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MARCH 2021

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Cover: 'Three-mirror gonio'
National Professional Services Advisor Sophie Koh asks: is this the most underused tool in optometry?
Image by Karen Wilson Photography

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1. Lemp, M.A., Crews, L.A., Bron, A.J., Foulks, G.N. and Sullivan, B.D., 2012. Distribution of aqueous-deficient and evaporative dry eye in a clinic-based patient cohort: a retrospective study. Cornea, 31(5), pp.472-478.

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The glaucoma patient journey

A note from Annie Gibbins
Chief Executive Officer, Glaucoma Australia

Just a few years ago, a glaucoma diagnosis was met with fear and trepidation. Each patient would remember a parent, grandparent or neighbour afflicted by the insidious disease that stole their sight without notice and worsened their quality of life in the process.

Considering that the majority of glaucoma patients have asymptomatic vision loss, which progresses over an extended period of time, our immediate challenge is to create an eye-health-awareness culture that drives people over the age of 50 to get tested for glaucoma regularly by an optometrist.

Glaucoma Australia's 2021 eye health awareness campaign is called 'Treat Your Eyes.' It's designed to prompt Australians to value their eyes and treat them to good health so they can save their sight well into the future. Our collaboration with Optometry Australia will help us dramatically extend our reach in driving those at risk to get tested.

We know glaucoma is strongly genetic, with first-degree relatives having an increased risk of developing glaucoma, a risk that only increases if their direct relative has advanced glaucoma.[1]

To address this, Glaucoma Australia has developed a new family-focused campaign 'It begins with you' that encourages those with glaucoma to tell their first-degree relatives to get tested for glaucoma from the earlier age of 40 due to their genetic predisposition. As family history is both a strong indicator of risk, and one that can be identified without the need for medical testing, this is an area of great opportunity to improve early detection rates.

Today, the diagnosis of glaucoma still brings with it varying levels of shock and anxiety, however I am pleased to hear (and share) positive patient stories on a regular basis; each brings tremendous hope.

> *I am very grateful that my optometrist and I kept watch on my eyes when I was aged in my 50s, so changes were detected as early as possible.* — Valda

> *The deterioration of my sight due to glaucoma halted soon after starting the drops, and I am no longer anxious about my glaucoma.* — Ross

> *While driving to work every day I would pass a huge billboard saying "Have you checked your eyesight lately?" After a month of reading it, I decided to go to the optometrist. It was not what I had expected. I was told I had eye pressure of 18 in one eye and 30 in the other. Getting tested saved my sight!* — Saskia

While the challenges of 2020 were stark, the detect-and-defeat strategy championed by Glaucoma Australia continued to show strong impact as it scaled to support more than 20,000 patients. With the average age of patient referral to Glaucoma Australia now 60-69, communications via the website, social media and electronic messaging have all been enhanced and integrated with the patient support pathway. Of the 8,000+ patients actively engaged in the patient support journey, 90 per cent were referred by their optometrist and are benefiting from the broad range of support services provided.

A recent patient survey conducted by Glaucoma Australia revealed that 92 per cent frequently/always attend their glaucoma appointments; 87 per cent state they have not missed their prescribed glaucoma treatment in the previous two weeks; 97 per cent felt their glaucoma knowledge was average-excellent; 15 per cent stated they felt anxious about their glaucoma and 92 per cent had told their family members to get tested by an optometrist.

While sight-saving interventions are readily available, they are only effective with early detection, consistent follow-up and treatment adherence. Our entry into a new era of collaboration that encourages education and support gives hope that Australia will one day be free of glaucoma blindness.

1. Glaucoma Australia [Internet]. Sydney: Glaucoma Australia TARRGET Report 2020 [cited 2021 Jan 18]. The Targeting at Risk Relatives of Glaucoma patients for Early Diagnosis and Treatment (TARRGET) study. Available from: https://glaucoma.org.au/news-details/news/glaucoma-australia-tarrget-report-2020

Annie Gibbins
Chief Executive Officer,
Glaucoma Australia

Myopia and glaucoma

Understanding the pathophysiology and limitations to current technology for myopic glaucoma

FEATURE ARTICLE

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Highly myopic nerves typically possess similar characteristics as glaucomatous nerves in their appearance, making it difficult to distinguish between the two. This limitation is becoming more worrisome due to the potential for irreversible vision loss from glaucoma and the increased prevalence of myopia in the general population today.

A study by Pan et al. identified high myopia (> -5 D) as a risk factor for the development of primary open-angle glaucoma, specifically by six folds.[1] Due to the increasing rate of co-morbidity of high myopia and glaucoma, clinicians are looking for ways to better manage these patients given the challenges of clinical assessment.

Highly-myopic versus glaucomatous nerves are difficult to distinguish for multiple reasons. Compared to normal, highly-myopic nerves are typically larger with a corresponding larger cup-to-disc ratio, a reduced spatial and colour contrast between the healthy rim tissue and the optic cup, and an associated area of parapapillary atrophy that resembles glaucoma-related histological beta zone. These clinical features may confound accurate assessment for detection and determination for progression of glaucoma. Furthermore, the rotation of the optic disc and oblique insertion of the nerve that are sometimes present in high myopia can further complicate clinical assessment.

Given the anatomical features of highly myopic nerves just described, ancillary testing such as visual field and retinal nerve fibre layer (RNFL) assessment through optical coherence tomography (OCT) becomes less reliable. Thus, patients with high myopia must be carefully and regularly examined to prevent oversight of co-existing glaucoma. A cohesive approach using multiple clinical tools

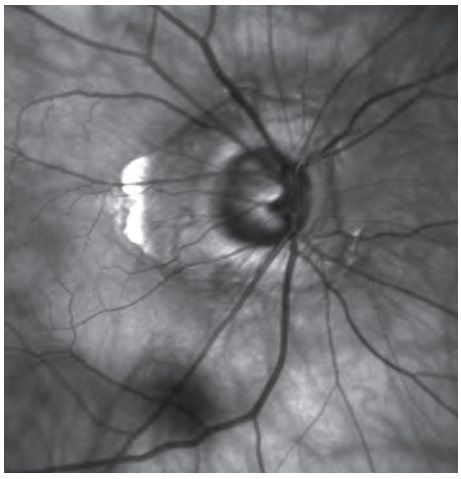

Figure 1.
Optic nerve OD is large with corresponding 0.75 round cup-to-disc ratio. Thinnest at superior temporal rim tissue, but no apparent notching. Extensive peripapillary atrophy 360 degrees, worse temporally. Inferior shadow from vitreal floater, not clinically significant.

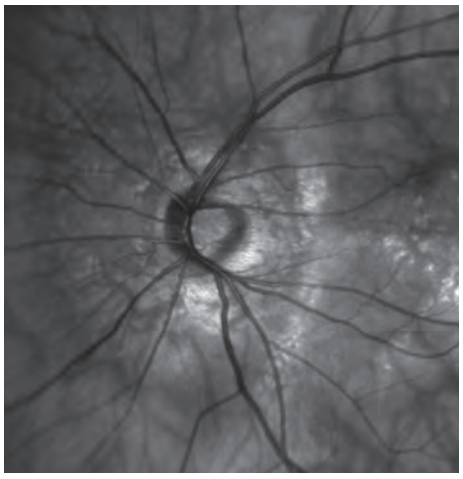

Figure 2.
Optic nerve OS is large with corresponding 0.75 round cup-to-disc ratio. Nerve size OS is slightly smaller than OD. Thinnest at superior and inferior rim tissues, but no apparent notching. Moderate peripapillary atrophy 360 degrees.

to assess both physiological and functional changes is necessary to distinguish myopic versus glaucomatous pathology.

Case history and examination

A 79-year-old Caucasian male presented for a routine eye exam without visual complaints. His ocular history included degenerative myopia OU, pseudophakia OU, posterior vitreous detachment OU, and lattice degeneration OU. Prior to cataract extractions, the patient's myopia prescription was OD -14.00 DS and OS -17.00 DS, though his vision was now corrected through posterior chamber intraocular lens OU.

