^{203,207-210}
- **Microcysts**
 - The presence of microcysts is evidence of transconjunctival filtration and subsequent outflow, more frequently resulting to more satisfactory IOP control^{203,211-213}

Bleb-Grading Systems

It is important to be able to accurately and efficiently describe and record bleb characteristics to optimise the results of trabeculectomy.

- **Moorfields Bleb Grading System (MBGS)**^{203,214-216}
- **Indiana Bleb Appearance Grading Scale (IBAGS)**^{203,216,217}

Bleb needling and subconjunctival 5-fluorouracil injection (5-FU)

Bleb needling is a common procedure that can be performed at the operating theatre or in a clinic set-up to improve the performance or appearance of the draining bleb or once intraocular pressures are inadequately controlled and there is evidence of increased fibrosis or scarring at the conjunctival and episcleral interface.

This can be augmented with injection of anti-metabolite such as 5-fluorouracil or Mitomycin-C. Bleb needling is performed using a 27/30-gauge needle inserted into the subconjunctival space adjacent to the bleb. Subconjunctival scarring is disrupted with firm multiple sweeping back-and-forth and side to side movements of the needle to ensure breaking of scar tissue in the region of the surgical site, carefully avoiding the surrounding conjunctival vessels while advancing into the scleral flap. If simple flap dissection fails to form a noticeable bleb, the needle is passed beneath the edge of the scleral flap and into the area of the sclerostomy through the ostium.

After adequate needling, the tip of the needle is then repositioned superior or adjacent to the bleb and 0.1 mL (50 mg/mL) of 5-FU or 0.01-0.1 mL (0.2-0.5 mg/mL) Mitomycin-C is injected into the subconjunctival space, with careful observation that there is no flow of fluid into the anterior chamber of the eye. The needle is gently withdrawn and a cotton-tip applicator used to apply pressure in the area for at least 5 seconds.

If the procedure is done in the OR, a paracentesis can be made into the cornea and the anterior chamber can be filled with additional BSS, elevating the bleb. The eye is then copiously irrigated with sterile saline solution to ensure that any possible leakage of the 5-FU or Mitomycin-C from the puncture site in the conjunctiva would be sufficiently washed out. Topical antibiotics and steroid drops are given postoperatively.

Successful needling leads to re-establishment of adequate aqueous outflow resulting in the formation of a normal to high bleb with subsequent decrease in the IOP.

Potential Complications

- bleb failure
- bleb/subconjunctival haemorrhage
- hypotony
- suprachoroidal haemorrhage

BLEB REVISION

Bleb revision is indicated for dysaesthetic, scarred, leaking, overhanging or post blebitis blebs. The main techniques employed in bleb revision are excision of the abnormal conjunctival tissue followed by patching of the defect with tenon's tissue, autologous sclera or Tutopatch. Conjunctival closure with advancement or autografting creates a watertight seal. Relieving incisions are indicated if significant tissue tension exists. Complications such as a recurrence of the original problem, elevated intraocular pressure (possibly requiring needling with 5FU or further surgery) can arise in the longer term.

LENS EXTRACTION FOR PRIMARY ANGLE-CLOSURE GLAUCOMA (PACG)

There is increasing evidence regarding the effectiveness of lens extraction for PACG. The surgery may be technically difficult because of frequently coexisting shallow anterior chamber, large bulky lens, iris atrophy secondary to ischaemia, and associated zonular weakness. Removing the lens may lower, and control IOP satisfactorily,²¹⁸ while deepening the angle may reduce the likelihood of progressive angle closure and chronic rise in IOP.²¹⁹

Good outcomes in terms of IOP control following lens extraction for PACG have been reported.^{220,222} Lens extraction should be considered in patients with PACG especially with hyperopia, and/or a thick and anteriorly vaulted lens.²²²

MINIMALLY INVASIVE GLAUCOMA SURGERY (MIGS)

MIGS is a collective term for procedures that are bleb-independent, including trabecular bypass stents and supra choroidal shunts, which aim to avoid the major bleb-related complications. However, MIGS has its own set of complications such as transient hyphaema, shunt dislocation and only very modest IOP lowering in some of the procedures.

The iStent and Ivantis's Hydrus implant are inserted into the Schlemm's canal and bypass the trabecular meshwork and in the case of the Hydrus, expand the canal of Schlemm. The Trabectome is an electrocautery cutting device that removes the internal wall of Schlemm's canal. Devices intended to enhance uveoscleral out-flow, include, but are not limited to Transcend Medical's CyPass and Glaukos's iStent Supra. The Xen Gel Stent (from Allergan), an ab interno device directs outflow to the subconjunctival space. There is an increasing interest in these operations which remain exclusively for open-angle glaucomas. To date, the iStent and Trabectome are FDA approved²²³ and so far have shown modest short term IOP lowering especially when combined with cataract surgery.²²⁴ Further studies are required to establish the long-term effectiveness of these devices.

GONIOSYNECHIALYSIS

Goniosynechiolysis, where the peripheral anterior synechiae (PAS) are deliberately broken with a surgical instrument under direct gonioscopic guidance, has been reported to be effective for IOP control and reduction of synechiae in ACG. It is frequently performed in conjunction with cataract surgery²²⁵ and may be augmented with laser iridoplasty to further flatten the iris.¹⁴³

Viscogoniosynechiolysis replaces the surgical instrument with viscoelastic which whilst less traumatic may be insufficiently strong enough to remove the more adhesive PAS.

Complications of combined phacoemulsification with surgical goniosynechiolysis include fibrinoid anterior chamber reaction, photophobia, transient elevation of IOP, hyphema and iridodialysis.²²⁵

FREQUENTLY ASKED QUESTIONS

Should intravenous hyperosmotics be used routinely prior to glaucoma filtering surgery or only in certain situations?

Routine use is not necessary. To avoid suprachoroidal haemorrhages intraoperatively, pre-operative IOP should not be too 'high'. Use standard medications, including hyperosmotics. Some surgeons gradually decompress the eye intraoperatively with a controlled paracentesis.

In what situations could filtering surgery be considered as first-line treatment?

CIGTS demonstrated that primary filtering surgery was effective to control IOP. Socio-economic factors or poor access to care necessitates primary filtering surgery. A patient presenting with visually significant cataract and glaucoma could warrant primary combined surgery, especially in a primary care setting.

Which is preferred, a 1- or 2-site phacotrabeculectomy?

No evidence exists that one technique is better than another.

In a single-site phacotrabeculectomy, is creation of a trabeculectomy flap mandatory or can the cataract incision be used to create the trabeculectomy?

Either technique may be used, depending on the surgeon's preference.

Does the size of the ostium matter?

Filtration is dependent on a number of factors, including the relative sizes of the sclera flap and ostium. A critical factor is the extent of overlap between the anterior scleral flap and the wound bed posterior to the trabeculectomy ostium. This is particularly relevant in the immediate postoperative period; long-term results depend more on wound healing processes. In angle closure, anterior block excision should be used to facilitate aqueous access to the fistula.

Should a trabeculectomy punch or surgical scissors or knives be used to create the ostium?

Either technique could be used depending on the experience of the surgeon.

Which is preferable – Argon Laser Suturelysis or releasable sutures?

Both techniques could be used to modulate filtration postoperatively. Argon laser suturelysis requires additional equipment (the laser and the lens), while a releasable suture carries the risk of damaging the flap (if the first attempt at placing the releasable suture is not successful), windshield wiper keratopathy, or inadvertent release. If the Tenon's capsule is thick, the suture might not be visible for argon laser suturelysis. The releasable technique can be modified by passing the suture intrastromally from the cornea to reduce the risk of keratopathy. If Ologen is used, a releasable suture is useful as laser suturelysis can be difficult.

Performing fornix-based trabeculectomy for a number of years has always obtained good success rates. Should limbus-based trabeculectomy be used instead?

Both techniques work well depending on the surgeon's expertise. The fornix-based technique with a large treatment area was devised to minimise the localised, thin, overhanging blebs more common with limbus-based surgery. Meticulous closure of the conjunctival edge is very important. The formation of localised, thin, overhanging blebs can be minimised by incorporating principles of large treatment area into limbus-based surgery.

Is it justified to suggest early cataract surgery to a patient with PAC and early visually significant lens changes instead of LPI?

If the cataract is interfering with the patient's daily activities then early cataract surgery is an acceptable alternative to a LPI. The type of surgery undertaken will also depend on the extent of closure. Theoretically, operating on an eye with an open angle (after LPI) may decrease the risk of ciliary block glaucoma.

If a patient with glaucoma who is stable and well controlled with a single medication or fixed combination develops visually significant cataract, should cataract surgery alone be planned, or should it be combined with filtering surgery?

Either option is acceptable; consult with the patient. Take into account the greater risks with the addition of glaucoma surgery, whether the patient had significant QOL issues with medication, could afford therapy, and is willing to continue to use medication indefinitely.

Is it mandatory to perform a LPI before cataract/glaucoma surgery in a patient with PACS, PAC, acute PAC, or PACG?

No. While it is not mandatory to perform an LPI before cataract/glaucoma surgery, these eyes are at increased risk for ciliary block glaucoma. The minimal risk of endothelial damage post LPI should be balanced against the benefits of an open angle post iridotomy in these eyes.

What are the indications for glaucoma drainage device surgery?

Consider the following situations for a glaucoma drainage device:

- Failed trabeculectomy with MMC
- Some secondary glaucomas:
 - neovascular glaucoma
 - uveitic glaucoma
 - aphakic or pseudophakic glaucoma
- Scarred anterior conjunctiva:
 - conjunctival scarring due to multiple surgeries – ocular conditions: allergies, inflammation
 - chemical injury
- Marked limbal thinning

How does non-penetrating glaucoma drainage surgery compare with trabeculectomy?

Trabeculectomy seems to achieve greater IOP-lowering than either viscocanalostomy or deep sclerectomy in eyes with POAG. The latter are not suitable for ACG. On the other hand, non-penetrating glaucoma drainage surgery seems to have fewer complications. Failed non-penetrating glaucoma drainage surgery or failed trabeculectomy compromises the results of subsequent glaucoma surgery.

When should the conjunctival suture be removed after trabeculectomy?

Absorbable sutures do not need removal, but may increase scarring. Non-absorbable sutures could be removed after one to two weeks, or longer if MMC was used intraoperatively.

What is the effect of cataract surgery in eyes with a functioning glaucoma filter?

A functioning filter has an increased risk of failure after cataract surgery – with ECCE more than with clear corneal phacoemulsification. If the interval between trabeculectomy and cataract extraction is less than six months, the failure rate is highest.

SECTION 3 FOLLOW-UP

3.1 FOLLOW-UP

Why?

The general aim of follow-up is:

- To implement the glaucoma management plan (or revise it if necessary)
- To detect progression and rate of change
- To detect any change in risk profile

For medical management:

- To detect effectiveness and any side effects of treatment
- To detect any change in health or systemic medications that may affect the glaucoma management plan
- To monitor patient compliance to therapeutic regimen

For surgical management:

- To assess functionality of performed procedure
- To adjust post-operative medications
- To address any surgical morbidity or decrease in vision
- To monitor/treat ocular comorbidity such as cataract and diabetic retinopathy
- Surgical blebs (refer to page 59) should be monitored at regular intervals to look for
 - Significant bleb thinning or leak
 - Possible associated infections
 - Increased vascularity of other signs of scarring suggestive of a need for further antifibrotic treatment (e.g., 5 FU needling) or revision/alternate procedures

What?

The follow-up process starts with the management plan made at the initiation of therapy. At the follow-up visits the doctor should:

- Assess the patient's subjective wellbeing, visual function, and QOL
- Reassess risk factors, especially IOP and gonioscopic change(s)
- Reassess structure and function of the optic nerve
- Estimate rate of (any) progression and discuss its significance in relation to patient's age and status of the other eye
- Identify adverse effect(s) of treatment
- Assess adherence to, and persistence with, the treatment plan
- Identify change(s) in medical and ophthalmological problems
- Reinforce appropriate patient information:
 - revise management if necessary
 - plan follow-up

When?

- The initial follow-up after diagnosis of manifest glaucoma should be relatively frequent so as to detect the rate of progression reliably²⁰³
- The more severe the damage, the greater the risk factors, the more frequent should be the follow-up
- The faster the rate of progression, the more frequent should be the follow-up
- Surgical follow-ups should be scheduled often enough to detect any sign associated with poor outcomes, e.g., inflammation, excess scar formation.

PATIENT'S SUBJECTIVE WELL-BEING AND VISUAL FUNCTION

- Patients often wish to tell the doctor how they feel their condition has/has not changed
- This discussion helps build a good doctor-patient relationship and therapeutic alliance
- There is a degree of association between patients' self-reported visual function and both VF status and VF progression

Subjective changes in vision with glaucoma are rare but, in advanced disease, changes in the following qualities of vision may indicate a deterioration of GON:

- Night vision (night driving difficulties – vehicles jump into vision, glare from oncoming headlights)
- Dark adaptation (difficulty walking into dark environment)
- Glare
- Stereopsis
- Acuity (high and low contrast – reading small print, especially in dim light; identifying faces while walking; contrast sensitivity problems; poor distance judgements)
- Missing pieces of vision
- Increased chances of falls and motor vehicle accidents

Although subjective changes in vision are rarely reported until late in the disease (see above), even patients with mild to moderate glaucoma may report problems with 'visual mobility'; bumping into things, difficulty with stairs, and difficulty finding things that have been dropped.

REASSESS RISK FACTORS

Intraocular Pressure

- IOP (note time of day)
- Assessment at every visit is vital with most accurate equipment/self-operated tonometry, consistency of equipment is important
- Establish whether target IOP has been achieved
- A single measurement of IOP cannot detect fluctuations – IOP should be reassessed at different times of the day
- Repeat unexpected readings at the same visit and soon after

CAUSES OF CHANGE IN INTRAOCULAR PRESSURE AT FOLLOW-UP

- Increased IOP:
 - reduced outflow
 - gradual loss of efficacy of a drug (tachyphylaxis)
 - poor adherence
 - MIGs - failure of filtration surgery
- Reduced IOP:
 - therapeutic effect
 - LASIK/corneal refractive surgery causing unexpected changes in measured but not actual IOP
 - resolving pathology (regression of pigment dispersion)
 - immediate post cataract surgery
 - bleb leakage
- Reduced or increased IOP:
 - regression to the mean
 - variation during the day and between days
 - change in systemic medications
 - poor instrument calibration/function

Gonioscopic Changes

- Maintain baseline examination conditions
- Perform gonioscopy at least every three years and more frequently for those with, or at high risk for, angle closure
- Look for increased appositional and/or synechial closure
- Pupil size changes have dynamic effects on the angle configuration
- Look for change in angle width, synechiae, and pigmentation
- Consider gonioscopic photography or anterior segment OCT/angle imaging if available for more objective comparison between visits

REASSESS STRUCTURE AND FUNCTION OF THE OPTIC NERVE

Optic Disc

Progression of GON usually occurs over a long period, which can make change detection difficult. The optic disc of patients with GON should be examined at every visit and at least every one year thereafter.

The occurrence of the following indicate likely GON progression (Appendix 12):

- Disc haemorrhage
- Neuroretinal rim notching (incidence or enlargement)
- Neuroretinal rim thinning (enlargement of CDR)
- Change in vessel position on the disc
- Wedge-shaped RNFL defects (incidence or enlargement)

Where baseline and serial optic disc imaging are available, detection of change is substantially enhanced. If imaging is not available, the pupil should be dilated (if it is not possible to do this safely, consider prophylactic iridotomy/iridoplasty) to obtain an adequate view of the disc for diagnosis and if progression is suspected.²²⁶

Visual Field

Apparent change is frequent in perimetry: a small proportion is owing to GON progression. The same test should be used to compare/detect progression.

CAUSES OF CHANGE IN VISUAL FIELDS

- Learning: VF performance usually improves with experience – usually this change is greatest between the first and second tests
- Reliability changes and poor concentration may cause generalised depression
- False-positive errors may reflect poor reliability – fixation losses may indicate improper fixation; assess other signs such as the gaze monitor or technician's notes
- Progression of disease
- Cataract: may cause generalised depression^{227,228} and may mask relative scotomas²²⁹
- Pupil size changes: miosis causes generalised visual field depression; minimum 3-mm diameter recommended
- Retinal disease (vein occlusion, macular degeneration, significant diabetic retinopathy)
- CNS, retrobulbar diseases
- Retinal laser
- Miscellaneous artefacts (lens rim, ptosis, deep-set eyes)
- Decline in general health

Detecting Progression

Progression is characterised by:

- Widening or deepening of existing visual field defects
- Development of new glaucomatous visual field defects
- Generalised field depression; consider concomitant cataract, miosis, or poor reliability (Appendix 13)

Changes in visual field should be confirmed by at least one repeat test. Visual field change is best detected by the use of software that highlights areas of possible change.

There is a close correlation between glaucomatous changes in structure of the optic disc and consequent visual field loss.^{230,231} However, there may be considerable variations in morphology of a 'normal' disc, and in a patient's ability to perform visual field tests adequately.

Changes should be regarded sceptically until the deviation exceeds the SD of serial measurements.²³² Guided progression analysis (GPA) such as available on the Humphrey Zeiss Field Analyser or Threshold Noiseless Trend (TNT) as available on OCULUS perimeters can be useful guides to determine progression over time.

Retinal Nerve Fibre Layer

Imaging of the RNFL should be considered when available. Good quality fundus photographs have a place in detecting progression but require a level of expertise from the grader. Fundus photography is less encumbered by changes in instrument manufacturers and models over time.

Diagnosing Progression on OCT

- It has been shown that the circumpapillary retinal nerve fibre layer (RNFL) thicknesses measured by the Spectral Domain (SD)-OCT attained higher intervisit reproducibilities than the time-domain OCT measurements.²³³ The high intervisit reproducibilities are essential for determining progression on OCT
- In an event analysis, progression is defined when the difference between the baseline and follow-up measurements of the parameter of interest is greater than its test-retest variability (or the reproducibility coefficient). In a trend analysis, regression analysis is performed between the parameter of interest and time. Progression is commonly defined when a significant negative slope is detected using linear regression analysis
- Spectral domain OCT has largely replaced time domain OCT. Swept source OCT has an even faster scanning speed. Some of the more commonly used SD-OCT devices are:
 - Cirrus HD-OCT (Carl Zeiss Meditec)
 - Spectralis OCT (Heidelberg Engineering, Carlsbad, CA)
 - RTVue-100 (Optovue, Fremont, CA)
 - NIDEK
 - Canon
 - Topcon swept-source 3D-OCT 2000 (Topcon, Oakland, NJ)

Each OCT has different glaucoma scan patterns and software for segmentation and progression analysis. They differ in degree of reproducibility, retinal nerve fibre layer (RNFL) thickness and deviation maps, as well as automated trend- and event-based progression analyses.