His medical history was significant for neurocognitive disorder, hyperlipidemia, migraine headaches, obstructive sleep apnoea, and depression disorder. At the time of the exam, the patient's active medications included donepezil Hcl 5 mg, sumatriptan succinate 50 mg, atorvastatin, calcium 80 mg, and riboflavin 100 mg. It is important to note that the patient was allergic to penicillin and amoxicillin, where adverse reactions included trouble breathing and rashes, respectively.

Pertinent exam findings were as follows:

- Best corrected visual acuity: OD 20/20, OS 20/20
- Intraocular pressures (mmHg): OD 15, OS 16 using Goldmann applanation tonometry
- Pupils: Equal, round, and reactive to light; no afferent pupillary defect
- Extraocular muscles: Full and unrestricted OU
- Pachymetry (µm): OD 545, OS 541
- Gonioscopy: OU most posterior structure observed was ciliary body in all four quadrants, trace pigment in all quadrants. No evidence of peripheral anterior synechia, angle recession, or neovascularisation of the angles/iris.

Slitlamp exam:

- Lids and lashes: OU 1+ MGD, 1+ blepharitis superior
- Conjunctiva/Sclera: OU normal
- Cornea: OU 1+ arcus 360, incision scars temporal
- Anterior chamber: OU deep and quiet
- Iris: OD transillumination defect 4:00 and 6:00, OS transillumination defect 3:00 and 6:00
- Lens: OU PCIOL well centred, (-) PCO Vitreous: OU PVD, Weiss ring noted

Dilated ocular fundus exam:

- Optic nerve: OD cup-to-disc ration (CDR) 0.75 with large area of peripapillary atrophy, OS CDR 0.75 with peripapillary atrophy, smaller nerve size than OD (Figures 1-4)
- Maculae: OD flat with uniform pigmentation, OS posterior staphyloma with foveal pigment changes
- Vessels: OU normal calibre
- Posterior pole: OU scattered areas of atrophy and pigment clumping
- Periphery: OU pigmentation clumping inferiorly

Discussion

Although the pathophysiologic connection between myopia and glaucoma has not been fully understood, it has been widely accepted that structural changes from axial elongation increases the susceptibility of developing glaucoma. The Beijing Eye Study showed a significant steep increase in glaucoma prevalence for axial lengths of 26.5 mm or higher, corresponding to a myopic refractive error of about -8.00 dioptres and above.[2] The increase of axial length causes stretching of the lamina cribosa and thinning of the peripapillary scleral flange. Myopic enlargement of the globe can lead to a lengthening of the scleral flange up to 10 times and thins the structure to as little as 10 percent of its original thickness.[3]

These structural changes lead to weakening of the biomechanical support at the level of the lamina cribosa. The structural architecture is further compromised by the associated enlargement of the optic disc, which is the lamina cribosa itself. Because the volume of the lamina cribosa remains unaffected, its enlargement leads to thinning and morphometric alterations within the structure.[4] Defects in the lamina cribosa structure may potentially induce shearing effects on the lamina cribosa pores and put mechanical strain on retinal ganglion cell axons passing through them.[5] The blood supply for the retinal ganglion cells is also compromised, because their vascular network also travels through the lamina cribosa.

In addition to structural loss, lamina cribosa thinning decreases the

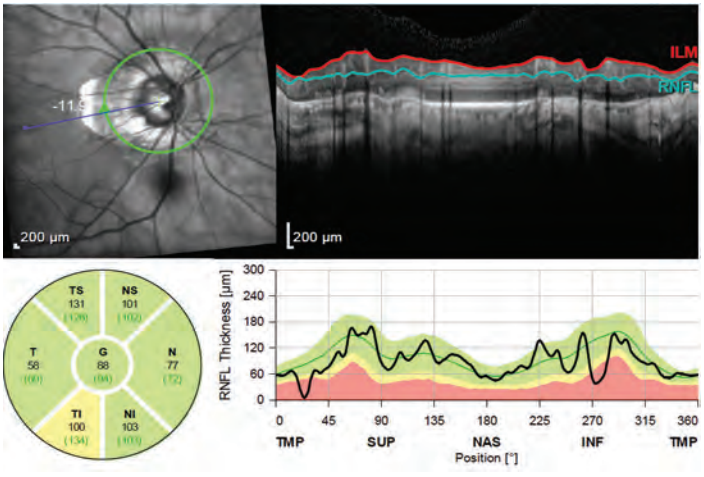

Figure 3.
Retinal nerve fibre layer on OCT OD shows borderline thinning at the inferior temporal sector, remaining sectors are within statistical norm. Mapping of the retinal nerve fibre layer may be confounded by the surrounding peripapillary atrophy, which can potentially affect the repeatability of subsequent scans impairing the ability to assess progression over time.

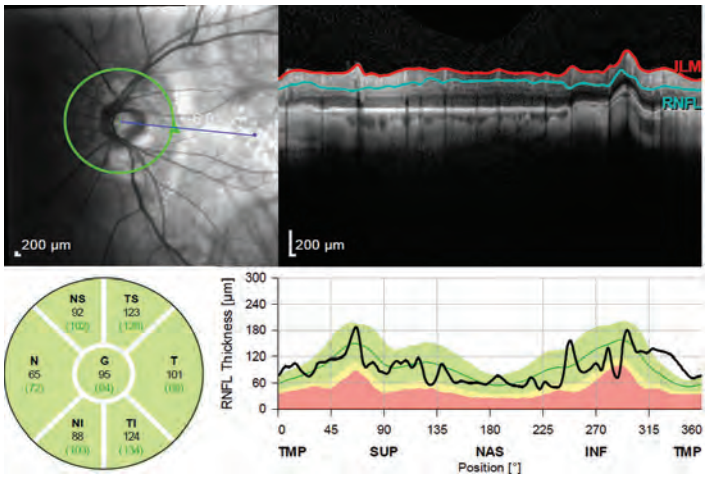

Figure 4.
Retinal nerve fibre layer on OCT OS shows all sectors are within statistical norm. However, there is inaccurate mapping of RNFL inferior-temporal to temporal region. Overall mapping of the retinal nerve fibre layer may be confounded by the surrounding peripapillary atrophy, which can potentially affect the repeatability of subsequent scans impairing the ability to assess progression over time.

distance between the intraocular compartment and the retrobulbar compartment, resulting in the steepening of the translaminar cribosa pressure gradient.[6] This increase in the gradient between intraocular pressure and orbital cerebrospinal fluid pressure exerts more force on the optic nerve fibres as they run through the lamina cribosa potentially leading to irreversible damage.

Clinical detection of glaucomatous change becomes increasingly challenging as structures of and around the lamina cribosa are altered. Axial elongation creates an enlargement of the parapapillary gamma zone in high myopia, which can be difficult to distinguish from beta zone with peripapillary atrophy in glaucoma.

Assessment of the neuroretinal rim tissue has been one of the primary ways for glaucoma evaluation. However, the spatial and colour contrast between the neuroretinal rim tissue and the optic cup are reduced in highly myopic eyes, making it challenging to judge true cupping of the nerve. The bright underground in the parapapillary gamma zone further complicates ophthalmoscopy assessment.

OCT assessment

In recent years, OCT has been utilised to measure neuroretinal rim tissue and assess peripapillary RNFL thickness. The parameter for OCT rim tissue measurement is defined by the minimum distance between the Bruch's membrane opening and the internal limiting membrane. For myopic eyes, Bruch's membrane is often shifted away from the optic disc border in axial elongation, making OCT ill-suited for neuroretinal rim assessment.

OCT assessment of the RNFL is also affected by the process of axial elongation, but it can still provide valuable information if analysed correctly. Through axial elongation, the distance between the fovea and the optic disc is increased, causing the superotemporal and inferotemporal RNFL bundles to stretch closer together temporally.[7] Therefore, temporalisation of the RNFL bundles may confound OCT RNFL reading and display falsely-thinned superior and inferior sectors, which are also common areas for glaucomatous thinning. Thus, it is important to recognise this RNFL peak shift in myopic eyes, particularly when paired with abnormally thickened RNFL temporally.