- We should ensure the quality of OCT scans obtained, a quality score eg. 7 or above on the Cirrus, is in general desirable. This is especially important for progression analyses. Clinicians should be aware of the various causes for suboptimal scans, such as media opacities, or coexisting pathologies like optic nerve head swelling, epiretinal membranes, macular edema, etc., which may cause overestimation of peripapillary RNFL and/ or macular thickness, resulting in inaccurate interpretations

IDENTIFY ADVERSE EFFECTS OF TREATMENT

Adverse effects of treatment should be actively sought. These include:

- General effects – self-rated health, feelings about/attitude towards treatment
- Systemic effects – respiratory, cardiovascular, digestive, neurological, impotence
- Local effects – stinging/burning, blurring, itching, redness

QUALITY-OF-LIFE ISSUES

- The patient's QOL should be estimated and the impact of glaucoma and its management on QOL assessed.²³⁴ A number of quality of life questionnaires are available, e.g. Glaucoma Quality of Life-15 questionnaire; Appendix 14. GLAU QuoL, Euro QoL, Glaucoma Activity Limitation-9 questionnaire.
- The emphasis of management should be customised towards improving patient's QOL; this forms part of the assessment of burden of disease and burden of treatment

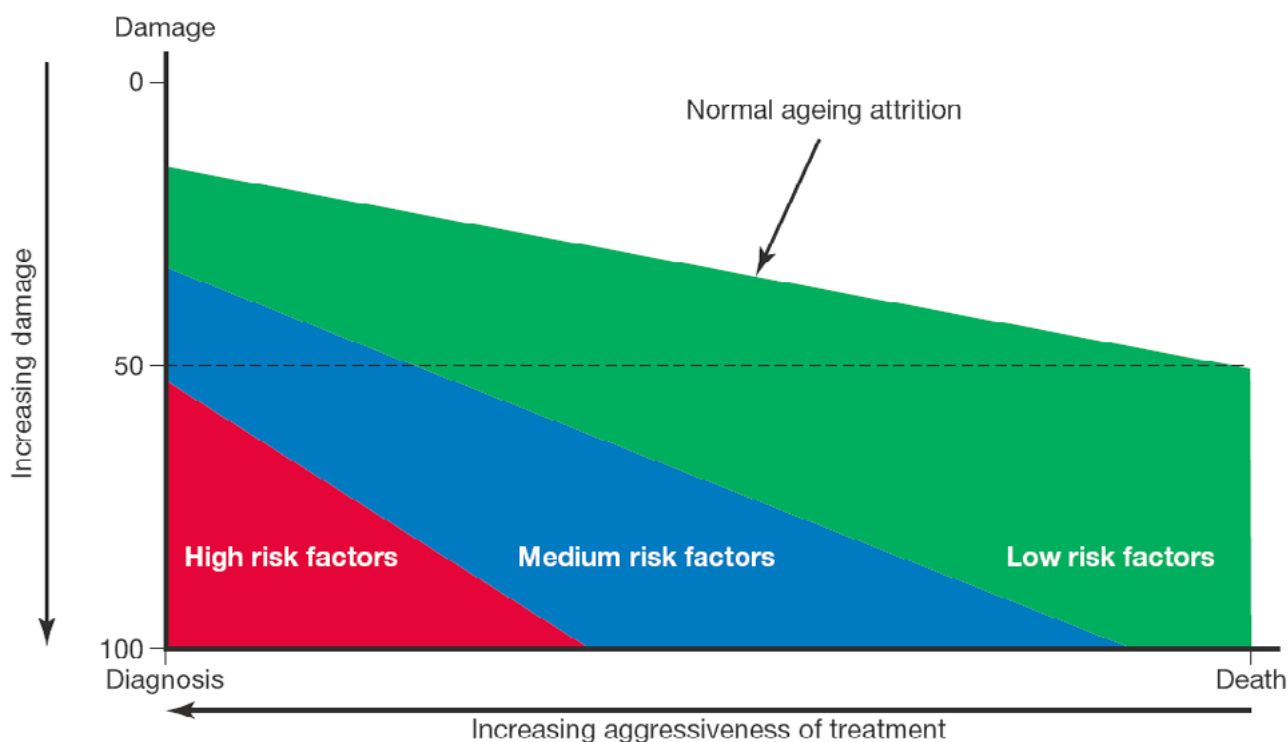
THE GLAUCOMA LIFE STORY

The aim of glaucoma treatment is to have the rate of progression slowed or halted such that they remain with minimal or no symptoms of visual loss as long as they live. Although rate of progression is the key factor for determining success of treatment, it is very difficult to measure accurately or reliably. Generally, risk factors are used to estimate the likely rate of progression, with that estimate then being acted upon. However, knowledge of risk factors is incomplete. Attempts can be made to reduce the rate of progression by reducing IOP. The minimum slope is the rate of normal ageing of the nerve. The target pressures are based on the slope that it is thought will allow the patient to maintain good vision for his/her life.

The determinants of the glaucoma life story (Figure 3.1) are:

- State of damage
- Life expectancy
- Rate of progression

Figure 3.1. The glaucoma life story.



The graph plots life expectancy against the extent of glaucomatous damage at diagnosis. The slope of the line is the rate of progression; this is determined by risk factors. Although rate of progression is the key factor for determining success of treatment, it is very difficult to measure accurately or reliably. Generally, risk factors are used to estimate the likely rate of progression, with that estimate then being acted upon. However, knowledge of risk factors is incomplete.

Attempts can be made to reduce the rate of progression by reducing IOP. The minimum slope is the rate of normal ageing of the nerve. The target pressures are based on the slope that it is thought will allow the patient to maintain good vision for his/her life.

The colour in the graph represents the risk of blindness from glaucoma. Green represents low risk and red represents high risk.

TIMING OF FOLLOW-UP

Follow-up timing is determined by the treatment regimen, if this has changed. If the patient has stable disease, the timing is determined mainly by the extent of damage (Table 3.1), however, other factors such as patient age and comorbidities should also be taken into account.

Table 3.1 Timing of follow-up.- these are a guideline but may vary according to available resources, health care setting and individual patient factors

	Extent of damage			
	Glaucoma suspect	Mild	Moderate	Severe
Follow-up (months)	6-24	6-12	4-6	1-4

FREQUENTLY ASKED QUESTIONS

Do the follow-up protocols for primary and secondary glaucomas differ?

Secondary glaucoma tends to present with higher IOP, which is often more difficult to control with an active primary process (steroid responsiveness, trauma, neovascularisation, inflammation). These patients may require closer follow-up. This decision needs to be made on an individual patient basis not on a protocol.

Is juvenile-onset POAG more likely to progress than adult-onset POAG? Do these patients need closer follow-up?

Juvenile-onset POAG tends to have a higher presenting IOP and often have worse response to medical treatment than adult-onset disease. These patients require close follow-up to assess response to medication and to detect progression.

Is a sudden deterioration in visual field in a patient with well-controlled IOP, whose visual fields have remained stable in the past, an indication for further investigation?

If there is no other significant history (steroid use, trauma, acute systemic hypotension) or clinical finding (new retinal pathology) that can explain the progression, imaging of the visual pathway should be considered.

Do patients who have undergone filtering surgery and are stable need to undergo regular follow-up examinations?

Any patient with glaucoma requires regular monitoring. Glaucoma surgery may not adequately control IOP for a person's lifetime. Periodic follow-up is required for detection of both progression and long-term complications of surgery.

Should first-degree relatives of patients with POAG and PACG be advised to undergo an eye examination? If the examination is normal, how often should follow-up be advised?

A family history of glaucoma is an important predictive risk factor. Depending on the clinical findings, the frequency of regular follow-up ranges from annually to every two to five years after the age of 35 years.

What is the best method to confirm glaucoma progression? What is the role of imaging technologies to detect progression?

Available statistical programmes such as the GPA and newer metrics (Visual Field Index) for the Humphrey field analyser or the TNT for OCULUS perimeters help detect visual field progression.

If a patient always has an IOP of 12-14 mmHg, but the visual field shows typical progression confirmed by repeat perimetry, should the patient be investigated for systemic diseases?

IOP control should be assessed at as many different times as possible – are IOPs fluctuating widely at different times of the day? Other risk factors such as nocturnal hypotension, systemic or topical steroid use, recent major surgery, or haemodynamic crises and an abnormally thin central cornea should be assessed. The patient's family physician should be liaised with regarding systemic hypertension and its control (avoid night-time dips), and to exclude sleep apnoea. The patient should be asked about practicing yoga, especially 'asanas' in the inverted position, use of wind instruments, and rapid consumption of large quantities of water or beer. An 'alternative medicine' programme of a litre of water in the morning mimics a water drinking provocative test and may contribute to optic nerve damage.

Are at least five to six visual fields needed to confirm progression?

While this is true in a research setting, clinically, other information such as achieving target IOP, peak IOP with treatment, IOP fluctuation, and changes in the optic disc are used. With 'corroborative' clinical signs, a single repeat visual field may confirm progression.

What is the role of patient education in the treatment of glaucoma?

Patient education is most important for glaucoma management. The patient should be an informed participant in the treatment programme. The clinician should explain the disease and its severity, present realistic expectations of treatment outcomes, possible effects of both medical and surgical treatment, and note the patient's preferences. This is an ongoing process; the patient should be kept informed about the course of the disease throughout follow-up.

3.2 SCREENING

GENERAL RECOMMENDATIONS

- Opportunistic glaucoma screening for:
 - patients who visit ophthalmologists, using a comprehensive clinical examination and directed investigations
 - patients who visit an optometrist, physician, or other trained health worker using more rapid and specific tests
- Universal glaucoma screening in isolation from other diseases is probably not feasible at present

Note: see Tables 3.2 to 3.4 for definitions of terms.

Table 3.2 Definitions of screening terms.

Term	Definition
Glaucoma screening	Examination of asymptomatic people to classify them as likely or unlikely to have glaucoma
Glaucoma diagnosis	Examination of a person by an expert health care practitioner to confirm or exclude the presence of glaucoma
Universal glaucoma screening (also known as population-based glaucoma screening)	Screening for glaucoma by inviting all people within a group to attend for a screening examination; this involves incorporating glaucoma screening into a universal periodical health examination programme
Opportunistic glaucoma screening (also known as case-based glaucoma screening or case detection)	Screening for glaucoma when people visit an eye care or medical professional for any reason
Prevalence	The proportion of people with the target disorder (glaucoma) in the population tested
Sensitivity	The ability of a test to correctly identify people who have glaucoma (true positive)
Specificity	The ability of a test to correctly identify people who do not have glaucoma (true negative or normal)
Positive predictive value	The proportion of people with positive test results who actually have glaucoma
Negative predictive value	The proportion of people with negative test results who do not have glaucoma

Table 3.3 Glaucoma screening versus glaucoma diagnosis.

Screening	Diagnosis
Aim to classify people as likely or unlikely to have glaucoma	Aim to confirm or exclude glaucoma with very high certainty
Most people will not have glaucoma, so the screening test needs to be very good at confirming normality	A much larger proportion will have glaucoma (although this may be <50%), so the tests need to be very sensitive for detecting glaucoma
Many people will be screened, therefore the process must be rapid and inexpensive	A smaller number of people will be examined, so the process must be thorough
The endpoint is the referral of a person with a positive result to an ophthalmologist; this must occur in a timely fashion	The starting point is a new doctor-patient relationship and lifelong care for people with glaucoma

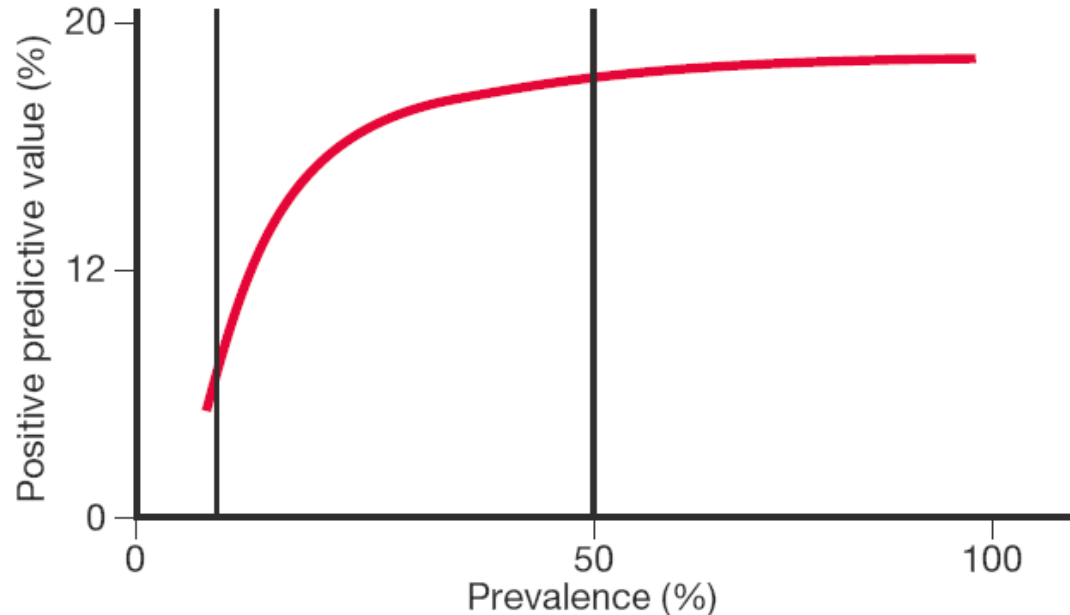
Table 3.4 Universal glaucoma screening versus opportunistic glaucoma screening.

Universal glaucoma screening ²³⁵	Opportunistic glaucoma screening
Health care professionals seek out patients: there is an implied pledge that people may be cured, but this may not always be true After screening positive, doctors are obliged to establish a diagnosis and treatment regimen using the best techniques Without the requisite equipment, trained personnel, and infrastructure, screening is not justified	Relies on detection of glaucoma in people who present for other reasons Patients seek out health care professionals, who treat them to the best of their ability but without the guarantee of a cure Success or failure of screening is marginal to the reason the patient presents
Patients who have a false-positive result carry the burden of being labelled with the disease: the consequences may be severe²³⁶	Based on detection of glaucoma in ‘at-risk’ patients in whom the prevalence of glaucoma is higher; therefore, most of the tests described below have a reasonably high positive predictive value
Patients who have the disease but have a test (false-negative result) are told they are healthy, which could lead them to stop participating in the screening programme	The optometrist and general physician can play an important role in screening for glaucoma; the same issues apply to infrastructure for diagnosis and treatment but the numbers may be smaller
Many countries in the region may not have the requisite infrastructure to follow-up and categorise people who test positive, or even treat them appropriately; even if possible, it may not be feasible	
Screening cannot be a one-time event and even developed countries may not be able to afford to screen the general population for glaucoma, as well as the burden of further testing, treatment, and follow-up	Most elderly people and those with diabetes or myopia (all at risk for glaucoma), often visit the offices of ophthalmologists and optometrists for other eye care needs; follow-up is also easier

PREDICTIVE VALUE

The predictive value of a test is dependent on the prevalence of glaucoma in the population being tested. As shown in Figure 3.2, assuming all other factors remain constant, the positive predictive value will increase with increasing prevalence.

Figure 3.2 Positive predictive value.



With a low prevalence of glaucoma, most people who test positive will have a false-positive result.

To increase the effectiveness of the tests, the prevalence of glaucoma in the population to be tested must be reasonably high. The prevalence of glaucoma can be ‘increased’ by targeting high-risk groups such as elderly people, those with a family history of glaucoma, and people with diabetes or myopia. Most people who are at high risk visit eye care professionals for other reasons, presenting an opportunity to screen them for glaucoma.

Why?

- To detect disease in the pre-symptomatic stage

How?

The epidemiology section outlines the current understanding of the magnitude of glaucoma blindness in Asia. This large burden raises the question of how best to detect glaucoma. Universal screening and opportunistic screening are two possible strategies.

The World Health Organization recommends that certain defined criteria be fulfilled before any universal screening is undertaken:²³⁶

- The disease must be an important public health problem
- There must be a recognisable latent or early stage, during which people with the disease can be identified before symptoms develop
- There must be an appropriate, acceptable, and reasonably accurate screening test
- There must be an accepted and effective treatment for people with the disease, that must be more effective at preventing morbidity when initiated in the early asymptomatic stage than when begun in the later symptomatic stages
- The cost of case finding must be economically balanced with possible expenditure on medical care
- Opportunistic screening should be a continuous process and not a once-only project

Other questions that need to be asked before embarking on any screening programme are listed here:²³⁷

- Does early diagnosis lead to improved clinical outcomes in terms of visual function and QOL?
- Can the health system cope with the additional clinical time and resources required to confirm the diagnosis and provide long-term care for people who screen positive for a chronic disease such as glaucoma?
- Will the patients in whom early diagnosis is achieved comply with subsequent recommendations and treatment regimens?
- Are the cost, accuracy, and acceptability of the screening tests adequate for the purpose?

Glaucoma fits many of the criteria required for universal screening, but other diseases are more problematic. It is likely that the health systems of only the most developed countries in the region may have the ability to cope with the additional clinical time and resources required for universal screening. Furthermore, there is lack of an ideal screening test for glaucoma.

Opportunistic screening is simply an extension of the usual clinical routine. Every patient who visits an eye care/health care professional can be considered a glaucoma suspect and undergo a screening examination. Every patient who visits an ophthalmologist can be considered a glaucoma suspect and undergo a comprehensive eye examination.

What?

Opportunistic screening is recommended rather than universal screening.

How to Perform Screening

For non-ophthalmic professionals, screening consists of a comprehensive risk factor assessment (including IOP measurement) and optic disc examination. If a slit lamp is available, assessment of the limbal anterior chamber depth predicts PAC when the IOP is above the normal range. It is critical that all people who are screened have an optic disc examination, as a large proportion of people with OAG have IOP within the normal range. In some centres, visual field testing is used; if so, it must not be used indiscriminately as false-positive functional test results are common.

Opportunistic glaucoma screening in an ophthalmologist's clinic relies on a comprehensive clinical examination (slit-lamp examination, IOP measurement, gonioscopy, dilated optic disc examination), followed by investigations that are directed by the results. Such an approach increases the positive predictive value of the tests used. Detecting early glaucoma is ideal, but requires a sensitive test, which leads to false-positive results.

For population-based screening, a test should have a reasonably high sensitivity with a very high specificity. Prevent Blindness America has suggested a sensitivity of 85% and a specificity of 95-98% to detect moderate-to-severe glaucoma.²¹⁶ For most populations older than 50 years, a specificity of 97-98% would mean that approximately half the people who have positive results would have glaucoma. A sensitivity of 85% would detect approximately two-thirds of currently undiagnosed cases in developed countries and 88% of undiagnosed cases in the developing world and Japan.

Screening for Primary Angle-Closure Glaucoma

Population-based studies from western countries have shown that the prevalence of OAG is five times that of PACG.²³⁹ However, it has been estimated that half the glaucoma in the world is caused by PACG.²⁴⁰ As approximately 75% of patients with PACG in Asia have optic nerve damage, screening strategies that detect functional damage in OAG may also be suitable for PACG.²⁴¹ Such tests will not detect eyes without functional damage, or eyes at risk for PAC:

- Tonometry will only detect PAC in the presence of raised IOP
- Optic disc examination and perimetry will only detect PAC in the presence of a damaged optic disc or VF

The ideal way to identify PAC and eyes at risk for PAC is to examine the angle using a gonioscope. The required clinical expertise and instrumentation render gonioscopy inappropriate for screening.