Ganglion cell analysis

Ganglion cell analysis on OCT at the macula has been increasingly helpful to evaluate glaucomatous damage. However, this method is often unreliable in highly myopic eyes due to irregularities at the macula such as atrophic thinning or cystoid thickening with retinoschisis. If macular evaluation confirms normal integrity of all retinal layers, OCT ganglion cell analysis should be incorporated into the assessment formulary.

Visual fields

Visual field evaluation provides valuable visual information that is most applicable and relevant to the patient's functionality. Due to the subjective nature of this test, there is often test-retest variability, as well as multiple sources of error that can affect the reliability of the results. The visual field defect patterns differ between non-myopic glaucoma versus highly-myopic glaucoma.

Due to the increased RNFL defects involving the papillomacular bundle in myopic glaucoma, early central or paracentral scotomas are more common compared to the typical Bjerrum area and nasal step defects seen in other types of glaucoma.[8] Therefore, managing myopic glaucoma should involve an updated protocol to alternate between central 24-2 and central 10-2 perimetry instead of only the central 24-2 perimetric analysis alone.

As myopic macular degeneration is also common in these patients, central visual field defects may be confounded and must be evaluated carefully. It is particularly important in these patients to monitor the trend of visual field function in conjunction to structural imaging for functional-structural agreement. Furthermore, high power trial-lens used during perimetry may cause prismatic deviation in extra-axial test points.[8] Thus, it is recommended for perimetry to be done using contact lens to avoid inducing false defects.

RNFL optical texture analysis

In addition to RNFL thickness, assessment of the RNFL texture also provides valuable information regarding the health of the RNFL itself. Normal RNFL has fine and bright striations that radiate from the optic disc, most apparent in younger individuals. The reflectance pattern seen on ophthalmoscopy or fundus photography are ways to qualitatively assess the health of the RNFL.

Recent technology allows for a quantitative assessment of RNFL health, using widefield swept source OCT RNFL optical texture analysis (ROTA).[8] ROTA has shown similar sensitivity and significantly higher specificity in diagnosing glaucoma compared to RNFL thickness and ganglion cell analyses combined.[8] Contrasting to RNFL thickness, texture analysis can be done independently without comparing to normative data. Thus, ROTA has great potential clinical application for myopic glaucoma management. Currently, ROTA is only available for research. However, with such promising results and clinical potential, ROTA programs for commercial use are soon to be available.

A different approach

High myopia may increase the risk of glaucoma development due to the anatomical alterations at the lamina cribosa and its surrounding supportive structures. The prevalence of myopic glaucoma will increase as the incidence of myopia continue to rise across the world. Thus, understanding the pathophysiology and limitations to current technology for myopic glaucoma becomes very important to properly manage these patients.

Clinical assessment on ophthalmoscopy, OCT RNFL thickness, and perimetry analyses require a different approach compared to other types of glaucoma. A new add-on program for the OCT to focus on RNFL texture analysis is a promising step forward in managing patients with myopic glaucoma. Overall, long-term trend analyses and structural-functional agreement are especially critical when managing highly myopic patients with co-existing glaucoma.

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Gonioscopy

Are you an optometrist who doesn't do gonio? Read this.

Sophie Koh
BOptom GcertOcTher LmusTCL

National Professional Services Advisor
Optometry Australia

I have to confess, at my first job as an optometrist, I didn't perform gonioscopy ('gonio') for the first few years. In my mind, it was an inconvenient technique that would only upset my appointment book; it seemed intrusive and uncomfortable for patients.

I can still recall the day I received my gonio lens as a student, alongside my retinoscope, fundus lenses, binocular-indirect head mount—all in that bemusing optometry case. It was one of the most expensive invoices I'd had to pay in my life. I couldn't fathom why this lens, the size of a 20-cent piece, cost more than my guitar, but it did dazzle like a toy kaleidoscope.

I have since learned that gonioscopy provides the clinician with a tremendous amount of information, and it can make an examination more interesting and rewarding. Admittedly, it can be awkward at first, but with a well-practised technique and a positive-mindset approach, gonioscopy proves to be an efficient procedure that is as fast as performing contact tonometry.

I thought of gonioscopy at university as a hurdle that we were required to jump over (or actually, a series of hurdles—we had to perform it at least 20 times in final year, with a supervisor sign-off) and now, as a clinical educator, I continue to see students approach this technique with hesitation and the same 'gonio-hurdle' mindset. 'Do I REALLY have to do gonio?' is often the look I get. And with the increasing availability of the anterior OCT machine, the argument is accompanied by the comment: 'but I have an anterior OCT, I don't need to do gonio.' It's something I hear often, from students as well as practising optometrists.

As a clinical procedure to inspect the anatomical structures of the anterior chamber angle (the angle), gonioscopy is the definitive test for determining angle depth, and permits the detection of anomalies otherwise unseen.[1] Anomalies such as those associated with secondary glaucoma, like pigment dispersion or peripheral anterior synechia are routinely detected in a gonio exam.[2]

So, exactly what are the barriers in real-life practice that results in this technique being under-utilised by optometrists?

I have no idea where my gonio lens is

First: where is your gonio lens? Out of sight, out of mind? Is it tucked at the back of your bottom drawer or hiding in your optometry case? Situate your lens at a visually-accessible place. And if your gonio lens requires the use of a viscous coupling solution (for example: Celluvisc), have that ready to go too.

If you're a locum optometrist, just as you would get your fundus lens and retinoscope ready to start your day at a new practice, display your gonio lens at a visually-accessible position too, and carry a few tubes of coupling solution in your optometry case as you move from practice to practice. Don't rely on all practices to have a ready supply of coupling solution for you. Generally, the four-mirror gonio can be used with or without coupling solution, whereas the three-mirror gonio requires coupling solution.[3,4]

Furthermore, if you're booking a subsequent appointment to perform a dilated fundus examination or visual field test, make a note in your patient's file so you are reminded to perform gonio at the second visit – a glaucoma work-up is incomplete without gonioscopy.[2,5]

But patients worry about the lens touching their eye

If you are happy inserting a contact lens into a patient's eye, gonio is no different. Furthermore, the patient's eye is anaesthetised.

Think in advance about how you are going to get the gonioscope onto the eye – will you instruct the patient to look up, down or straight-ahead? Prepare the slitlamp table so that your elbow is stable and the patient is comfortable. Prepare the patient with a reassuring phrase like: 'this will come close to your eye, just like a contact lens, and will feel slightly cold' so that it's not a surprise when the lens approaches. (It's also good to warn the patient that the coupling solution may run down their cheek.) Ultimately, if you're committed to doing gonio, it becomes as second-nature as inserting a contact lens.

Referral? Wait, have you done gonio?

When you refer a glaucoma suspect to an ophthalmologist, does your referral letter include gonio findings? Gonioscopy is an essential part of your glaucoma work-up.[5] Your referral letter is incomplete without gonio findings. Even if the angle seems open after Van Herick screening, you need to practice seeing plenty of normal open angles before you are comfortable picking out an abnormal or diseased one.

In order for a diagnosis of glaucoma to be made, the angle must be assessed using gonioscopy – the 'gold standard' technique.[6] Therapeutically-endorsed optometrists in Australia can independently diagnose and treat glaucoma as long as there is a referral to an ophthalmologist or ophthalmology service within four months of commencing treatment.[7]

Ultimately, if you didn't perform gonio as part of your glaucoma work-up, you should not be diagnosing or treating glaucoma.

Van Herick 1.0 and suspicious optic disc? Van Herick 1.0 and high pressures?

Do gonio. Too many optometrists only think of doing gonio if the angle seen via Van Herick screening seems narrow, for example, less than 0.3. Furthermore, gonio is not just for visualising whether the angle is open or closed. A diseased or abnormal angle is possible, even when the angle seems open or 'normal' on Van Herick screening.[5]

If there is glaucomatous-looking optic disc, wide Van Herick and history of blunt eye trauma, perform gonio on each eye and compare eyes to determine if the ciliary body band is abnormally wide in one

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eye. Angle recession glaucoma could be the etiology.