Methods to identify eyes at risk for PAC include anterior chamber depth measurement and anterior chamber depth-axial length ratio. The sensitivity and specificity of these techniques do not make them appropriate for screening.

Easier techniques include the torchlight test and the Van Herick test. In the torchlight test, a light is shone from the temporal side onto the cornea, parallel but anterior to the iris. A shadow on the nasal limbus identifies an eye with a shallow anterior chamber at risk for PAC. The sensitivity of the torchlight test is 80-86% and the specificity is 69-70%.^{241,242}

The van Herick test uses a slit beam to compare the peripheral anterior chamber depth with the corneal thickness. The sensitivity and specificity of the test are 61.9% and 89.3%, respectively.²⁴² Expressing the test in decimals yields similar results.²⁴³

If the van Herick test is positive and the IOP is increased, the specificity improves to 99%. Therefore, as a screening strategy, if the IOP is raised and the van Herick test is positive, the specificity is sufficiently high to diagnose PAC. However, this strategy is not appropriate for diagnosis or screening in an ophthalmology clinic; the latter requires the use of a gonioscope.

Imaging modalities for the anterior segment have also been evaluated for screening for angle closure. However, these modalities did not show high specificity for angle closure detection, when compared to gonioscopy.²⁴⁴

SPECIFIC RECOMMENDATIONS

Universal Glaucoma Screening

This is not recommended as a strategy:

- Universal screening is not feasible for developing countries without adequate infrastructure
- Adequate infrastructure implies:
 - the availability of the expertise (trained ophthalmologists), time, and instrumentation required to confirm the diagnosis among people with positive test results in an appropriately modern manner
 - the availability of expertise (trained surgeons) and instrumentation to appropriately treat those for whom the diagnosis is confirmed. The requirements for the diagnosis and management are covered in Section 1.

Individual countries need to decide on universal screening based on an assessment of the costs, benefits, and societal preferences.

Opportunistic Glaucoma Screening

Any person older than 35–40 years who seeks ophthalmic attention for any reason should have a comprehensive ophthalmic examination. This includes tests used to opportunistically screen for glaucoma (Tables 3.5 and 3.6).

Currently, the optimal method for detection of individuals with glaucoma is periodic routine comprehensive eye examinations. The feasibility of this depends on the health care system in an individual country. In lieu of an ideal screening method, opportunistic screening is recommended. This is especially important in people with a family history of glaucoma in a first degree relative.

Table 3.5 Additional requirements for glaucoma diagnosis in an ophthalmology clinic.

Test	Ideal	Acceptable	Less than ideal	Comments
Gonioscopy	Indentation gonioscopy using a Sussman, Zeiss, or Posner lens	Goldmann single or 2-mirror lens With manipulation ^a	NA	NA
VF examination(if the IOP is >21 mmHg and/or the disc is suspicious)	A full threshold test using a calibrated white-on-white automated perimeter	Frequency doubling perimetry Kinetic perimetry Henson's VF screen	NA	A trained technician must perform Goldmann perimetry, automated perimetry, frequency doubling perimetry and Henson's screen
Optic disc photography/imaging (if optic disc suspicious)	Dilated stereoscopic evaluation by slit-lamp biomicroscopy and stereoscopic optic disc photography One of the optic disc imaging technologies (OCT, GDx, or HRT) for follow-up for early and moderate glaucoma	Dilated stereoscopic evaluation by slit-lamp biomicroscopy	Direct ophthalmoscopy	Imaging has a limited role in the diagnosis of glaucoma. In the hands of an experienced clinician, can provide additional information for borderline cases May have larger role to play in identifying early progression

Table 3.6 Tests used for screening for glaucoma.

Test	Ideal	Acceptable	Less than ideal	Comments
Tonometry	Goldmann applanation tonometry	Perkins applanation tonometry, Tonopen, or similar Rebound tonometer iCare is useful in some cases who has small eyes or in childhood.	Pneumotonometer Schiotz tonometer	New tonometry methods that take into account corneal hysteresis may have an important role in the future
Dilated evaluation of the optic disc	Dilated stereoscopic evaluation by slit-lamp biomicroscopy Stereoscopic optic disc photography	Direct ophthalmoscopy	NA	Monoscopic optic disc assessment will underestimate CDR and will increase false negative results
Slit-lamp	NA	NA	NA	The torchlight and/or Van Herick tests are not appropriate tools to screen for angle closure. A positive torchlight or Van Herick test requires confirmation by gonioscopy A negative test does not exclude PAC
Gonioscopy – for all screening performed by ophthalmologists	Indentation gonioscopy using a Sussman, Zeiss, or Posner lens	Goldmann single- or 2-mirror lens with ‘manipulation’	NA	Mandatory for every glaucoma suspect, irrespective of whether the suspicion is based on raised IOP, optic disc, or visual field findings In view of the high prevalence of angle closure in the region, routine gonioscopy for all clinic patients is recommended Ideal to have both types of gonioscope
Visual field examination	NA	Full threshold Suprathreshold white-on-white Frequency doubling Hensons visual field screen	NA	Has limited value unless comprehensive examination suggests glaucoma and tests are performed reliably Should not be performed universally

FREQUENTLY ASKED QUESTIONS

There is a lot of undiagnosed glaucoma in the region around the clinic, therefore screening the local population may be beneficial. Is there a single screening test that can be used to diagnose glaucoma?

There is no single screening test to diagnose glaucoma, which is one of the reasons why 'screening' for glaucoma is not really possible. It is often difficult to be sure about the diagnosis, and the reliability of each test is variable.

Who should undergo gonioscopy in a general ophthalmology clinic?

Ideally, every person older than 40 years who reports for eye examination, especially everyone with glaucoma, family history of glaucoma, eye trauma, uveitis, and/or diabetes.

Should LPI be advised for all patients with a Van Herick test less than one-quarter the peripheral corneal thickness?

The Van Herick test is only a screening test to detect a narrow angle. The decision to perform LPI is based on gonioscopic and anterior segment imaging findings.

MEDICAL TREATMENT OF CHILDHOOD GLAUCOMA

Childhood glaucoma generally requires surgical treatment, but topical and systemic medications are often important first-line treatment as well as adjunctive therapy.

- A child with glaucoma should be referred to a center specializing in congenital/ childhood glaucoma

ANTI-GLAUCOMA THERAPY

Childhood glaucoma (developmental glaucoma and various secondary glaucomas) usually needs surgical therapy. Safety of anti-glaucoma medications in young children has not been established. Systemic side effects may be more common due to small distribution volume and reduced metabolism.

Adverse effects of medications may manifest atypically in children, hence parents should be informed of the potential side effects.

β-Blockers

They often serve as first line agents in suitable paediatric cases, but side effects must be anticipated and minimized by cautious use and starting with lower concentrations. Other than frank wheezing, persistent nocturnal cough should be recognized as an exacerbation of asthma or 'hyperactive airways'. Apnoea and bradycardia may occur in newborns and infants hence extreme caution is required in the very young.²⁴⁵

Prostaglandin Analogues

Latanoprost has been reported to have similar efficacy to Timolol in the paediatric population.²⁴⁶ Side effects in children are uncommon (sleep disturbance, sweating, ocular hyperaemia, irritation, increased iris pigmentation, eyelash growth).

α₂-Agonists

Avoid in neonates, infants, and children younger than 7 years. Apnoea and cyanosis, hypothermia, and hypotony related to CNS depression (from blood-brain barrier immaturity) have been reported.²⁴⁷⁻²⁴⁹

Carbonic Anhydrase Inhibitors

Both Dorzolamide 2% and Brinzolamide 1% are effective in reducing IOP in children. They are often used successfully alone and in fixed combination with timolol as a first-line medical treatment. Systemic acetazolamide has potent efficacy in children and is often used when more than 30% IOP reduction is needed, such as before goniotomy to enable clearing of corneal edema preoperatively. Chronic use may lead to failure to thrive, enuresis, lethargy and nephrolithiasis.

TOPICAL STEROIDS

Must be used at lower concentrations and with caution. Ocular hypertensive response is common and so IOP must be monitored while the child is taking steroids.²⁵⁰

TREATMENT IN PREGNANCY AND LACTATION

PREGNANCY AND INTRAOCULAR PRESSURE

Pregnancy often alters IOP, which tends to be lower in mid to late term,²⁵¹ possibly from hormonal changes or decreased episcleral venous pressure.

ANTIGLAUCOMA MEDICATIONS AND PREGNANCY

The FDA has classified drugs for use in pregnancy as follows:

- Class A: safety established using human studies
- Class B: presumed safety based on animal studies
- Class C: uncertain safety; animal studies show an adverse effect, no human studies done.
- Class D: unsafe; evidence of risk that, in certain clinical circumstances, may be justifiable
- Class X: highly unsafe — risk of use outweighs any possible benefit

Most ophthalmic medications (β -blockers, topical and systemic CAIs, PGAs, cholinergic agents, anticholinesterases, and apraclonidine hydrochloride) are FDA pregnancy class C. Brimonidine is pregnancy class B. Carefully balance the patient's risk of functional visual loss with the potential risk to the foetus or neonate.²⁵²

No anti-glaucoma medication has been proved completely safe in pregnant patients with glaucoma or OH. When circumstances permit, discontinuation of the drug(s) or reduction of the dose is recommended.

For all medications, decrease systemic absorption by teaching the double DOT technique — 'don't open the eyelid' and 'digital occlusion of the tear duct' after instilling any eye drops.

Closely collaborate with the obstetrician.

Be proactive — discuss with female patients of childbearing age the available options for glaucoma management before pregnancy. Laser or surgical treatments may be offered in advance, to decrease or stop medication use.²⁵³⁻²⁵⁵

Non-Selective α_1 -, α_2 -, and β -Agonists, β -Antagonists, and Pilocarpine

May be used with caution. Brimonidine may cause CNS depression and apnea in newborns and should not be used in late pregnancy near term. β -Receptors have been found in human placental tissue and placental transfer of β -antagonists have been reported.²⁵⁶ Monitor the foetus regularly for arrhythmia and bradycardia for patients using β -antagonists.^{257,258}

Prostaglandin Analogues

Should be avoided in pregnancy. Prostaglandin F2 α can cause uterine contractions and influence foetal circulation.^{259,260}

Systemic or Topical Carbonic Anhydrase Inhibitors

Should be avoided in pregnancy. CAI teratogenicity has been reported in animals.²⁶¹

Antiglaucoma Medications and Lactation

β-Blockers

Are used systemically during pregnancy for blood pressure control. Use with care during lactation. β-Blockers are excreted in breast milk at concentrations several times higher than those in plasma, potentially resulting in systemic cardiorespiratory side effects in infants.^{245,262} Timolol and dorzolamide are approved by the American Academy of Pediatrics for use during lactation and should be used with punctal occlusion.²⁶³

After topical instillation of an antiglaucoma medication, the drug level in the plasma usually reaches a pharmacologically active level.

FOR FURTHER INFORMATION

See the Organization of Teratology Information Specialists website at:
www.mothertobaby.org

or the European Network of Teratology Information Service website at:
www.entis-org.eu

SYSTEMIC MEDICATIONS THAT MAY INDUCE ANGLE CLOSURE

SYSTEMIC MEDICATIONS THAT CAN PRECIPITATE ACUTE ANGLE CLOSURE:

Pupillary block :

1. Anti-cholinergics: e.g., Ipratropium bromide, Atropine
2. Adrenergic agents: Nasal ephedrine, Salbutamol
3. Anti-depressants: Tri-cyclic anti-depressants, selective serotonin reuptake inhibitors (SSRIs) and serotonin-norepinephrine reuptake inhibitors (citalopram, paroxetine, and venlafaxine)- mechanism unclear
4. Anti-histamines: diphenhydramine, chlorpheniramine, and loratadine can induce mydriasis

Non-pupillary block:

1. Anti-convulsants/Migraine prophylaxis: Topiramate (idiosyncratic reaction causing ciliary body edema and secondary angle closure)
2. Other sulphur derivatives: Acetazolamide, hydrochlorothiazide, cotrimoxazole (induce angle closure by a similar mechanism)
3. Atypical antipsychotics: Arpiprazole
4. Anti-depressives: Bupropion hydrochloride

HOW TO TEST CALIBRATION OF A GOLDMANN TONOMETER

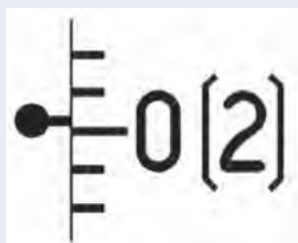


Figure 1

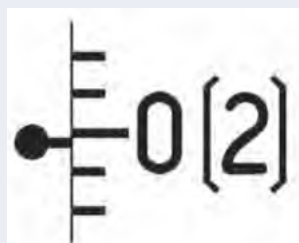


Figure 2

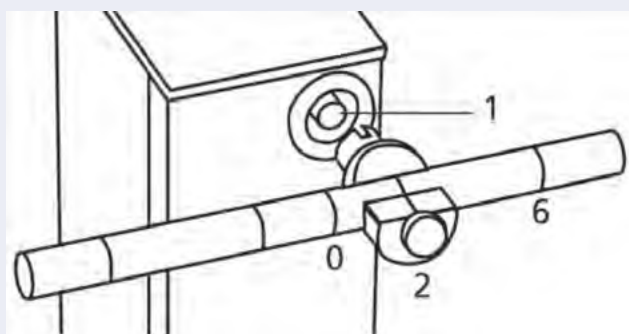


Figure 3

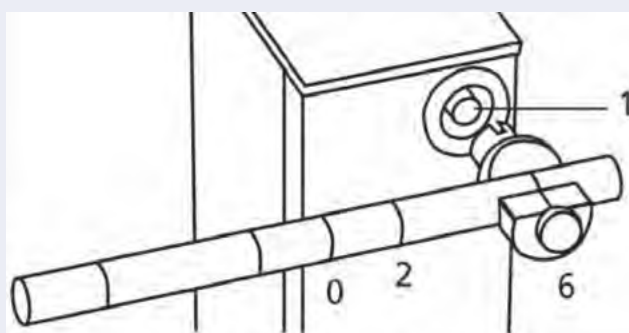


Figure 4

- Standard method for measuring IOP⁵⁵
- Periodic calibration check recommended: at least twice yearly

1. Set the tonometer in position on the slit-lamp stand, with the perspex biprism head in place and the tension on the circular dial on the right side (from the examiner's side of the slit lamp) set at 5 mmHg. The head should lean slightly forwards (away from the examiner)
2. Slowly twirl the circular dial counter-clockwise until the head rocks back towards the examiner. The tension should read 0-2 mmHg below zero (Fig. 1)
3. Slowly twirl the dial clockwise until the head rocks forwards again. The tension should read 0-2 mmHg (Fig. 2)
4. Remove the calibration rod from its box. Firmly screw into position the holding bracket that slides along the rod so that the closest mark in front of the centre one (on the other side of the centre from you) is aligned as exactly as possible (Fig. 3)
5. Slip the rod and its holder into the receptacle on the right side of the tonometer. The head will rock backwards towards the examiner
6. Slowly twirl the circular dial clockwise until the head rocks forwards. Note the tension reading on the dial: it should be 20-23 mmHg
7. Slowly twirl the circular dial counter-clockwise until the head rocks backwards. The tension on the dial should read 17-20 mmHg
8. Remove the rod and holding bracket from the tonometer and reposition the bracket so that it is aligned exactly with the most forward mark on the

rod – furthest away from the examiner (Fig. 4)

9. Replace the rod in its bracket in the tonometer receptacle. The tonometer head should rock backwards, towards the examiner
 10. Slowly twirl the dial clockwise until the head rocks forwards. The tension should read 60-64 mmHg
 11. Slowly twirl the dial counter-clockwise until the head rocks backwards – the tension should read 56-60 mmHg
- The three threshold tension levels being used to test the tonometer's calibration are at 0, 20, and 60 mmHg
 - At each of these thresholds, you can gently twirl the dial backwards and forwards, reading the tension as the head responds
 - These points should bracket the threshold level evenly – the higher the level being tested, the greater the interval is likely to be

Figures 1, 2, 3, and 4 reproduced by courtesy of Haag-Streit AG and Mandarin Opto-Medic Co Pte Ltd.

APPENDIX 5

TONOMETRY MIRES



Fig. 5.1a. insufficient corneal applanation (IOP higher than tonometer reading).



Fig. 5.1b. Correct endpoint corneal applanation (IOP equals tonometer reading).



Fig. 5.1c. Excess corneal applanation (IOP lower than tonometer reading).

Photographs reproduced by courtesy of Renyi Wu, China.

GONIOSCOPY

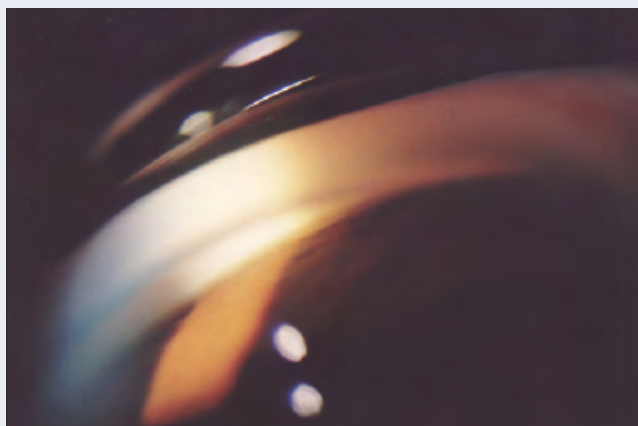


Fig. 6A.1 Gonioscopy narrow angle without indentation



Fig. 6A.2 Gonioscopy narrow angle without indentation showing PAS.

GONIOSCOPY

- Biomicroscopic examination of the anterior chamber angle
- Essential for glaucoma diagnosis, treatment, and follow-up

METHODS

Gonioscopic contact lens permits the angle to be seen.

Direct Gonioscopy

Place the Koeppel gonioscopic lens on the anaesthetised cornea with the patient supine. Fill the space between the lens and the cornea with a contact fluid (saline or methylcellulose). View the angle with a handheld biomicroscope and an illuminator.

Indirect Gonioscopy

At the slit lamp, place a mirrored lens (Goldmann-type or 4-mirror indentation) on the anaesthetised cornea.

- For the Goldmann-style 1- (or 2-) mirror lens, use viscous material (methylcellulose 2%) to fill the space between the cornea and gonioscopic lens
- For the 4-mirror Zeiss-type lens (larger radius of curvature and small corneal contact area), no space-filler is needed
- 4-mirror gonioscopic lens allows the entire angle to be viewed without lens rotation, and permits dynamic gonioscopy through corneal indentation
- To avoid light-induced miosis falsely deepening the angle, gonioscopy is a 'dark art': dim or dark room, minimal slit lamp light height

INDENTATION (PRESSURE/DYNAMIC) GONIOSCOPY

- With 4-mirror indirect gonioscopic lens, press on the cornea to displace fluid into the angle to visualise the anatomic landmarks and to differentiate appositional from PAS closure
- Facilitate visualisation into narrow angles by:
 - static primary position gonioscopy
 - dynamic gonioscopy
 - ♦ tilting lens
 - ♦ patient gaze to mirror
 - ♦ indentation

look over central iris
depress peripheral iris

Photographs reproduced courtesy of Atsuo Tomidokoro, Japan.

GONIOGRAM/GONIOSCOPIC CHART

Grading system for gonioscopic findings (without indentation):^{264,265}

VAN HERICK METHOD USES CORNEAL THICKNESS AS A UNIT OF MEASURE

Grade 0	Iridocorneal contact
Grade I	Peripheral anterior chamber depth between iris and corneal endothelium is $<1/4$ corneal thickness (occludable)
Grade II	$>1/4$ but $<1/2$ of corneal thickness
Grade III	$\geq 1/2$ of corneal thickness (non-occludable)

SCHAFFER METHOD

Grade	0	I	II	III	IV
<i>Method Shaffer</i>	Closed	10°	20°	30°	40°
<i>Method Modified Shaffer</i>	Schwalbe's line is not visible	Schwalbe's line is visible	Anterior TM is visible	Scleral spur is visible	Ciliary band is visible

SPAETH METHOD

1. Iris insertion

Anterior to Schwalbe's line or TM
 Behind Schwalbe's lines
 Centred at scleral spur
 Deep to scleral spur
 Extremely deep/on ciliary band

2. Angular width

Slit
 10°
 20°
 30°
 40°

3. Peripheral iris configuration

Queerly concave
 Regular
 Steep

4. TM pigment

0 (none) to 4 (maximal)

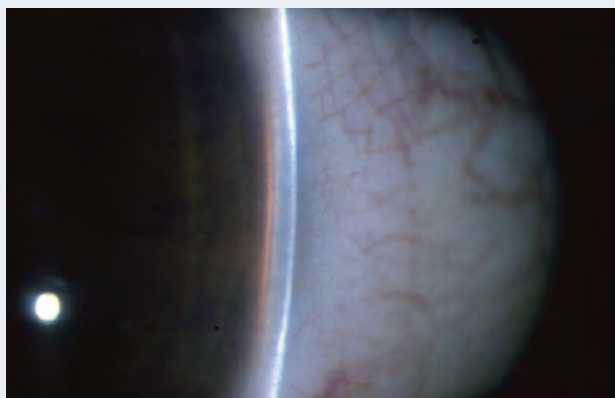
APPENDIX 6C

MODIFIED VAN HERICK GRADING

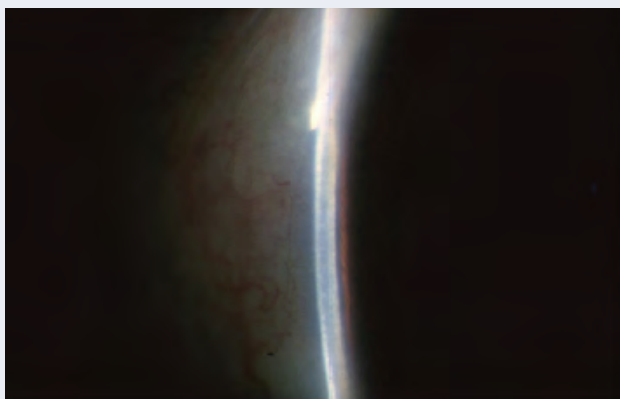
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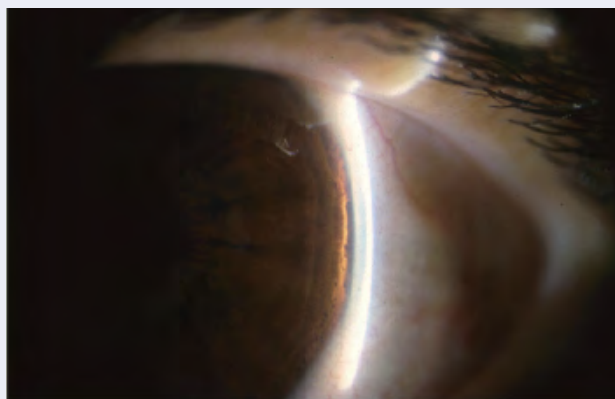
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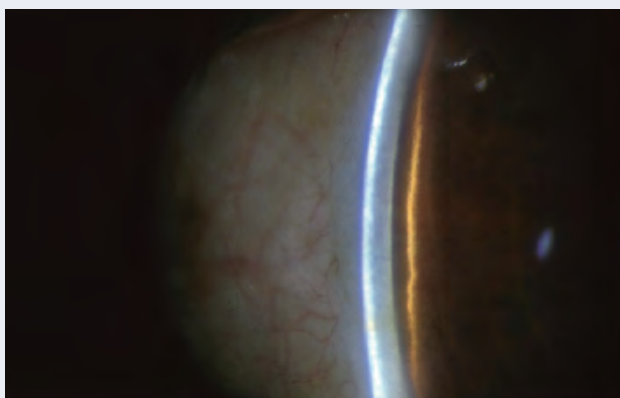
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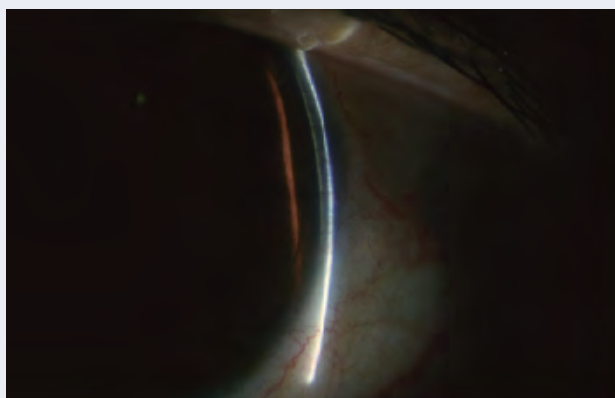
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APPENDIX 6D

ULTRASOUNDBIOMICROSCOPY



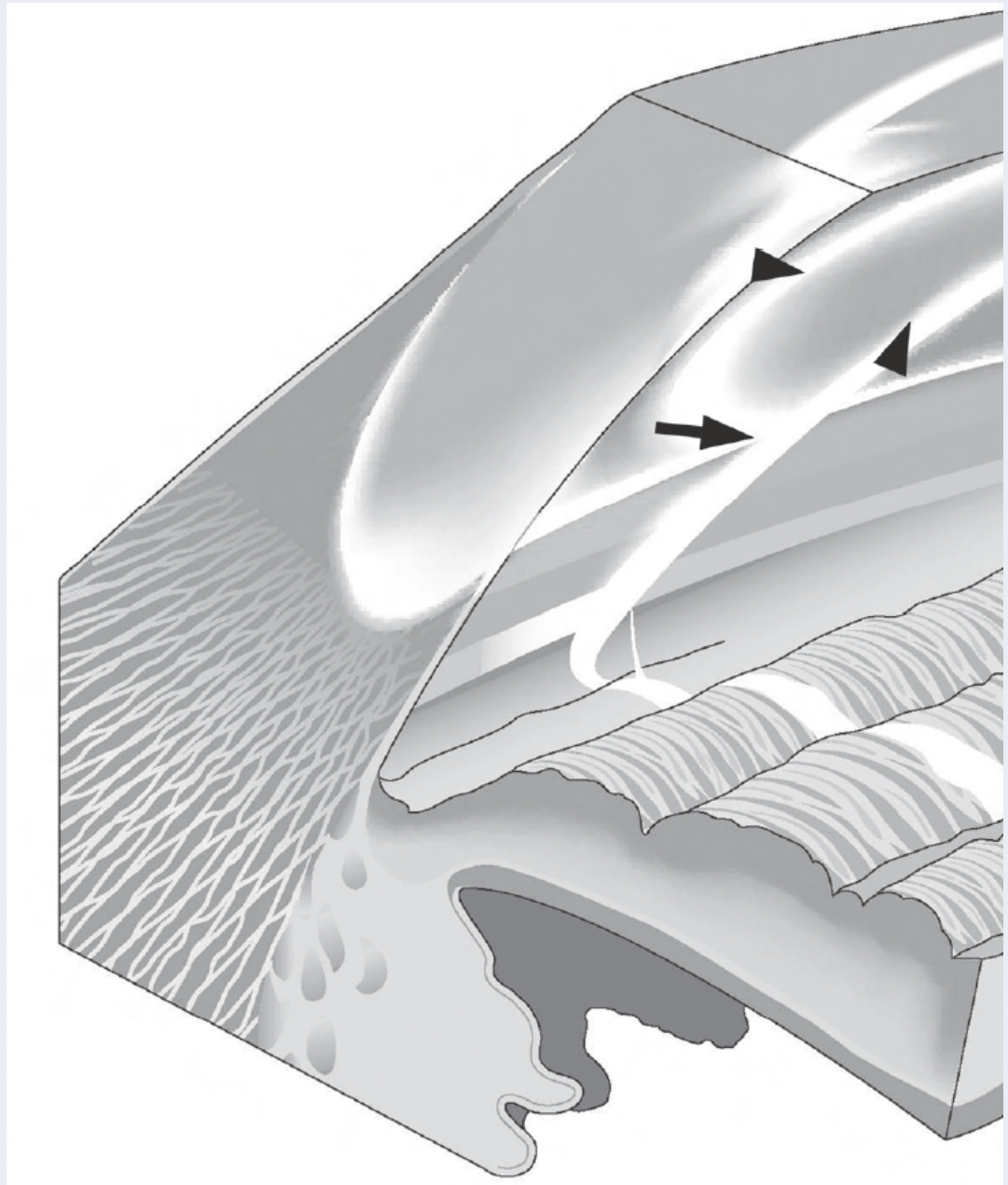
Photographs reproduced courtesy of Renyi Wu, China.

ANTERIOR SEGMENT OPTICAL COHERENCE TOMOGRAPHY (AS-OCT)



Photographs reproduced courtesy of Renyi Wu, China.

CORNEAL WEDGE DIAGRAM



- A gonioscopic view of the drainage angle at high magnification (x 16 or x 25)
- The thin slit beam illuminates the angle region and splits to form the 'corneal wedge' (arrow heads)
- The boundaries of the wedge meet at Schwalbe's line (arrow).

Schematic reproduced with permission from BMJ Books; Copyright © 2000.²⁶⁶

HOW TO OPTIMISE PATIENT PERFORMANCE IN SUBJECTIVE PERIMETRY

1. CHOOSE THE MOST APPROPRIATE INVESTIGATION

- On the Humphrey Field Analyser:
 - Test pattern: 24-2 – early/moderate damage and glaucoma suspects;
 - 10-2 – advanced damage or paracentral scotomas
 - Test strategy: SITA – most patients and suspects
- On OCULUS Perimeters:
 - SPARK strategy for most patients and suspects
 - Fast Threshold strategy on 10-2 pattern for advanced damage or paracentral scotomas

2. PATIENT SET-UP AT THE PERIMETER

- Use near lens power based on current refraction
- Support the patient's feet comfortably so that the thighs are horizontal
- Support the patient's back
- Adjust chin rest height so the forehead touches the holding band easily
- Cover other eye fully – some patients prefer open, some prefer closed
- Support the arms so shoulders and neck do not tire

3. INSTRUCTIONS TO THE PATIENT BEFORE STARTING THE TEST

- 'We are getting you to do this test to give us information. We want to see how full and perfect your vision is or, if it isn't, we want to know where the damage is, and what sort of damage it is.'
- 'The test is not difficult, but to get the best information for your care, it needs to be done in a particular way.'
- 'The key to success is to look straight ahead all the time. [Point where you want them to look.] Let the light come to you – don't go looking for it.'
- 'You won't see the light a good deal of the time, so don't worry if time seems to be passing without a light appearing. The machine makes the light very dim so that it can tell when you can just see it.'
- 'Press the button when you think you see the light. All the lights you see, count – they can be fuzzy, dim, bright, it doesn't matter.'
- 'Blink whenever you need to, but do so when you press the button. That will stop your eyes drying out and hurting, and you won't miss any lights.'
- 'Hold the button down when you want to rest. That will pause the machine. Release the button when you want to continue. Remember you can rest as often as you like. You're the one controlling the machine.'
- 'Let's have a practice run now so you can get a feel for the whole thing.'
- This is essential for perimetric novices, but may be important for many others as well. Run the demonstration programme

4. PATIENT SUPPORT DURING THE TEST

- Do not abandon the patient during the test – have your technician return regularly and frequently to supervise
- Reassure and encourage the patient during the test
- Restart the test if the performance is proving unreliable; try to identify and to rectify the cause of the problem; do not disparage or 'blame' the patient
- Consider rescheduling the test if the patient cannot cope
- Be patient, more patient, and then even more patient

5. MAINTAIN A QUIET ENVIRONMENT TO SUPPORT CONCENTRATION

COMMON ARTIFACTS FOR VISUAL FIELD MEASUREMENTS

Common artifacts may be caused by:

- Refractive error, especially hyperopia, may influence the central field and threshold sensitivities
 - in patients with high myopia ‘refraction scotoma’ may be confused with glaucomatous changes
- Cataract and other opacities in intermediate ocular media (corneal opacity, after cataract, vitreous haemorrhage/opacity) can influence visual field
- Small pupil may exaggerate VF abnormalities, especially in eyes with cataract
 - the pupil size at the time of examination should be recorded
- Patient’s experience with and concentration for the test can influence the perimetric results
- Lens rim artifact
- Drooping eyelids, deep-set eyes, prominent brows or nose
- Multifocal IOL

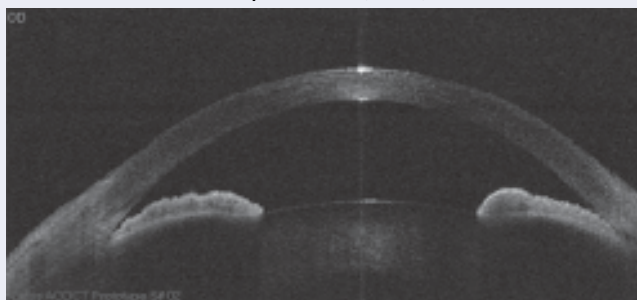
SECONDARY GLAUCOMAS – PRINCIPLES OF MANAGEMENT

Strategy	An example of the approach to management – uveitic glaucoma
Diagnose the underlying cause(s)	Diagnose uveitis and its cause(s)
Treat the underlying cause(s)	Anti-inflammatory agents
Identify the mechanism(s)	Posterior synechiae with pupil block
Treat the mechanism(s) – they may change over the course of the disease	LPI
Medical therapy First-line agents are aqueous inflow inhibitors	β -Blockers, α_2 -agonists, CAIs

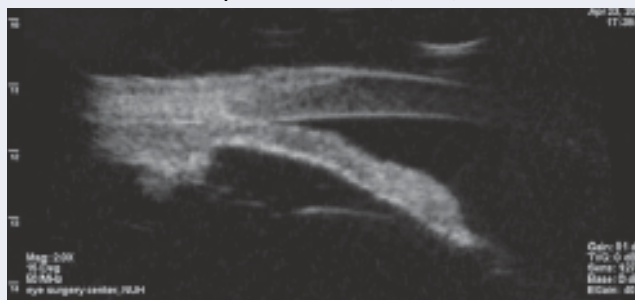
APPENDIX 9

ANGLE CLOSURE MECHANISMS

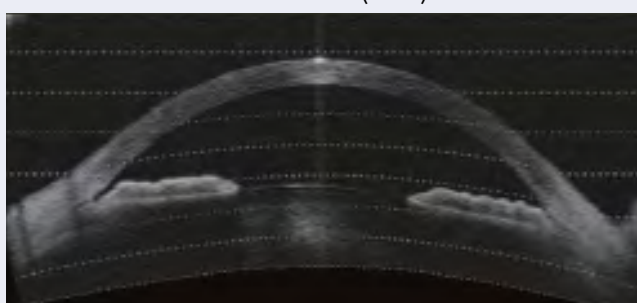
Pupil block (OCT)



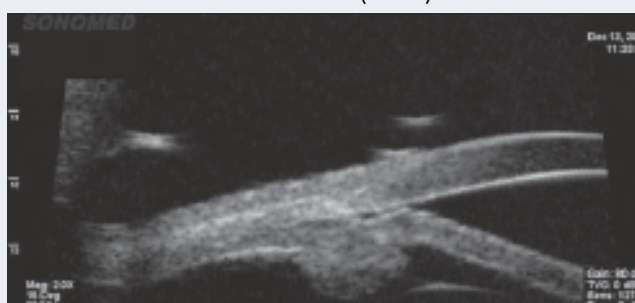
Pupil block RLE (UBM)



Plateau iris (OCT)



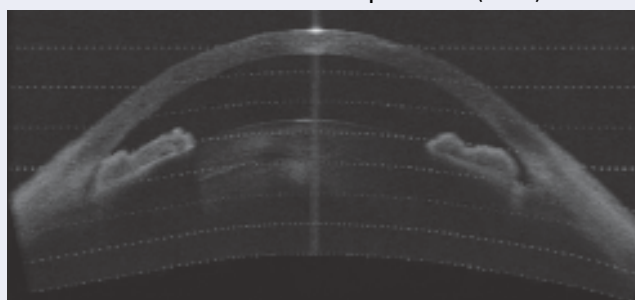
Plateau iris (UBM)



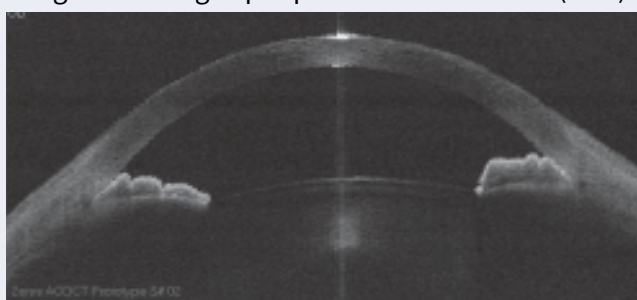
Pseudoplateau iris — ciliary body cyst (UBM)



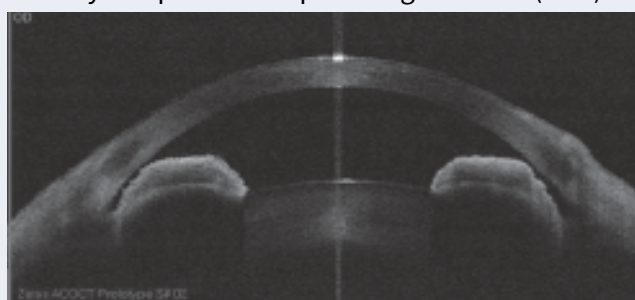
Lens — thick forward position (OCT)