If you see signs of iris transillumination, Krukenberg's spindle or pseudoexfoliation (PXF), gonio will help you assess the angle for risk of these conditions leading to secondary glaucoma, manifesting in high or fluctuating intraocular pressures. Pigment in the trabecular meshwork, for example, is a classic sign of PXF glaucoma.[5]

For a full list of gonio indications, contraindications and situations when gonio should be repeated, please refer to Optometry Australia's Gonioscopy Clinical Note.[4]

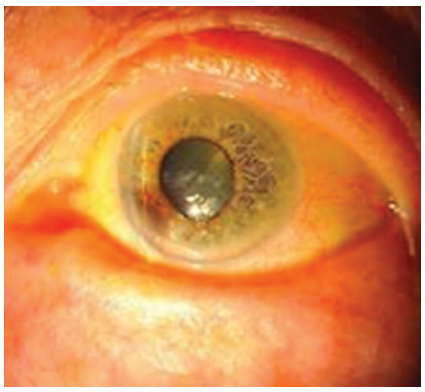


Figure 1.
An 87-year-old female patient with iris naevus

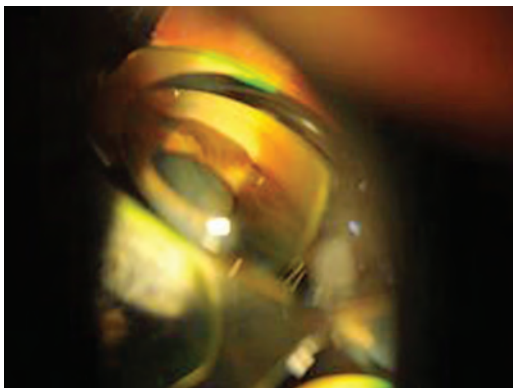


Figure 2.
Gonioscopy view of same iris naevus shows raised lesion

But I've got an anterior OCT

You may have an anterior segment OCT and use it as your non-invasive 'go-to' for determining if the angle is open or closed. However, it doesn't replace gonioscopy as the best way to view the angle.[4,6,8] Gonioscopy lets you appreciate vital characteristics you cannot fully grasp with an anterior OCT, such as pigment, peripheral anterior synechiae, new blood vessels on the iris characteristic of neovascular glaucoma and angle recession (just to name a few) which then informs subsequent management of your patient.

Furthermore, OCT also does not allow for manipulation and manual moving of the angle. Anterior OCT may be useful for visualising the iris contour and certain retroiridal pathologies but should be used only as a complementary technique to gonioscopy.[5]

Gonio is not just for glaucoma

Your gonio helps you visualise anatomical structures in the anterior chamber. For example, next time you see a suspicious iris naevus, gonio may help ascertain whether the naevus has changed over time, or is raised.

Figure 1 shows the iris naevus of an 87-year-old patient via frontal slitlamp view. Gonioscopy was subsequently performed (Figure 2) showing that the lesion was significantly raised and suspicious. The patient was subsequently referred to an ophthalmologist for opinion on the iris naevus.

Do more gonio

Gonio is underutilised in everyday optometry practice, even though, once mastered, it takes about as much time as checking someone's intraocular pressure with a Perkins or Goldmann tonometer. The patient's eye is anaesthetised. Almost all patients are comfortable with the procedure. Are you?

Optometry Australia has updated the Gonioscopy Clinical Note. For clinical pearls and expansion of this commentary, visit the 'Clinical Areas of Interest' section of Optometry Australia's website.

With more day-to-day practice viewing normal angles, your efficiency will improve and you will discover that you have been missing out on information; information that facilitates better patient management, and frankly just makes your day more interesting.

Why not reach into the back of your bottom drawer or in your optometry case this week and prepare your gonio lens for your next patient with a suspicious-looking disc and wide-open Van Herick angles? When approached with a renewed appreciation for gonio as an efficient, comfortable, essential and educative technique, you will improve your patient's quality of care and make your optometry career more rewarding.

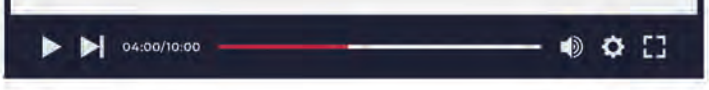
Gonio on video

The University of Iowa Carver College of Medicine's website Gonioscopy.org (www.gonioscopy.org) is dedicated to teaching gonioscopy through the use of videography. It is a resource I have found to be quite useful for introducing and educating optometrists in gonio techniques.

The videos help troubleshoot and explain various four-mirror and three-mirror techniques. It helps you break free from the preconceived idea that gonioscopy is hard, time-consuming and uninteresting.

The site makes gonioscopy seem almost effortless and it highlights the importance of gonioscopy as part of a great eye examination.

Highly recommended.



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Primary open-angle glaucoma

Optometry and pre- and post-op management

The treatment paradigm for glaucoma is constantly evolving with new therapies and new ways of using old therapies. Medical therapy alone is still appropriate for the majority of primary open-angle glaucoma (POAG) patients. However, for patients who are unable to tolerate medication, who no longer respond to medication alone or who prefer to be drop independent, there is now a plethora of alternative options.

Regardless of the treatment approach, I believe seamless co-management by a united ophthalmologist/optometrist team can positively influence the patient's visual outcomes. In this article, I explore the major role that optometrists can play in co-managing non-medical glaucoma.

Key milestones for optometric co-management of non-medical glaucoma

1. Identifying and recommending the appropriate therapy for the patient

Patients trust their optometrist and value their opinion, so optometrists can guide their patients towards alternative glaucoma therapy that the patient may be unaware of or perhaps afraid to consider. For example, I had an optometrist refer a patient for a second opinion about the suitability of selective laser trabeculoplasty (SLT) because that patient was struggling with medication side-effects. Another example is patients with concomitant glaucoma and cataract referred for combined

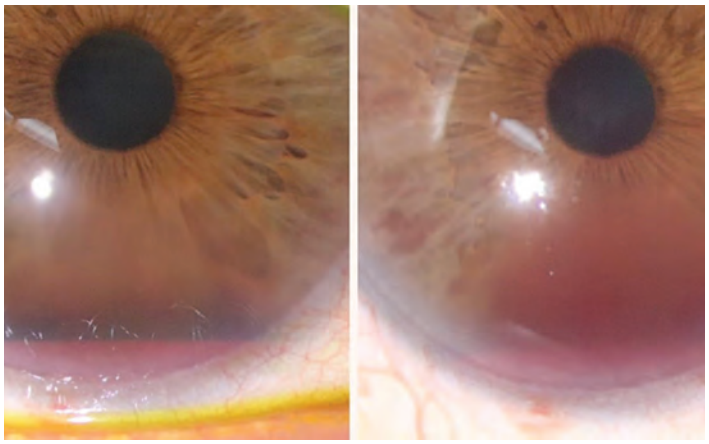

Figure 1.
Left: A post-operative hyphaema that has settled to the inferior angle. Right: With eye movement, the blood scatters in a 'snow globe effect' causing 'sudden' blurring of vision

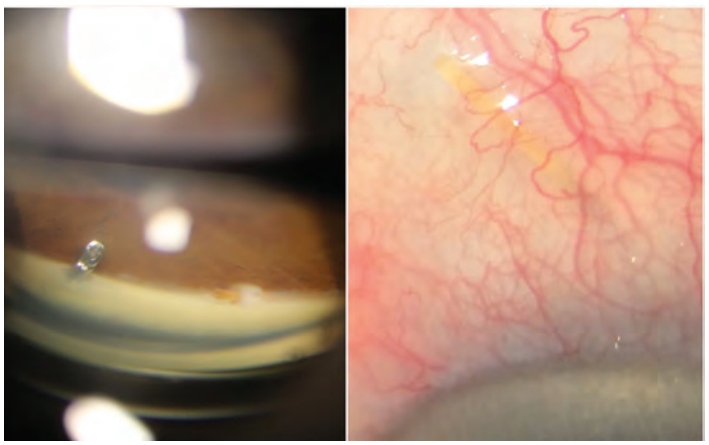

Figure 2.
Left: An Ex-PRESS implant (silver) next to a XEN implant (yellow) as seen using a gonioscopy lens. Right: A yellow XEN implant under the upper eyelid under the conjunctiva

phacoemulsification-MIGS (minimally invasive glaucoma surgery).