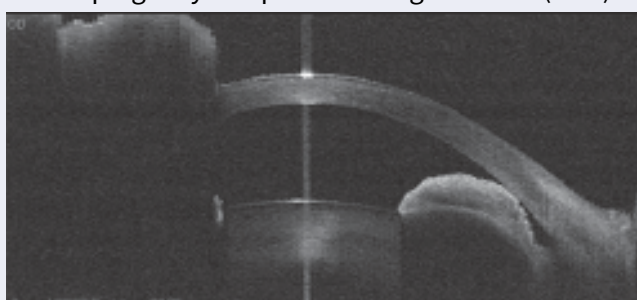
Angle crowding — peripheral iris roll in dark (OCT)



Very steep nasal temporal angle in dark (OCT)



Creeping very steep inferior angle in dark (OCT)



Photographs reproduced courtesy of Paul Chew, Singapore

SIDE EFFECTS OF GLAUCOMA MEDICATIONS

Preparations by class	Contraindications*	Drug interactions	Local side effects	Systemic side effects
α_2-Adrenergic agonists <i>Selective α_2-adrenergic agonists</i> Brimonidine 0.2%, 0.15%, 0.1% Apraclonidine 1%, 0.5% <i>Non-selective α_2-adrenergic agonists</i> Epinephrine 2% Dipivefrin 0.1%	MAOI therapy Age younger than 2 years Caution is recommended for children younger than 7 years	CNS depressants: Alcohol Barbiturates Opiates Sedatives Anaesthetics Tricyclic antidepressants	Allergy Burning Stinging Blurring Foreign-body sensation Itching Hyperaemia Follicular conjunctivitis	CNS depression Oral dryness Headache Fatigue Drowsiness Bradycardia Hypotension Hypothermia Apnoea
β-Blockers <i>Non-selective agents</i> Timolol 0.25%, 0.5%, 0.1% Laevobunolol 0.25%, 0.5% Carteolol 1% Metipranolol 0.3%	Absolutely contraindicated in: Bronchial asthma COPD Bradycardia Heart block To be used cautiously in: Cardiac failure Punctate epithelial keratopathy	Systemic β -blockers CCBs	Burning Stinging Bradycardia Itching Tearing Decreased corneal sensitivity Hyperaemia	Bronchospasm Hypotension Photophobia Heart block Mask hypoglycaemia Adversely affects lipid profile (except carteolol) Loss of libido Fatigue Aggravation of myasthenia gravis Depression Memory impairment Reduced exercise tolerance Increased falls Hair loss Fatigue
<i>Selective agents</i> Betaxolol 0.25%, 0.5%	Relatively contraindicated in: Bronchial asthma COPD Bradycardia Heart block Cardiac failure	As for non-selective β -blockers with wider safety margin	As for non-selective β -blockers, with wider safety margin	As for non-selective β -blockers with wider safety margin
CAIs <i>Topical</i> Dorzolamide 2% Brinzolamide 1%	Relatively contraindicated in compromised corneal endothelium and sulfonamide allergy	None reported, but potential exists for similar interactions as for systemic CAIs	Burning Stinging Itching Punctate epithelial keratopathy Blepharoconjunctivitis Corneal endothelial cell decompensation	Bitter taste

Continued on next page

Preparations by class	Contraindications*	Drug interactions	Local side effects	Systemic side effects
Systemic Acetazolamide 125 mg, 250 mg Methazolamide 25 mg, 50 mg Dichlorphenamide 50 mg	Sulfonamide allergy Renal stones/failure Respiratory/metabolic acidosis Hypokalaemia	Steroids Diuretics Digoxin	Transient myopia	Fatigue/lethargy Anorexia/weight loss GI upset Paraesthesia Taste disturbance Stevens-Johnson syndrome Blood dyscrasias Renal stones/failure Hypokalaemia Acute leukopenia Agranulocytosis Aplastic anaemia Haemolytic anaemia Neutropenia Pancytopenia Thrombocytopenia
Cholinergics Pilocarpine 1%, 2%, 3%, 4%, 6% Carbachol 1.5%, 3% Phospholine iodide 0.03%, 0.06%, 0.125%, 0.25% Acetylcholine chloride 20 mg/2 mL	Uveitic, neovascular, and lens-induced glaucomas Post-drainage surgery Aqueous misdirection syndrome Phospholine iodide in phakic patients	Many for phospholine iodide, see: www.drugs.com/drug-interactions/phospholine-iodide_d01195.html or consult full prescribing information	Cataract Pain Dimness of vision Blurring Myopic shift D Retinal detachment Aggravation of pupillary block	Headache Salivation Lacrimation Urinary frequency Iarrrhoea Abdominal cramps Diaphoresis Headache Tremor Salivation Bronchospasm Pulmonary oedema Hypotension Bradycardia Nausea Vomiting
Hyperosmotic agents Mannitol 5%, 10%, 15%, 20%, 25% Glycerol Isosorbide	Heart failure Pulmonary oedema Renal failure Caution in hypertension	NA	NA	Headaches Unpleasant taste Heart failure Pulmonary oedema Diuresis Death
PGAs Latanoprost 0.005% Travoprost 0.004% Bimatoprost 0.01% Bimatoprost 0.03% Tafluprost 0.0015%	Cataract surgery complicated by posterior capsular rupture and vitreous loss Herpes simplex keratitis (active or quiescent) Relatively contraindicated in: Active inflammatory ocular conditions Cystoid macular oedema	Chronic pilocarpine use may reduce efficacy	Blurred vision Burning Stinging Conjunctival hyperaemia Foreign-body sensation Itching Increased pigmentation of the iris/periorbital skin Longer, darker, and thicker lashes Punctate epithelial keratopathy Cystoid macular oedema Reactivation of herpetic infection Facial rash	Unlikely, but possible — consult full prescribing information

Continued on next page

Preparations by class	Contraindications*	Drug interactions	Local side effects	Systemic side effects
Proprietary fixed combinations† Combigan (brimonidine/timolol 0.2%/0.5%) Cosopt (dorzolamide/timolol 2%/0.5%) Azarga (brinzolamide 1.0%/timolol 0.5%) DuoTrav (travoprost/timolol 0.004%/0.5%) Ganfort (bimatoprost/timolol 0.03%/0.5%) Xalacom (latanoprost/timolol 0.005%/0.5%) Simbrinza (brimonidine tartrate/brinzolamide 0.2%/1%) Tapcom (tafluprost/timolol 0.0015%/0.5%)	As for individual components	As for individual components	As for individual components	As for individual components

Note: Please refer to manufacturer's summary of product characteristics before prescribing.

* Known hypersensitivity to any component of the product or pregnancy.

† Differences may exist between fixed combinations and the individual components.²⁶⁷

- The incidence of ocular allergy with Combigan bd (26%) is significantly lower than with brimonidine 0.2% tds used as monotherapy(40%)
- There is less conjunctival injection with Xalacom and DuoTrav than with latanoprost and travoprost, respectively

LASER TRABECULOPLASTY

ARGON LASER TRABECULOPLASTY

- Approximately 100 equally spaced laser spots (diameter 50 μ ; arrow head) each for 0.1 seconds are applied over 360° of TM, often in 2 sessions of 180°, separated by 1 to 2 weeks
- Ideally, the spots should be applied over Schlemm's canal, avoiding the iris root, at the junction of the anterior one-third and posterior two-thirds of the TM
- The energy level should be set to induce a reaction from a slight transient blanching of the treated area, to small bubble formation

SELECTIVE LASER TRABECULOPLASTY

- Recently, SLT has been regarded as a safe and effective procedure for patients with POAG, that is equivalent to ALT in terms of IOP reduction
- The settings are: spot size 0.4 mm, duration 0.3ns, laser power 0.8 mJ depending upon the tissue reaction
- Laser spots are applied on the TM over 180° in one session, with each spot being in contact with the adjacent one (arrow)
- The laser power should be adjusted to induce minimum reaction at the irradiated area
- Bubble formation should be avoided

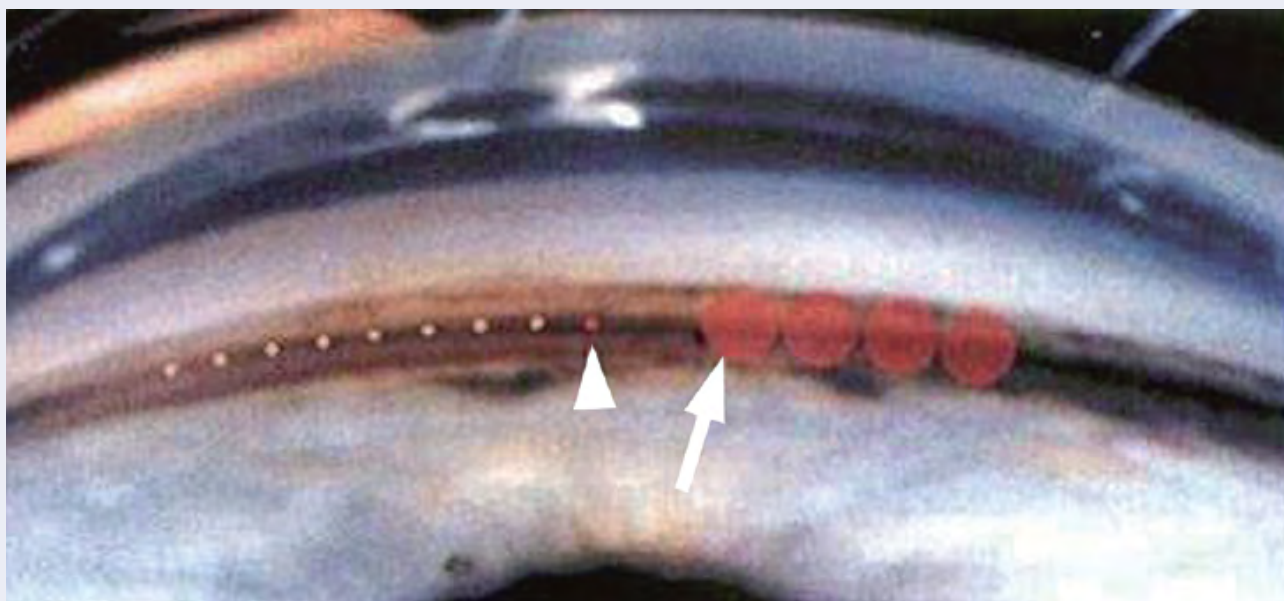
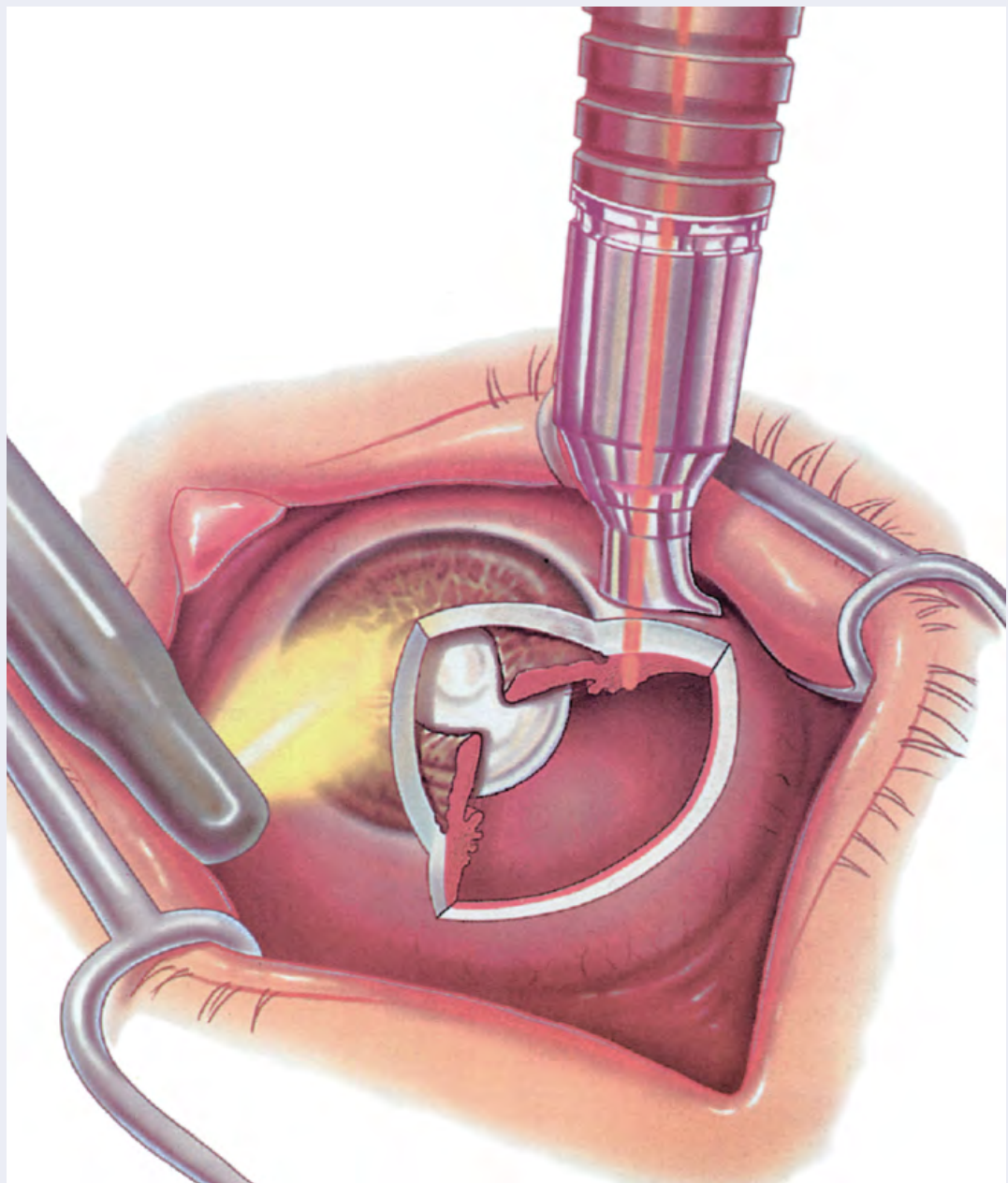


Fig. 1 Selective laser trabeculoplasty

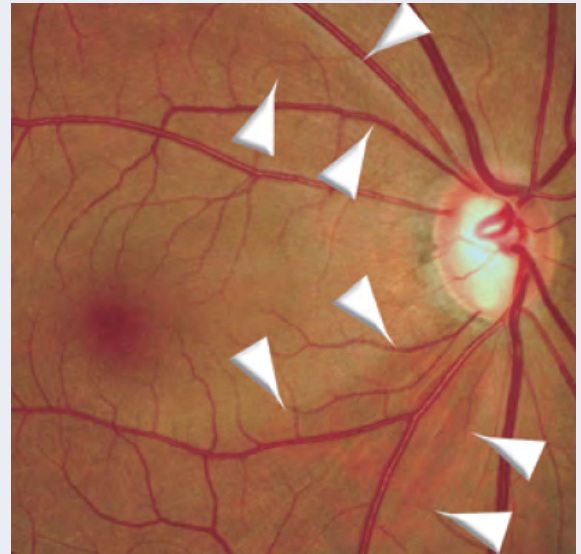
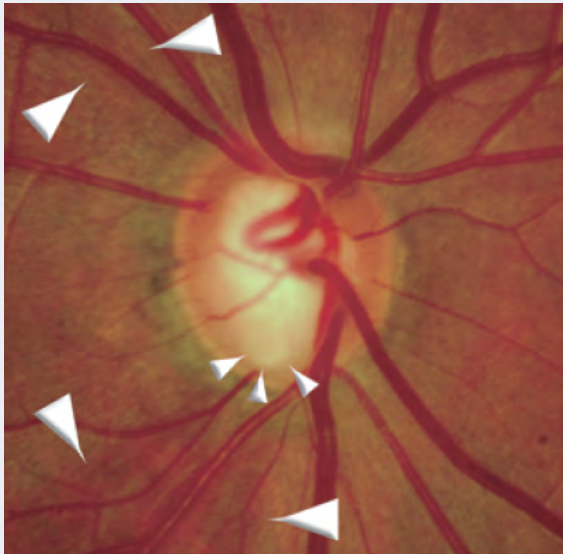
CONTACT TRANS-SCLERAL DIODE LASER



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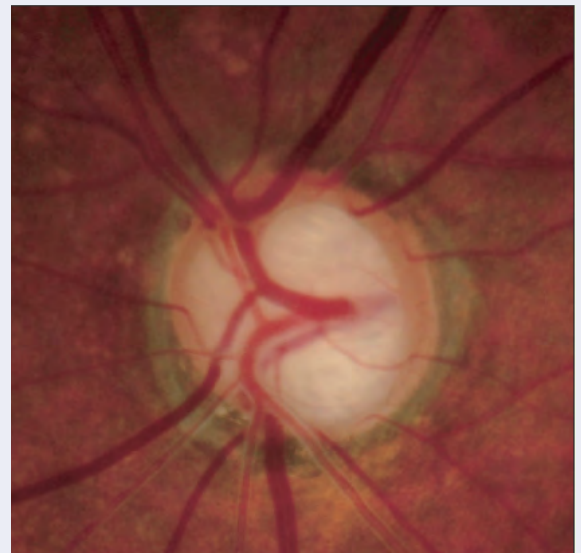
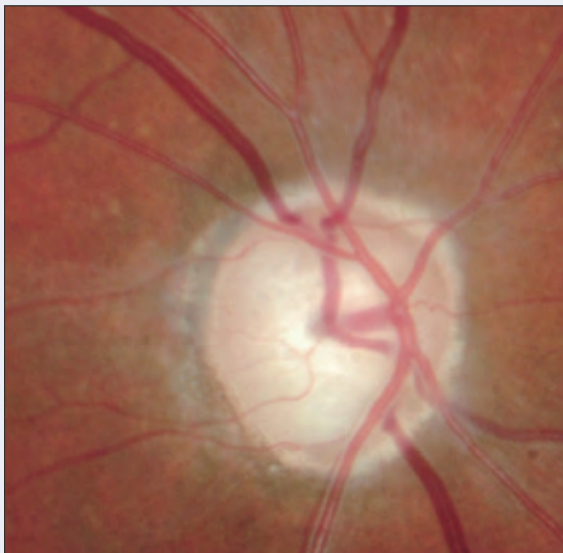
- A cold light source transilluminates the anterior segment, allowing identification of the ciliary body behind the lucent cornea and limbus
- With the G-probe, the fibre-optic laser tip is 1.5 mm behind the anterior edge of the footplate and protrudes 0.7 mm
- The laser tip should be placed over the ciliary body- the dark band posterior to the peri-limbal haloe seen with transillumination
- Indentation improves energy delivery and blanches the conjunctival blood vessels
- The schematic shows a relatively posterior ciliary body treatment, which may improve pressure reduction