2. Pre-operative counselling of the patient

Glaucoma is not an intuitive disease from a patient's perspective – they are asymptomatic, drops make them feel worse and surgery does not improve their vision. At this critical time, the optometrist can provide reassurance and manage patient expectations by explaining the goals of surgery and any associated risks.

3. Post-operative management of the patient

Patients often go to the optometrist if there is a problem after glaucoma surgery, such as pain, vision loss or irritation from sutures. In these situations, the patient should be triaged and either reassured, treated or referred as urgently as appropriate.

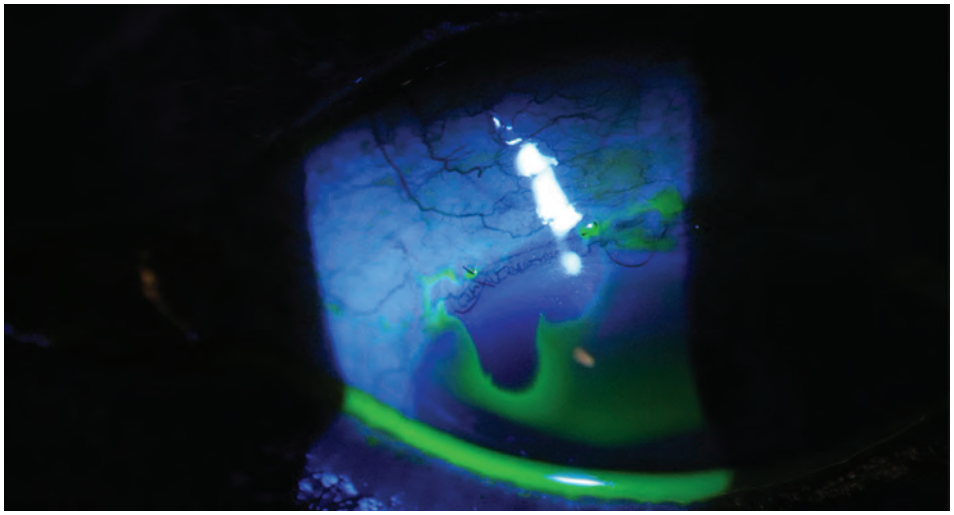

Figure 3.
A conjunctival wound leak with a flat bleb a few days after trabeculectomy surgery

Surgical options for POAG

Laser

SLT is commonly performed in POAG.[1,2] Patients need counselling that it is not a cure and monitoring with regular visual field and optic nerve assessments is still required, even if the IOP seems controlled. SLT is safe and effective in around 80 per cent of patients and lasts a few years, after which it can be repeated.[1,2] Despite this, I am always surprised by how many patients decline laser treatment, either as primary therapy or an adjuvant. Part of this is driven by fear of the unknown and also by an unfounded fear of adverse events. I think both optometrists and ophthalmologists can do more to promote this therapy.

If patients present with symptoms of post-laser inflammation, then a short course of steroids is sufficient.

Following SLT, I warn patients that they should expect to feel a little ache, photophobia and blurring of vision for a day or two. Several clinical trials have shown mixed results when using steroids, NSAIDs or a placebo after SLT.[2,3] In my practice, I do not give any post-laser anti-inflammatory medication. If patients present with symptoms of post-laser inflammation, then a short course of steroids is sufficient (for example, dexamethasone QID for a week). IOP spikes are common after laser,[1,2] so I give an alpha-agonist drop before and after in anticipation. More severe side-effects like hyphaema and cystoid macular oedema are rare.[1,4]

Angle-based surgery

Operations involve dilating (ABiC) or scaffolding (Hydrus) Schlemm's Canal or bypassing the trabecular meshwork (iStent and Hydrus) are truly minimally-invasive, with an excellent safety profile and are commonly combined with cataract surgery (although can be used independently).[5]

The pressure-lowering effect is less than traditional filtration surgery,[5] making them suitable for milder POAG with target pressures closer to 18 mmHg. A key demographic is the cataract patient with mild open-angle glaucoma on one (or two) glaucoma medications, as they have the greatest chance of becoming drop independent. Long-term glaucoma monitoring is still required.

Post-operative care is very similar to standard cataract surgery. I use the same combination, frequency and duration of steroid and antibiotic drops. Blood reflux from the episcleral vascular system often occurs when Schlemm's canal is penetrated and is actually a positive location sign. Overfilling the eye will help tamponade the flow. Therefore, a small (or large) hyphaema can be expected on day one after surgery, which may cloud the vision. Post-operative pressure spikes can be seen and respond well to aqueous suppressants (for example, carbonic anhydrase inhibitors).[4]

Patients who experience fluctuating blurring of vision caused by the 'snow globe effect' (where head movement stirs up the blood cells) should be reassured and followed up closely (Figure 1).

Endophthalmitis is rare[5] but needs to be ruled out in patients presenting with a painful, red eye three to four days after any intraocular surgery. The implants themselves do not seem to cause any long-term problems sitting in the angle. They are usually inserted in the nasal angle and can be viewed with a gonioscopy lens.

Subconjunctival-based surgery

The XEN implant is a tiny, gelatin tube inserted between the anterior chamber and subconjunctival space, just behind the supranasal limbus. It is a bleb-forming operation, so an elevated, blister-like dome is seen when the upper eyelid is lifted. The yellow implant is visible through the transparent conjunctiva (Figure 2). Any aqueous draining into the bleb is slowly absorbed into the surrounding tissue. It is much less invasive than traditional filtration surgery, with a shorter recovery time, but at the expense of efficacy.[5,6]

The optometrist can provide reassurance and manage patient expectations by explaining the goals of surgery and any associated risks.

Trabeculectomy remains the operation of choice for patients who need a low target pressure of 12 mmHg or less.[6] Again, this operation is bleb forming, but the fluid drains out through a dissected scleral trap door. Multiple sutures are used on the trap door and the conjunctiva, so irritation is a common complaint. Complications include hypotony (IOP < 5 mmHg) from over filtration or wound leaks (Figure 3), which can lead to a shallow or collapsed anterior chamber, choroidal effusion, hypotonous maculopathy and suprachoroidal haemorrhage.[5,7] Hypotony is bad news and needs careful management. Atropine 1% drops and night-time eye shield protection can assist recovery, but revision surgery may be necessary in severe cases.

Patients with a bleb and a painful red eye should be referred urgently.[4]

Bleb-based operations can fail due to excessive scarring restricting the outflow. Scarring usually occurs within the first four-to-eight weeks and patients are typically reviewed every one-to-two weeks during this period, which is much more frequent than other glaucoma operations.

Mitomycin C is an antimetabolite that is almost always used during surgery to prevent this scarring. However, mitomycin C has its own risks, affecting corneal stem cells and increasing the risk of thin-walled cystic blebs (Figure 4) and bleb infections.[8] Patients with a bleb and a painful red eye should be referred urgently.[4]

The Baerveldt and Molteno drainage tubes have a large flexible plate that sits between two rectus muscles and a relatively large tube connecting the plate to the anterior chamber or sulcus. The tube is usually covered by a white doner scleral patch graft, under the conjunctiva. Fluorescein dye will show up any defects or device exposure.

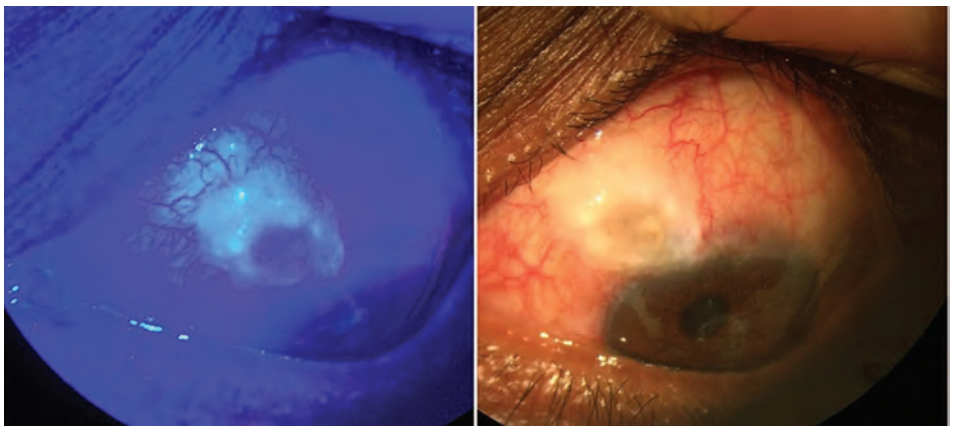

Figure 4.
A thin-walled, leaking cystic bleb from a mitomycin C trabeculectomy. This is a long-term complication, and the patient is at risk of bleb-related infections. Antibiotic cover and revision surgery are required

Suprachoroidal space

The CyPass was the only suprachoroidal device made available in Australia. It was withdrawn from the market due to concerns about its effects on the corneal endothelium.[9] Patients who have had a CyPass will be monitored by their surgeon. Removal is not advised unless endothelial cell loss is evident.[9]

Successful collaborative care of patients undergoing glaucoma surgery hinges on good communication

Ciliary-body approach

Laser ablation of the ciliary body to reduce aqueous production can occur through the sclera (transscleral cyclodiode photocoagulation/TCP or micropulse diode laser) or under direct camera visualisation (endoscopic cyclophotocoagulation/ECP). Aggressive laser application can cause severe inflammation, pain and even hypotony. The modern approach uses gentle power with frequent applications, resulting in improved outcomes.[10] Patients should be warned about pain and simple analgesia advised. Frequent steroids will help control the associated inflammation.

Successful collaborative care of patients undergoing glaucoma surgery hinges on good communication, be it planned IOP checks, incidental findings, or emergency presentations. Key signs to look for include wound leaks (Figure 3), exposure of devices, intraocular infections, loose sutures, IOP spikes and hypotony. It would be entirely reasonable to have a low threshold to phone or refer back to the operating surgeon.

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About the author

Dr Jason Cheng is a fellowship-trained glaucoma specialist who performs complex glaucoma surgery, including trabeculectomy, tube implant, angle surgery and MIGS. He is a highly-skilled cataract surgeon and frequently combines cataract and glaucoma surgery.

Dr Cheng practises at Vision Eye Institute, Hurstville, NSW.

CLINICAL RESOURCE

Glaucoma clinical pearls

An overview of Optometry Australia's new glaucoma clinical practice guide

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In 2020 alone, there were almost 4,000 peer-reviewed articles on glaucoma listed on PubMed – a staggering number and an indicator of how quickly the field evolves over time. In March 2019, a diverse group of clinicians and academics with an interest in glaucoma care convened to review the glaucoma literature to date for Optometry Australia's glaucoma working group. The group aimed to provide an updated, practical guide for clinicians to implement the most recent evidence into their practice to better care for their patients with glaucoma.

Major differences to the 2016 guidelines

Since the publication of the last set of Optometry Australia clinical guidelines in 2016, there has been a number of changes in our understanding of glaucoma clinical care. Some of the key changes are outlined in Table 1.

The following clinical pearls expand further on the key changes from Table 1.

Top five clinical pearls

1. Diagnosis and risk stratification in glaucoma is complex

Unlike diseases of the eye like macular degeneration and diabetic retinopathy, there is no single 'lesion' within the eye that defines glaucoma like drusen or haemorrhages. Instead, diagnosing glaucoma requires the integration of clinical findings including careful examination of the optic nerve head and visual fields for characteristic, concordant signs.[1,2] The combinatory process also includes the consideration of risk factors for glaucoma, which may lead a clinician to lean towards or away from glaucoma.

Several risk factors have been identified to contribute to the development of glaucoma. In particular, family history is a strong risk factor.[3] Family members of patients with glaucoma should undergo a comprehensive glaucoma examination as well. Other ocular (such as high intraocular pressure and myopia) and systemic (such as diabetes, hypertension, migraines and sleep apnoea) risk factors may contribute to an increased risk, but there is debate about the strength of these factors and their interactions with each other.[4,5] However, it is also important to remember that there are many cases where patients do not have a family history, or any other significant risk factors – that is to say their glaucoma may be 'sporadic.'

Clinical pearl: Perform a comprehensive examination of the disc on all patients, followed by the application of risk factors to guide review and management.

Less emphasis	More emphasis
On quantitative 'cut-off' values, e.g. cup-disc ratio, intraocular pressure, an absolute 'number' of signs of glaucoma present	Concordance of structure (integrity of neural tissue) and function (retinal nerve fibre layer bundle visual field defects)
Prescriptive intraocular pressure reduction treatment targets and mandated follow-up plans	Individualising the treatment plan based on patient characteristics (e.g. demographics) and disease trajectory
'Soft' signs of glaucoma – disc haemorrhages, peripapillary atrophy, and other risk factors – as diagnostic markers of glaucoma	High-quality examination techniques and data-driven diagnoses (e.g. more follow-up examinations, intraocular pressure profiling)
Glaucoma as the foremost diagnosis of optic nerve head disease	Glaucoma is a diagnosis of exclusion, and clinicians need to rule out all other possible optic nerve head or neurological conditions

Table 1.
Some major changes in glaucoma clinical care reflected in the updated Clinical Practice Guide

Differential diagnoses	Key relevant signs
Ischaemic optic neuropathy or retinal nerve fibre layer loss	Disc pallor (rather than cupping) Vascular anomalies (e.g. attenuation, loss of perfusion, haemorrhaging, cotton wool spots)
Trans-synaptic retrograde degeneration	Disc pallor (rather than cupping) Vertical or quadratic neural and/or visual field loss
Consecutive optic atrophy	Retinal anomalies (e.g. retinitis pigmentosa, toxoplasmosis scar, photocoagulation scars)
Optic atrophy due to disc swelling (e.g. papilloedema, optic neuritis, optic nerve head drusen)	Blurry disc margins Small and shallow cup Diffuse nerve loss and non-specific visual field defects
Myopic optic neuropathy	'Myopic' disc configuration (e.g. tilt, torsion, extensive peripapillary atrophy) Typically non-progressive Other myopic retinal signs (e.g. tessellation of the fundus, myopic maculopathy, peripheral retinal degenerations)

Table 2.
Some examples of commonly seen differential diagnoses for consideration in optometric practice

2. Primary open-angle glaucoma is a diagnosis of exclusion

Although glaucoma is the most common optic neuropathy in the eye, clinicians need to exclude other potential optic nerve or retinal pathologies that may mimic glaucoma.[6] This is because glaucoma is a lifelong diagnosis that requires a specific form of therapeutic management.

Common alternative diagnoses are listed in Table 2 (page 15) and examples of these presentations are shown in Figure 1 (page 17).

The clinician should also investigate different subtypes of glaucoma which may have different treatment modalities or natural histories.[7] Angle closure is also underdiagnosed, and the clinician needs to carefully examine the anterior chamber angle.[8] Secondary causes of glaucoma may require different treatment plans, as some interventions may not be suitable for all types of glaucoma.[9] Gonioscopy is a critical test to conduct for all patients with suspected glaucoma.

Clinical pearl: Exclude other causes of optic atrophy and investigate different subtypes of glaucoma before diagnosing primary open angle glaucoma.

3. Glaucoma is typically slowly progressive

The Early Manifest Glaucoma Trial described the natural history of different types of open-angle glaucoma, with some progressing faster than others.[7] As such, it is important to understand the trajectory of the individual patient, as it will enable clinicians to devise the most appropriate treatment plan.

In most cases, even untreated glaucoma tends to progress very slowly. For example, if we consider an 'average' progression rate of normal-tension glaucoma of approximately -0.8 dB per year in mean deviation, it would take 25 years to go from pre-perimetric glaucoma (0 dB mean deviation loss) to perimetric blindness of worse than -20 dB. However, rapidly progressive pseudoexfoliative glaucoma, at approximately -3 dB loss per year, would be expected to lead to blindness more than three times quicker. Examples of these considerations are in Figure 2 (page 17).