GLAUCOMATOUS OPTIC NEUROPATHY



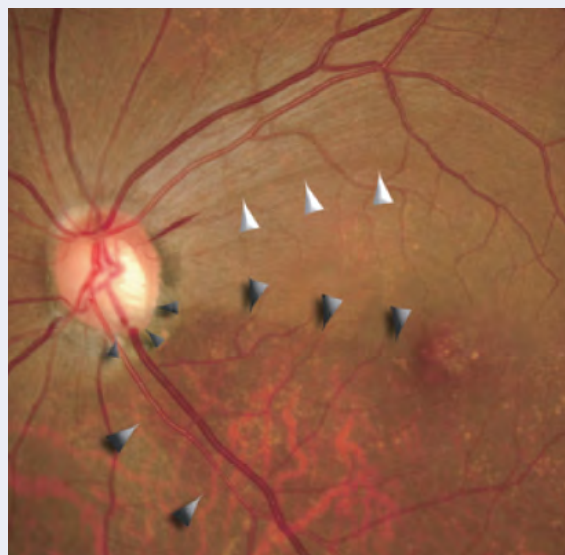
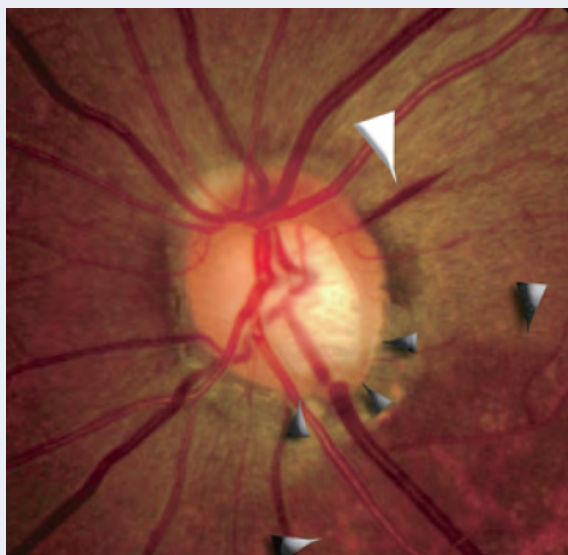
Moderate Glaucomatous Optic Neuropathy

- Localised loss of both inferior and superior neuroretinal rim
- A classic inferior notch (small arrow heads)
- Nerve fibre layer defect in both superior and inferior arcuate area (large arrow heads)



Advanced Glaucomatous Optic Neuropathy

- Neuroretinal rim thinning
- The cup extends to the disc rim
- Circumlinear blood vessel baring
- Bayoneting of the blood vessels
- PPA (Peripapillary atrophy)



Disc Haemorrhage

- Splinter, superficial flame-shaped, haemorrhage at disc margin (large arrow head)
- Localised nerve fibre defect at corresponding area (small arrow heads)
- Laminar dots are visible
- A deep notch at the infero-temporal neuroretinal rim with broad nerve fibre defect (dark arrow heads)

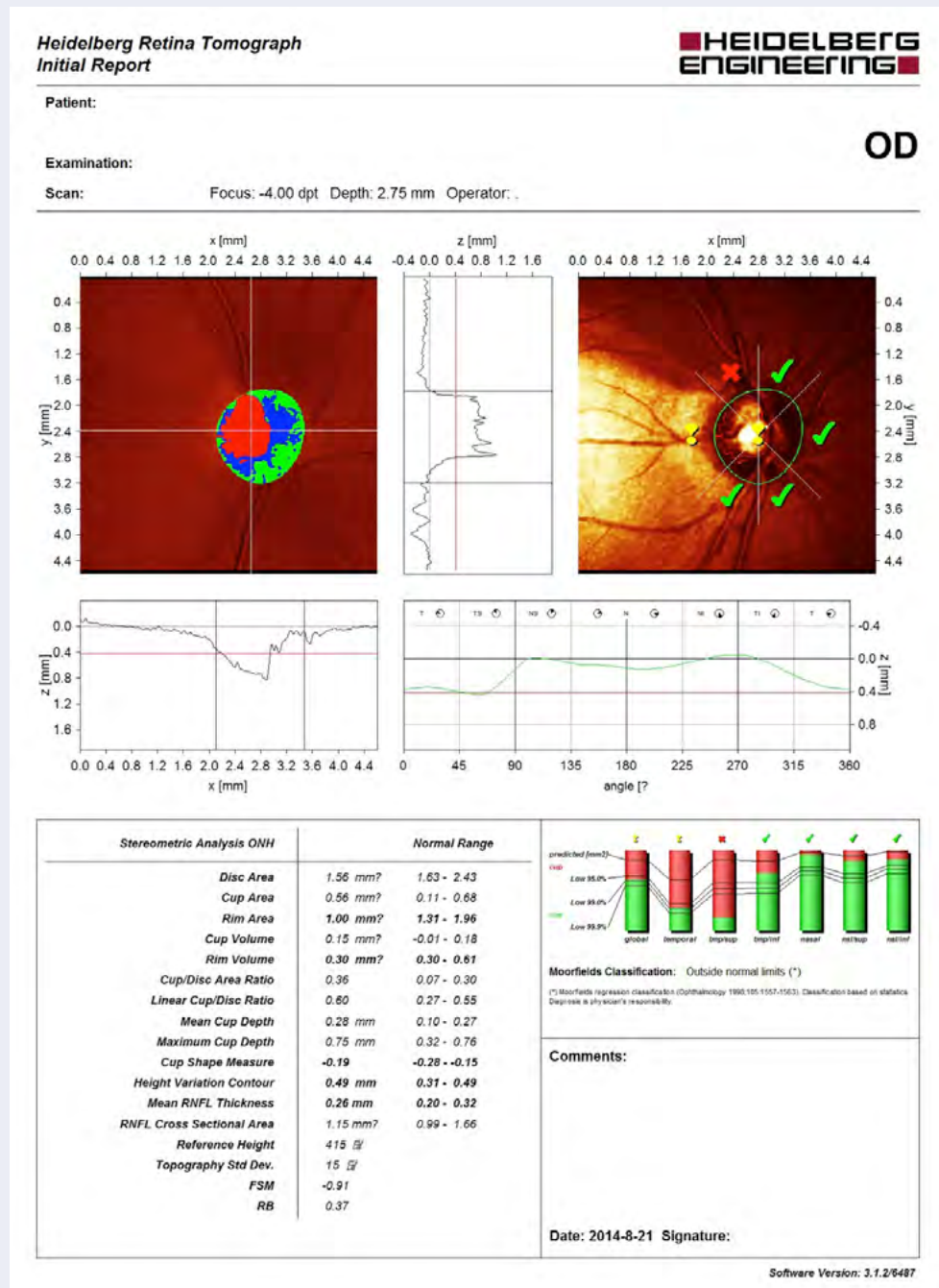
Photographs reproduced by courtesy of Prin RojanaPongpun, Thailand.

APPENDIX 13A

IMAGING DEVICES

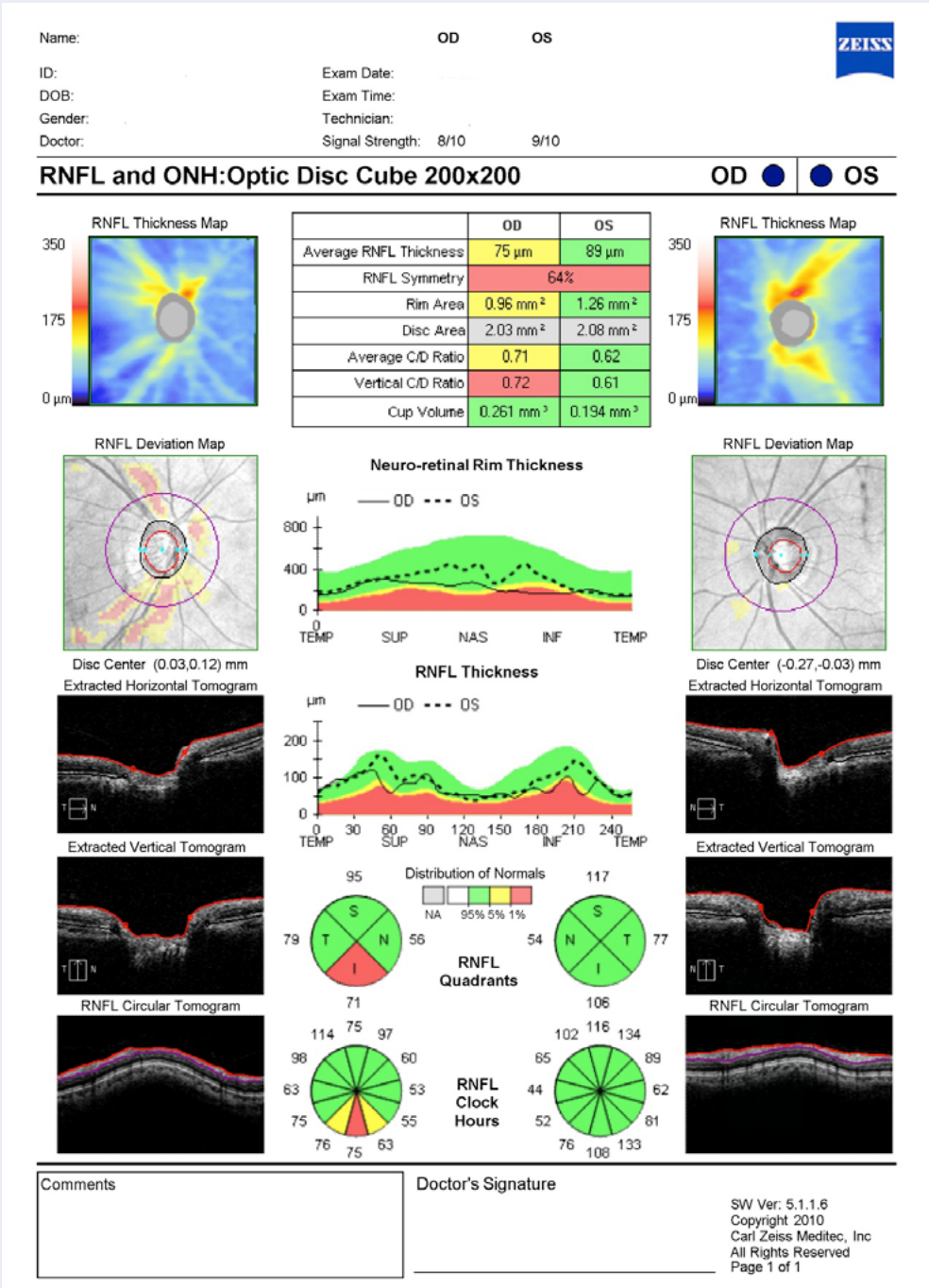
- Modern technology for optical imaging can enable us to quantitatively and objectively estimate glaucomatous structural changes in the optic nerve head and retina.

Heidelberg Retina Tomography



Photograph by courtesy of Dr. Seok Hwan Kim, Seoul, Korea.

Optical Coherence Tomography (Cirrus)



Optical Coherence Tomography (Spectralis)

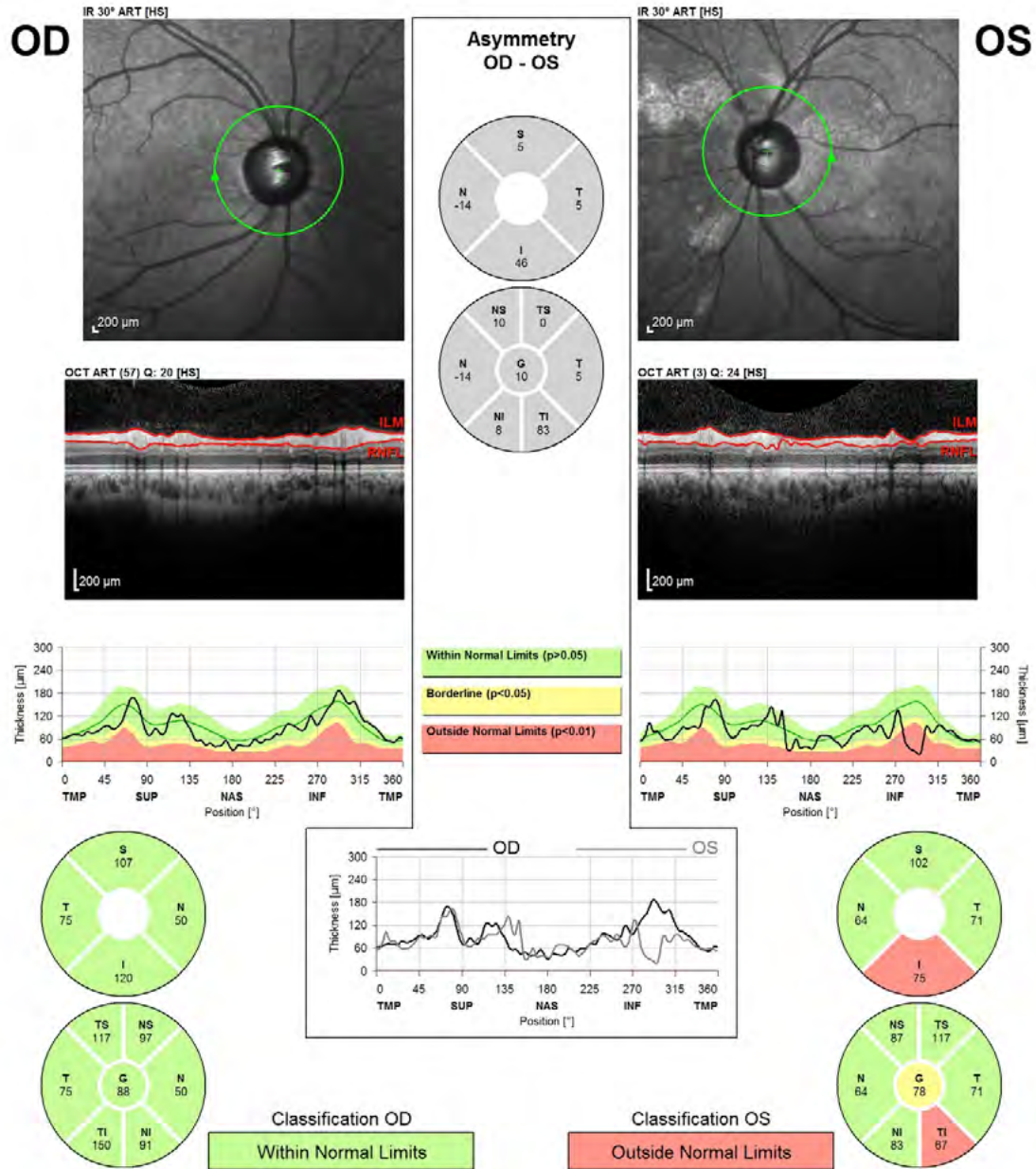
RNFL Single Exam Report OU with FoDi™ SPECTRALIS® Tracking Laser Tomography

**HEIDELBERG
ENGINEERING**

Patient:
Patient ID:
Diagnosis:

DOB:
Exam.:
Comment:

Sex:



Notes:

Date:

Signature:

Software Version: 5.6.4

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RNFL Single Exam Report OU with FoDi™

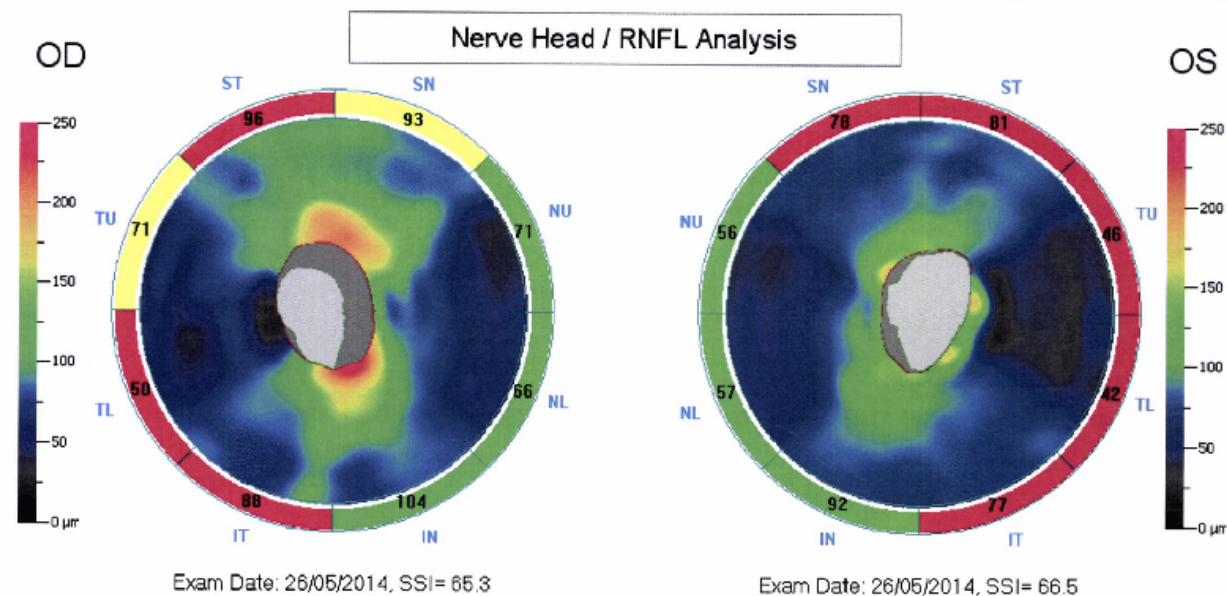
Photograph by courtesy of Dr. Seok Hwan Kim, Seoul, Korea.

Optic NerveHead(ONH) Symmetry Analysis Report

Patient:
Physician:
Operator:
Disease:

Gender: M
ID:

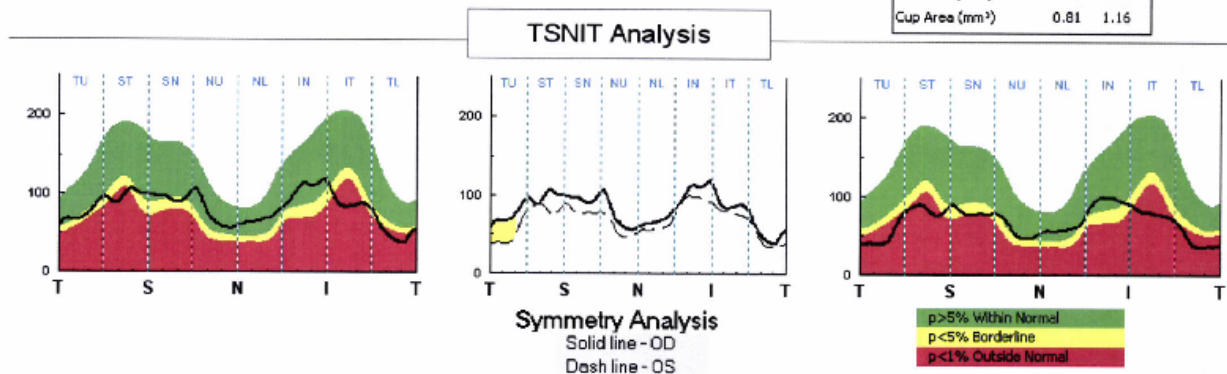
Exam Date: 26/05/2014
DOB(age):
Ethnicity: Asian
Algorithm Version: A6, 3, 0, 68



RNFL Parameters	OD	OS
Avg. RNFL	79.96	66.14
Sup. Avg	82.99	65.24
Inf. Avg	76.93	67.05

Nerve Head Parameters (Volume)	OD	OS
Rim Volume (mm ³)	0.084	0.009
Nerve Head V _{in} (mm ³)	0.149	0.021
Cup Volume (mm ³)	0.169	0.350

Nerve Head Parameters	OD	OS
Optic Disk Area (mm ²)	1.56	1.38
Cup/Disk Area Ratio	0.52	0.84
Horizontal C/D Ratio	0.73	0.95
Vertical C/D Ratio	0.80	0.99
Rim Area (mm ²)	0.75	0.22
Cup Area (mm ²)	0.81	1.16



Report Date: Monday May 26 14:15:15 2014

Software Version #6, 3, 0, 68

Comments:

Signature:

Defining the OCT Revolution



Photograph by courtesy of Dr. Dexter Yu-lung Leung, Hong Kong, China.