Two important reminders regarding glaucoma progression:

Structure and/or function can demonstrate disease progression – they may not occur at the same time, and each may precede the other.

Other signs such as pressure elevation and disc haemorrhages are not signs of progression, but may signal the need to reassess structure and function.

If progression is suspected at a follow-up visit, it is sometimes tempting to change the treatment plan immediately. However, it is advisable to confirm the change at another follow-up visit, as instrument variability (such as in visual fields or imaging) may contribute spurious impressions of disease progression.[10] The clinician needs to understand how quickly their patient is progressing, and assess this relative to other demographic factors such as age and life expectancy, and the potential detrimental effects of treatment.

Clinical pearl: Glaucoma progression varies by individual – don't panic, but carefully reassess and confirm before recommending a change in the treatment regimen.

4. Data, data, data

Due to the normal variability in eye data (visual fields, imaging and intraocular pressure), it is advisable to collect as much data as possible. Modern testing methods are very quick, such as very fast visual field thresholding algorithms and optical coherence tomography, and it is now feasible for clinicians to capture multiple results per visit to confirm the presence or absence of glaucoma or its progression.[11]

Intraocular pressure remains a key component of the glaucoma examination, and it is not a static number.[12] Techniques for profiling intraocular pressure are readily accessible to clinicians, including the water drinking test and phasing.[13,14] Collecting this data to identify peaks in pressure and its fluctuations may be helpful in assessing glaucoma risk and setting treatment targets.

In this digital age, a wealth of patient information is stored electronically; the ability to access this information is important for effective patient management. Identification of changes in a patient's medical record enables clinicians to identify glaucoma risk.

Examples of relevant information include the recent diagnosis of glaucoma within the family, the manifestation of systemic diseases, and changes to ocular parameters such as intraocular pressure or optic nerve status over time.

Clinical pearl: More clinical and historical data enables a more comprehensive evaluation of glaucoma risk.

5. Intraocular pressure reduction remains the mainstay treatment

Despite advances in the understanding of the pathophysiology of glaucoma, the reduction of intraocular pressure remains the mainstay proven treatment for reducing the rate of disease progression. Current strategies include topical medications, laser trabeculoplasty, drainage device implantation, filtration surgery and cycloablation procedures. The target intraocular pressure reduction is dependent on the stage of glaucoma and the rate of progression. The intraocular pressure number is not static and should be evaluated at every follow-up visit.

Historically, the preferred first-line treatment has been topical therapy, typically with a prostaglandin analogue. More recently, selective laser trabeculoplasty has been shown to be effective as a first-line treatment option in patients with high baseline pressures.[15] For suitable patients, it may be an option as drop-sparing therapy. However, the likelihood of success tends to diminish with lower baseline intraocular pressures, and is typically not preferred as a first-line option for pressures below 15 mmHg.[16] Clinicians need to consider a range of factors to determine the best patient management option.[17]

Two new medications have been used in other countries and may arrive in Australia in the near future: latanoprostene bunod[18] and rho-kinase inhibitors.[19] Both drugs offer unique mechanisms of action that may complement the current range of topical therapies.

Latanoprostene bunod incorporates a nitric oxide donating component to the prostaglandin analogue. The nitric oxide portion is suggested to improve trabecular outflow and relax the canal of Schlemm, which is a complementary mechanism to the uveoscleral outflow pathway targeted by the latanoprost.

Rho-kinase inhibitors are also thought to act on the trabecular meshwork, reducing resistance to outflow and thus reducing intraocular pressure. A second proposed mechanism of action of rho-kinase inhibitors is inhibition of norepinephrine and a reduction of aqueous production.

The advantage of these two medications is that they act on structures not typically targeted by the current list of anti-glaucoma medications (typically aqueous production or the uveoscleral outflow pathway). Thus, they provide an additive, complementary mechanism of action.

Glaucoma patients in Australia are surely looking forward to the next generation of topical glaucoma therapy.

Clinical pearl: Strategies for reducing intraocular pressure can be tailored for each patient.

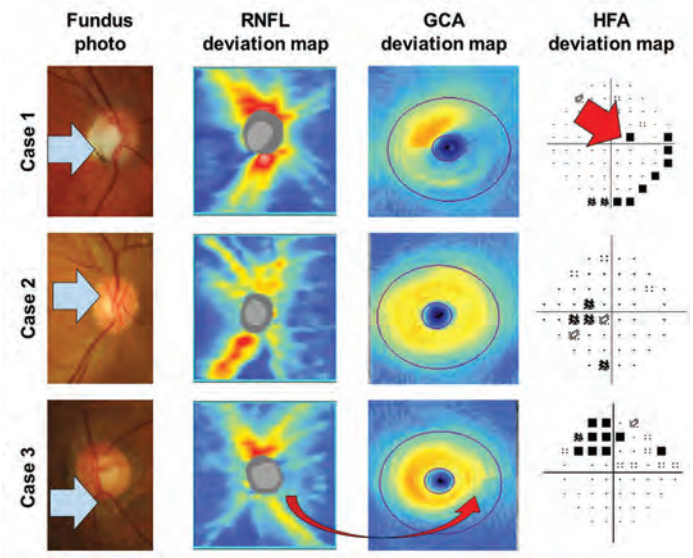

Figure 1.
Cases of other optic neuropathies compared to glaucoma. Case 1 is an example of a congenital optic atrophy, with a deep, static central neural and visual field loss, with no evidence of progression in over 20 years. Case 2 is an example of ischaemic retinal nerve fibre layer loss, with an obvious retinal nerve fibre layer loss but in the absence of neuroretinal rim thinning, thereby precluding glaucoma. Case 3 is a classic example of glaucoma, with marked neuroretinal rim thinning, adjacent retinal nerve fibre layer loss that extends towards the macula, and a corresponding visual field defect.

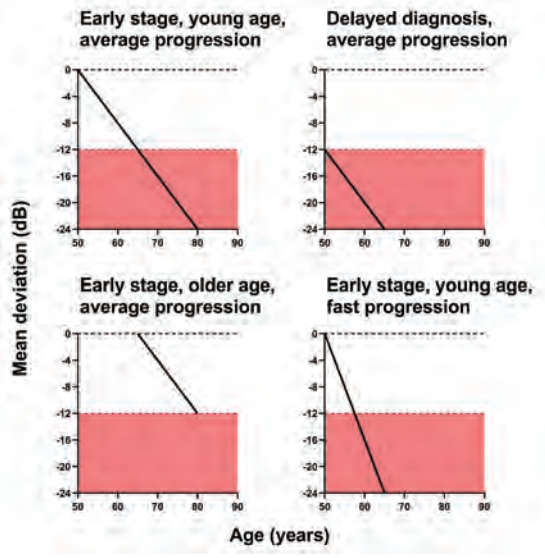

Figure 2.
Four examples of scenarios of patients with glaucoma, depending on the stage of disease at diagnosis (early or late), age of diagnosis, and progression rate. The progression is signified by the change in mean deviation (dB) over their lifetime with the black line. The red dashed line indicates a mean deviation of -12 dB, which is typically regarded as advanced glaucoma, and the bottom of the y-axis indicates perimetric blindness.

The next frontier?

Glaucoma remains a highly complex disease, with many areas of research dedicated to understanding its pathophysiology, detection, and treatment. Some things to look out for in the near future:

Clinical examination techniques beyond the eye. Evaluations of systemic health, and not just the eye, will become an increasingly important component of the glaucoma assessment, including cardiovascular health and neurological status.

Personalised and portable techniques for diagnosis and management. Large, clinic-only equipment will eventually be replaced by portable technologies that will enable patients to access eye health care.

Personalised medicine approaches. By understanding the overall eye and systemic health of the patient, new medications, lasers and surgeries will be able to target specific vulnerable areas of interest to enable optimised treatment plans.

With these exciting innovations, clinicians can look forward to more changes with the next iteration of Optometry Australia's Clinical Practice Guide for the Diagnosis and Management of Glaucoma.