ID: A0014

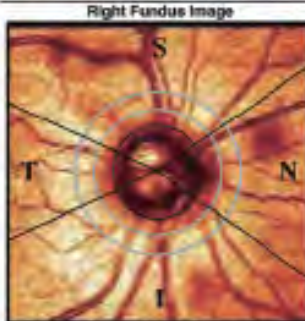
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OD Right

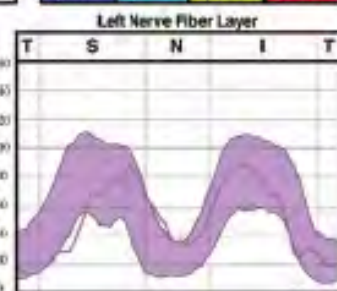
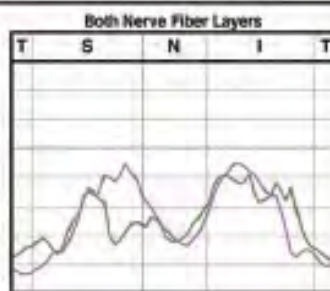
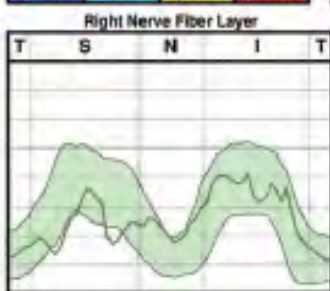
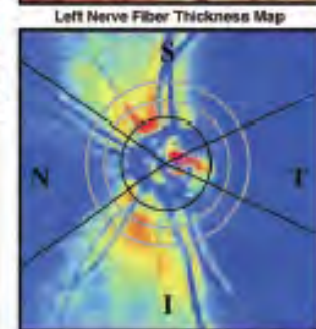
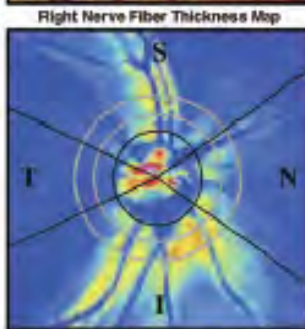
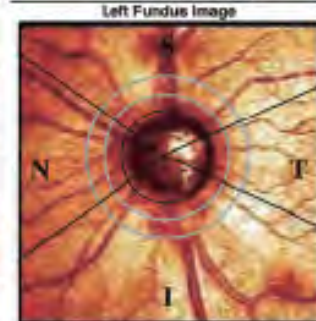
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: 1790 V: 1061
Date: 2007-8-8 00:56

OS Left

Q: 9 Operator:
Ht: 1760 W: 1801
Date: 2007-9-8 09:58



TSNIT Parameters	OD Actual Val.	OS Actual Val.
TSNIT Average	51.5	51.6
Superior Average	49.6	59.5
Inferior Average	56.4	61.7
TSNIT Std. Dev.	17.8	24.9
Inter-Eye Symmetry	0.72	
NFI	26	23



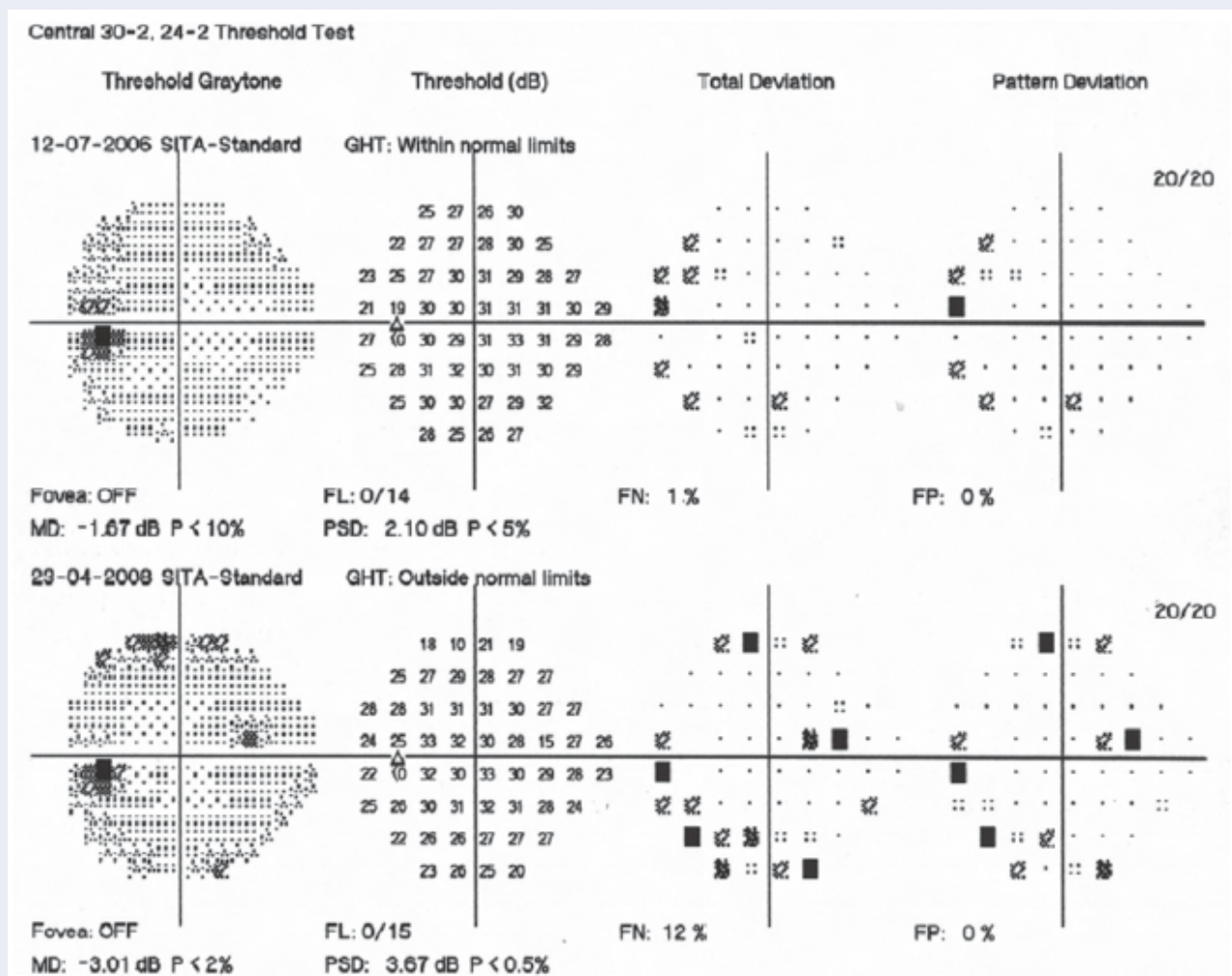
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Photograph by courtesy of Dr. Yuanbo Liang, China.

FIELD PROGRESSION

New Scotoma



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Deepening Scotoma

GPA - Baseline

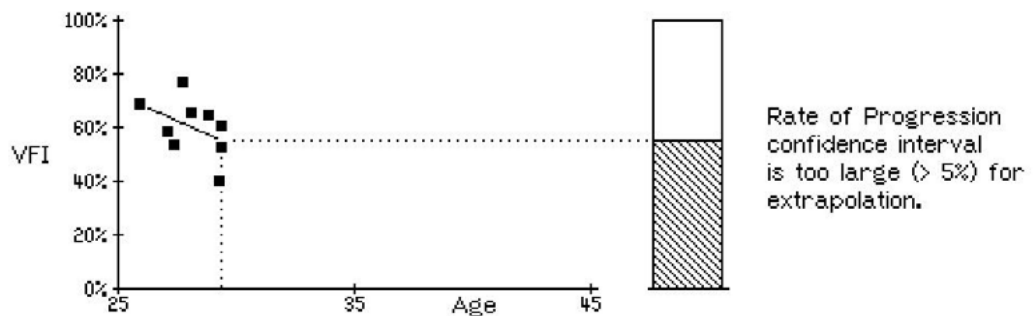
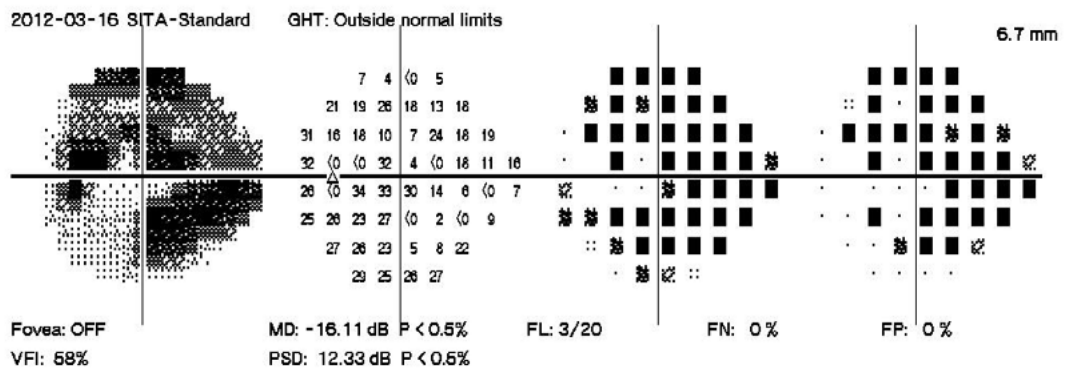
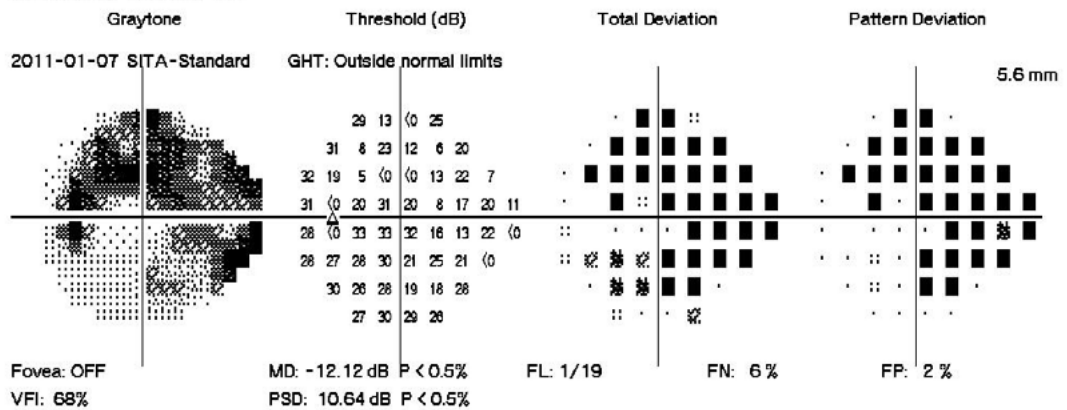
Eye: Left

Name:

DOB:

ID:

Central 24-2 Threshold Test



Rate of Progression: -4.0 ± 7.0 %/year (95% confidence)
Slope not significant

Notes:

● < 5%
● < 2%
● < 1%
■ < 0.5%

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HFA II 750-12412-4.2

Photograph by courtesy of Dr. Seok Hwan Kim, Seoul, Korea.

Deepening and Enlarging Scotoma

GPA - Baseline

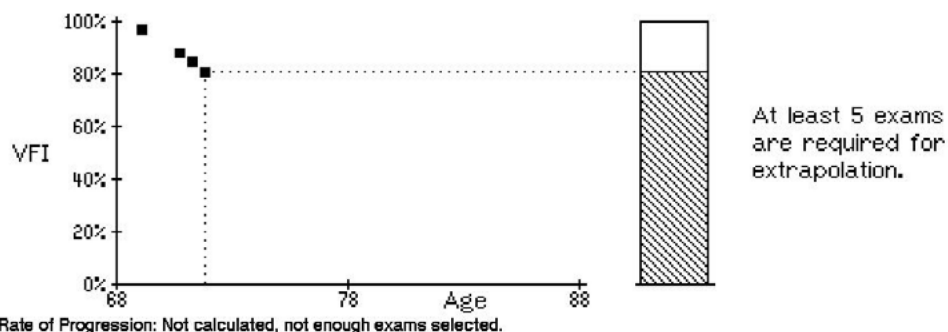
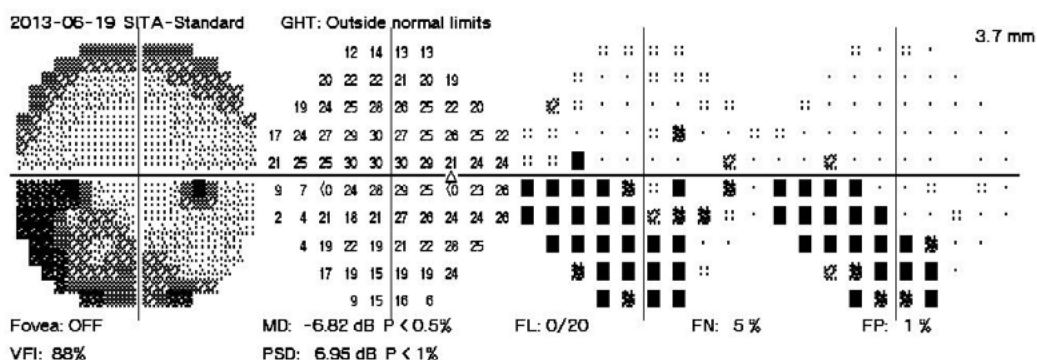
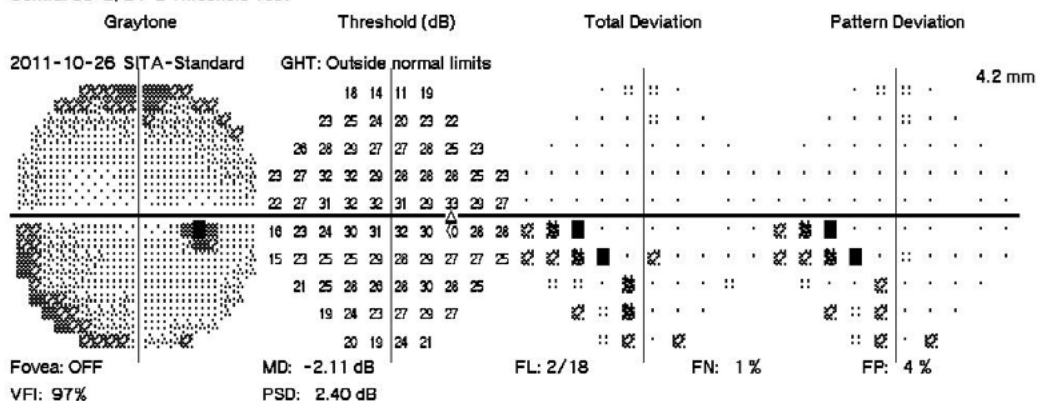
Eye: Right

Name:

DOB:

ID:

Central 30-2, 24-2 Threshold Test



Notes:

∴ < 5%

✱ < 2%

✱ < 1%

■ < 0.5%

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HFA II 750-12412-4.2

Photograph by courtesy of Dr. Seok Hwan Kim, Seoul, Korea.

Anderson-Hodapp-Parrish criteria

All criteria assume confirmation on at least one subsequent field and clinical correlation with no other explanation for deterioration.

Criteria for Minimal Abnormality in Glaucoma²⁶⁸

Three or more adjacent points in an expected location of the central 24° field (must be non-edge points in central 30° field test), on the same side of the horizontal meridian, that have $p < 5\%$ on the Pattern Deviation (PD) plot, one of which must have $p < 1\%$. Glaucoma Hemifield Test (GHT) should be outside normal limits. Corrected Pattern Standard Deviation (CPSD) with $p < 5\%$ if available.

Criteria for Judging Glaucoma Progression²⁶⁸

Point-wise comparison:

Defect deepened or enlarged if two or more points within or adjacent to an existing scotoma have worsened by at least 10 dB or three times the average of the Short-term Fluctuations, whichever is larger.

Glaucoma Change Probability

Deterioration of two or more adjacent points within or adjacent to an existing scotoma at $p < 5\%$ level, as indicated by a black triangle.

Regression analyses of the global field indices MD or VFI showed significant worsening at the 5% level.

Diagnosing and Detecting Progression on OCT

- Cirrus HD-OCT provides Guided Progression Analysis (GPA) to visualize RNFL changes and progression. A visual display of the amount and location of significant change by comparing individual pixels of the follow-up images to the same pixels of the baseline image (event-based analysis), is provided. It can also display linear regression analysis of the average, superior and inferior RNFL thickness measurements (trend-based analysis)
- Spectralis OCT provides a change report with event-based progression analysis of circumpapillary RNFL thickness profiles and trend-based progression analysis of average and sector RNFL thickness measurements. This analysis graphically shows the location and amount of significant changes in the RNFL thickness profile from baseline as a red area. The trend-based analysis plots the serial global and six sectoral maps over time to assess the rate of change using linear regression analysis and shows differences from baseline. Unlike the Cirrus OCT there is no program to classify statistically significant progression, either as event-based or trend-based analysis
- RTVue provides baseline and follow-up RNFL thickness profiles for comparison. The device also offers the Statistic Image Mapping module, which analyses global RNFL thickness and six sectoral thicknesses. Based on these measurements, a trend-based analysis is carried out to create a regression line for rate of progression
- Topcon 3D-OCT 2000 provides a linear regression analysis of average, superior and inferior RNFL thickness and graphical comparison of baseline and follow up RNFL thickness profiles
- Currently there are more studies demonstrating the usefulness of circumpapillary RNFL thickness for progression, and less on the usefulness of macular thickness/ganglion-cell layer thickness/lamina cribrosa displacement. More studies are needed for the later three parameters
- Measurement errors related to scan circle misalignment in time-domain OCT like the Stratus OCT are difficult to avoid, limiting the performance of Stratus OCT in detecting progression²⁶⁸

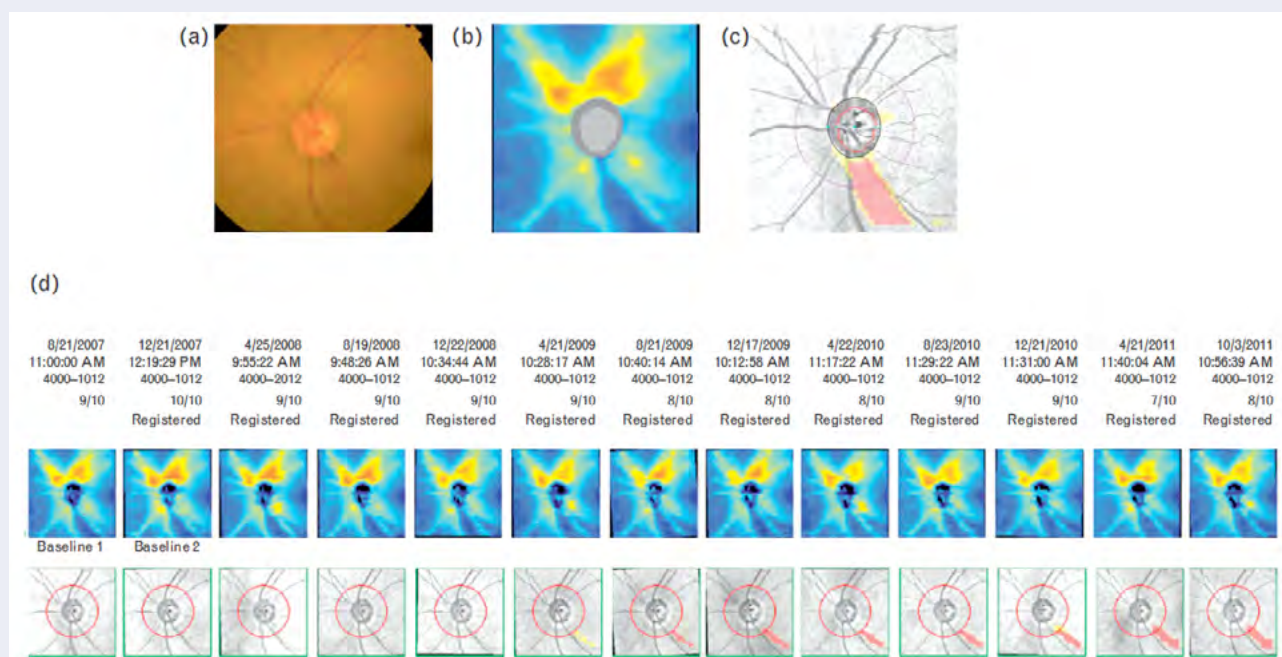


Fig. 13B.4 (a) Optic disc photograph showing inferotemporal disc haemorrhage, (b) optical coherence tomography retinal nerve fiber layer (RNFL) thickness map, (c) RNFL thickness deviation map and (d) guided progression analysis printout (GPA, Carl Zeiss Meditec, Dublin, CA, USA) of a glaucomatous eye with an inferotemporal RNFL defect. The RNFL thickness map (b) is a topology map (red signifies thick and blue signifies thin RNFL measurements) showing the RNFL distribution profile at the 6×6 mm² optic disc region. The RNFL thickness deviation map (c) indicates the pixels with abnormal RNFL thickness. A pixel would be coded in yellow or red if the RNFL measurement is below the lower 95 and 99% of the centile ranges for that particular pixel, respectively. The GPA (Carl Zeiss Meditec, Dublin, CA, USA) printout shows serial RNFL thickness maps (upper panel) and RNFL thickness change maps (lower panel) of the same eye (d). Pixels with RNFL thickness difference exceeding the test-retest variability between a follow-up and the first and the second baseline images would be coded in yellow. If the same changes are evident in a consecutive follow-up image, the pixels would be coded in red. Significant progressive loss of the RNFL is noted at the inferotemporal sector.

Adapted from reference 270

Picture courtesy from Prof. Chris Leung, The Chinese University of Hong Kong.

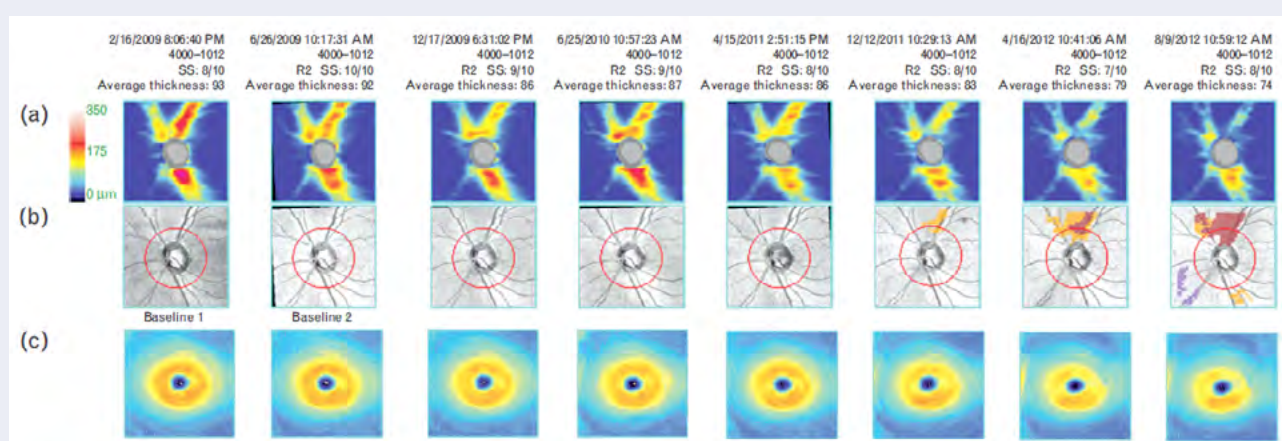


Fig. 13B.5 Progressive superior retinal nerve fibre layer (RNFL) thinning of a glaucomatous eye is detected in the RNFL thickness maps (a) and RNFL thickness change maps (b) obtained with a spectral-domain optical coherence tomography (Cirrus HD-OCT, Carl Zeiss Meditec, Dublin, CA, USA). Although the instrument software does not provide progression analysis of macular thicknesses, progressive reduction of ganglion cell inner plexiform layer (GCIPL) over the superior macula can be appreciated in the GCIPL thickness maps (c).

Picture courtesy from Prof. Chris Leung, The Chinese University of Hong Kong.

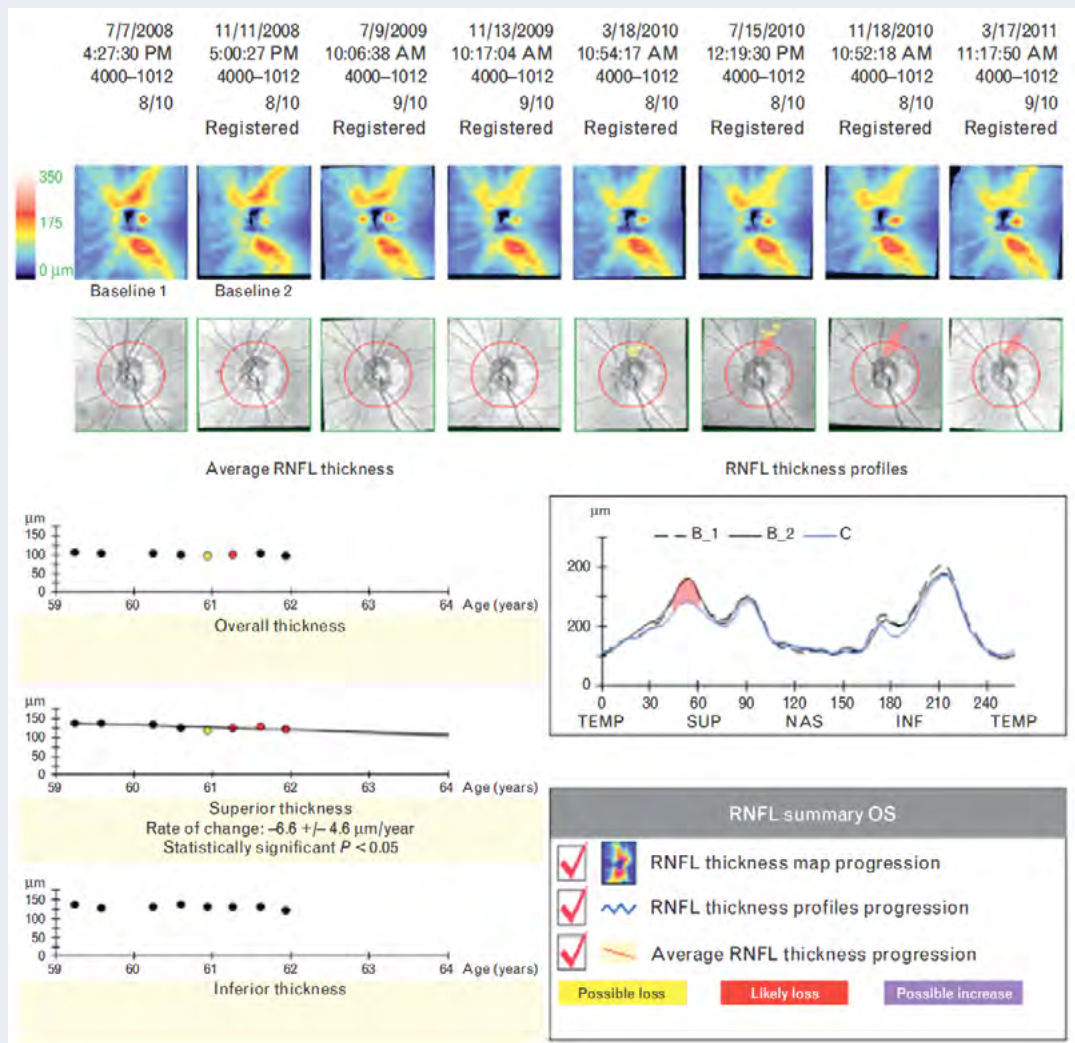


Fig. 13B.6 Guided progression analysis (GPA, Carl Zeiss Meditec, Dublin, CA, USA) printout of a normal healthy eye followed from July 2008 to March 2011. Progressive superotemporal retinal nerve fibre layer (RNFL) thinning is detected in the RNFL thickness maps, the RNFL thickness change maps and the RNFL thickness profiles during the follow-up period. There is also a significant negative trend (rate of change = $-6.6 \pm 4.6 \mu\text{m}/\text{year}$) in the analysis of superior RNFL thickness against age. However, optic disc assessment showed no signs of glaucomatous damage. The intraocular pressure was all along below 21 mmHg and visual field testing was normal. This eye shows evidence of progressive age-related RNFL thinning.

Picture courtesy from Prof. Chris Leung, The Chinese University of Hong Kong.

THE GLAUCOMA QUALITY OF LIFE-15 QUESTIONNAIRE

The Glaucoma Quality of Life-15 questionnaire: list of daily activities with the strongest relationship with visual field loss in glaucoma.*

Patient instructions: please circle the correct answer on the scale ranging from 1 to 5 where (1) stands for no difficulty, (2) for a little bit of difficulty, (3) for some difficulty, (4) for quite a lot of difficulty, and (5) for severe difficulty. If you do not perform any of the activities for other than visual reasons, please circle (0).

Does your vision give you any difficulty, even with glasses, with the following activities?

**Based on the results of this study.²⁷¹*

	None	A little bit	Some	Quite a lot	Severe	Do not perform for non-visual reasons
Reading newspapers	1	2	3	4	5	0
Walking after dark	1	2	3	4	5	0
Seeing at night	1	2	3	4	5	0
Walking on uneven ground	1	2	3	4	5	0
Adjusting to bright lights	1	2	3	4	5	0
Adjusting to dim lights	1	2	3	4	5	0
Going from light to dark room or vice versa	1	2	3	4	5	0
Tripping over objects	1	2	3	4	5	0
Seeing objects coming from the side	1	2	3	4	5	0
Crossing the road	1	2	3	4	5	0
Walking on steps/stairs	1	2	3	4	5	0
Bumping into objects	1	2	3	4	5	0
Judging distance of foot to step/curb	1	2	3	4	5	0
Finding dropped objects	1	2	3	4	5	0
Recognising faces	1	2	3	4	5	0

DEFINITION OF TERMS

Adherence

Alternative and identical word for compliance.

Angle neovascularization

New vessel formation within or on the surface of angle structures with or without formation of a fibrovascular membrane.

Anterior ischaemic optic

Optic nerve head ischaemia resulting from disturbance neuropathy in the short posterior ciliary artery circulation.

Ciliary block

An anatomical/functional abnormality at the level of the lens, zonule/anterior vitreous, and ciliary processes preventing normal aqueous circulation. May also be known as 'malignant glaucoma'.

Cup-disc ratio

The fractional decimal value obtained by dividing the cup diameter with the disc diameter. The closer the value is to 1, the worse the damage.

Double DOT

Technique for instilling eye drops: combination of 'don't open the eyelid' and 'digital occlusion of the tear duct'.

Glaucoma suspect disc

Optic nerve head appearance suggestive of glaucomatous damage.

Glaucomatous optic disc

Characteristic pattern of damage to the optic nerve neuropathy head caused by glaucoma.

Neovascular glaucoma

Glaucoma resulting from a fibrovascular membrane across the angle in response to ischaemia.

Normal tension glaucoma

Characteristic glaucomatous optic neuropathy in the presence of statistically normal intraocular pressure.

Occludable angle

Clinical term for an angle that is gonioscopically open but narrow enough to be considered at risk of closure.

Ocular hypertension

Intraocular pressure more than 2 standard deviations above the population mean with open angles, normal central corneal thickness, and no evidence of glaucomatous optic neuropathy or visual field loss.

Peripapillary atrophy

Zone of chorioretinal atrophy abutting the optic nerve head.

Peripheral anterior synechiae

Permanent adhesions between the peripheral iris and synechiae other angle structures.

Pigment dispersion

Abnormal scattering of iris pigment into the anterior segment of the eye.

Plateau iris configuration

An occludable angle in the absence of pupil block.

Plateau iris syndrome

Angle closure in the presence of a patent iridectomy/iridotomy.

Posner-Schlossman

Episodic anterior uveitis and presumed trabeculitis syndrome with secondary elevation of intraocular pressure.

Primary angle closure

Primary angle closure suspect with either statistically raised intraocular pressure, and/or peripheral anterior synechiae, or signs of trabecular damage.

Primary angle closure glaucoma

Primary angle closure with glaucomatous optic glaucoma neuropathy.

Primary angle closure suspect

An eye in which appositional contact between the suspect peripheral iris and posterior trabecular meshwork is present or considered possible. *Epidemiologically:* “an angle in which 180° to 270° of the posterior trabecular meshwork cannot be seen gonioscopically.”

Primary open angle

Chronic progressive optic neuropathy with glaucoma characteristic changes in the optic nerve head and/or visual field in the absence of primary causes.

Primary open angle glaucoma suspect

Significant risk factors for glaucoma (ocular glaucoma suspect hypertension, family history) and/or glaucoma suspect disc in the absence of frank glaucomatous optic neuropathy or visual field loss.

Pseudoexfoliation syndrome

Deposition of an abnormal fibrillo-granular protein predominantly in the anterior segment of the eye.

Secondary angle closure

Glaucomatous optic neuropathy with angle closure glaucoma and an identifiable cause.

Secondary open angle

Raised intraocular pressure in the presence of glaucoma identifiable cause(s). Without treatment, it is presumed this will cause glaucomatous optic neuropathy.

ABBREVIATIONS

5-FU	5-Fluorouracil
AC	Angle closure
ACD	Anterior chamber depth
ACE	Angiotensin-converting enzyme
ACG	Angle closure glaucoma
AGIS	Advanced Glaucoma Intervention Study
ALPI	Argon laser peripheral iridoplasty
ALS	Argon laser suture lysis
ALT	Argon laser trabeculoplasty
APGS	Asian Pacific Glaucoma Society
bd	Twice daily
CAC	Chronic angle closure
CAI	Carbonic anhydrase inhibitor
CCB	Calcium channel blocker
CCT	Central corneal thickness
CDR	Cup-disc ratio
CI	Confidence interval
CIGTS	Collaborative Initial Glaucoma Treatment Study
CNS	Central nervous system
COPD	Chronic obstructive pulmonary disease
CVA	Cerebrovascular accident
DLT	Diode laser trabeculoplasty
ECCE	Extracapsular cataract extraction
EMGT	Early Manifest Glaucoma Trial
FAQs	Frequently asked questions
FDA	Food and Drug Administration
GAT	Goldmann applanation tonometry
GDx	Scanning laser polarimetry
GI	Gastrointestinal
GON	Glaucomatous optic neuropathy
GPA	Glaucoma progression analysis
HRT	Heidelberg Retinal Tomograph (a type of Confocal scanning laser ophthalmoscope).
ICE	Irido-corneal endothelial
IOL	Intraocular lens
IOP	Intraocular pressure

LASEK	Laser-assisted subepithelial keratectomy
LASIK	Laser in situ keratomileusis
LPI	Laser peripheral iridotomy
MAOI	Monoamine oxidase inhibitors
MMC	Mitomycin C
NA	Not applicable
Nd:YAG	Neodymium yttrium aluminum garnet
NMDA	N-methyl-D-aspartate
NTG	Normal tension glaucoma
OAG	Open angle glaucoma
OCT	Optical coherence tomography
OH	Ocular hypertension
OHTS	Ocular Hypertension Treatment Study
PAC	Primary angle closure
PACG	Primary angle closure glaucoma
PACS	Primary angle closure suspect
PAS	Peripheral anterior synechiae
PGA	Prostaglandin analogue
PI	Peripheral iridotomy
POAG	Primary open angle glaucoma
PPA	Peripapillary atrophy
PPS	Peripheral posterior synechiae
PRK	Photorefractive keratectomy
PSD	Pattern standard deviation
PXF	Pseudoexfoliation
qid	4 times daily
QOL	Quality of life
RNFL	Retinal nerve fibre layer
SD	Standard deviation
SEAGIG	South East Asia Glaucoma Interest Group (now AGPS)
SITA	Swedish Interactive Thresholding Algorithm
SLT	Selective laser trabeculoplasty
tds	3 times daily
TM	Trabecular meshwork
VF	Visual field
WGA	World Glaucoma Association
YAG	Yttrium aluminum garnet

CONFLICT OF INTEREST

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Nothing to disclose

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Tin Aung

Alcon, Allergan, Carl Zeiss Meditec, Roche, Santen: consultant, lecture fees/travel, research support; Ellex, Ocular Therapeutics: research support; Pfizer: consultant, lecture fees/travel; Quark: consultant, research support; Tomey: lecture fees/travel, research support

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Alcon, Allergan, AMO, Santen: lecture fees

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Ivantis: Grant/Research support; Allergan, Ellex, Alcon: employment/honoraria/consulting fees/travel expenses; Allergan: membership on an advisory panel, standing committee, or board of directors

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NOTES

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Your notes

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