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CLINICAL RESOURCE

Glaucoma risk factors

From Optometry Australia's *Clinical Practice Guide for the Diagnosis and Management of Open-Angle Glaucoma 2020*

Risk factor	Notes	Approximate relative risk†
Ocular history		
Myopia	After dividing levels of myopia into low myopia (up to -3 D) and higher myopia (greater than or equal to -3 D) the odds of having glaucoma are approximately 1.8 and 2.5 times higher, respectively.[50] Myopia and myopic disc configuration can confound interpretation of the optic nerve head and visual field result, mimicking glaucoma.[51,52]	Moderate-high*
Trauma	Assess the seriousness of blunt trauma to determine its additive risk for development of glaucoma (assess for signs of angle recession).[53,54]	Moderate
Vascular disease history		
Diabetes	The Blue Mountains Eye Study found an association between diabetes and glaucoma (relative risk 2.2 times), independent of intraocular pressure (IOP).[57] Overall, although there is evidence that diabetes may be associated with glaucoma, there are confounding issues at play and thus it is likely that the overall risk is attributable to an interplay of other associated factors such as cardiovascular disease and ageing changes.[58]	Low
Hypertension/ hypotension	A recent meta-analysis demonstrated that the overall risk of developing glaucoma was higher in individuals with hypertension (relative risk 1.2 times), but there were differences between high-tension glaucoma (significant risk) compared to low-tension glaucoma (non-significant risk).[59] Either very low diastolic (70 mmHg or lower) or high diastolic (above 90 mmHg) blood pressure were associated with an almost two-fold increased risk of glaucoma.[60] The effects of anti-hypertensive medications should be considered in patients with glaucoma: dosing medications at night may be detrimental to ocular perfusion pressure.[61] At some point during the disease progression, cardiovascular health may play a role in progression or management.[62]	Low
Vasospastic disorders/ migraine	There is a spectrum of vasospastic disorders (migraine, Raynaud's phenomenon) that may have implications in the risk of developing normal tension glaucoma, as vasospasm can cause chronic or recurrent ischaemic events occurring at the ONH, leading to glaucomatous changes.[63-65] There is a 1.2 times increased risk of glaucoma in those who get migraines.[66] Younger individuals or those with more frequent migraine attacks may be at greater risk of glaucoma.[67]	Moderate (in younger individuals)*
Thyroid disease	The link between thyroid disease and glaucoma is arguably less clear compared to other systemic risk factors. Most commonly, hypothyroidism has been considered the stronger association compared to hyperthyroidism and Graves' disease.[85]	None to low*
Sleep apnoea	Ocular disorders associated with obstructive sleep apnoea include floppy eyelid syndrome, papilloedema, anterior segment disease and optic neuropathy.[68,69] Sleep apnoea results in nocturnal relative hypoxia, which can lead to ischaemic damage to the ONH. One large cohort study in Taiwan showed a significantly elevated risk of 1.7 times after controlling for a number of confounding factors.[70] There is weak evidence to suggest that treating the sleep apnoea will result in a lowered risk of glaucoma progression.[71,72]	Moderate*

Glaucoma is the one of the leading causes of irreversible blindness in the world, and half of all glaucoma cases are undiagnosed. As primary eye-care practitioners, optometrists are ideally positioned to detect patients who have risk factors for glaucoma during routine eye examinations.

Optometry Australia's Clinical Practice Guide for the Diagnosis and Management of Open-Angle Glaucoma 2020 provides an update on all aspects of glaucoma care. It was developed in consultation with an expert working group of experienced practitioners with extensive experience in glaucoma assessment and management.

The table presented below is an excerpt from the guide, summarising the risk factors for glaucoma.

Risk factor	Notes	Approximate relative risk†
Other history		
Age[1-3]	Glaucoma can be considered to be an accelerated age-related process. Patients are > 17 times more likely to be diagnosed with glaucoma at age 80+ years compared to patients aged < 40 years.	High
Family history[48]	A positive family history of glaucoma increases the risk by approximately four times compared to no family history.[49] As many as 40-60 per cent of all patients with glaucoma have a positive family history. The type of glaucoma, age of onset, any surgery and the severity of glaucoma in family members is relevant to a patient's own risk. First-degree relatives (parents, siblings, children) are likely to play a predominant role in risk elevation.	High
Corticosteroid usage	Steroid responders are classified into low (< 6 mmHg compared to baseline, around 2/3 of individuals), moderate (6-15 mmHg increase, < 1/3 of individuals) or high response (>15 mmHg, around three per cent of individuals) tiers.[73,74] Risk factors for steroid response include: myopia, personal ocular history of glaucoma or family history of glaucoma.[75,76] An individual who experiences a steroid response is more likely to develop glaucoma in the future.[77,78] Topical ocular corticosteroids have the strongest association with increase in IOP and secondary glaucoma[79] with the response occurring within weeks; evidence for the contribution of topical dermatological, nasal and oral corticosteroids is weaker.	Moderate to high*
Smoking	There may be a dose-dependent effect of smoking, where heavy smoking (40 pack years or more) is associated with glaucoma, but not anything less than that.[80,81] At this stage, although recommendations for cessation of smoking should be provided to patients, there is no evidence for a direct link between smoking and glaucoma.[82-84]	None*
Neurodegenerative conditions	Questions regarding this may form part of general or specific history Similar macular VF defects can be seen in Alzheimer's as in glaucoma so practitioners should be cognisant to comorbidity.[86]	N/A

The full list of references is available in the Optometry Australia's Clinical Practice Guide for the Diagnosis and Management of Open Angle Glaucoma 2020

*Although strong evidence (longitudinal cohort studies) are not currently available for these risk factors, it is nonetheless prudent to explore these during history-taking.

†The calculations of risk are an approximate amalgamation of the magnitude of effect, as per the expert and consensus opinion from a review of the literature. A significant increase in risk was deemed as "low" = > 1.00 to < 1.50; "moderate" = 1.50 to < 2.00; "high" ≥ 2.00 relative risk.

Nicola Peaper
National Sales and Professional Services Manager
Rodenstock Australia

Optimisation and compensation

A guide to the tech and the effect

The terms 'optimisation' and 'compensation' sometimes seem to be interchangeable within the optical industry. When considering the best lens options for patients, a full understanding of these terms and the implications of the technologies associated with them is important. This article is a quick guide to the technology described by each term and their effect on your patients' adaptation to and enjoyment of their spectacles.

Optimisation

A lens design is optimised to reduce or eliminate the base curve effect. When a lens is produced with the minimal amount of aberration it is referred to as 'best form.' Tscherning showed this could be plotted graphically, producing Tschernings ellipses (Figure 1). Best form lenses can be produced on two curves: Wollaston and Oswalt. In practice the shallower, Oswalt, curve is used. As the base curve used moves away from ideal, peripheral aberration will increase, causing barrel or pincushion distortion (Figure 2).[1]

To encompass all scripts between +7.50 and -22.00 D, an impossible number of base curves would have to be held in stock by lens manufacturers. Depending on the manufacturer, numbers held tend to range from five to twenty base curves. Before freeform technology was available, this impacted negatively on the performance of progressive lenses.

Conventional (traditional grind) progressive lenses, as a rule, have a molded front progressive surface, while the prescription is worked onto the back surface after the order is received. The molded blanks have one base curve available for a range of powers with the front surface optimised for the mean spherical power. For example, the range -0.25 to -4.00 may be produced on a front curve optimised for a -2.00 D lens.[2]

This will work well if the prescribed power corresponds to the optimised power, but the more the prescription values differ from the mean power in both spherical and cylindrical power, the greater the restrictions in the vision zones caused by aberration. The lens shown in Figure 3A has a clear base curve effect since the power of this lens differs significantly from the optimised mean power of the blank, unlike the lens shown in Figure 3B.

The advent of digital surfacing—a combination of complex algorithms, allowing for real time optimisation and freeform technology—makes it possible to optimise a lens at several thousand points across the surface, instead of only determining the curvature of the spherical/toric prescription surface at one point as previously.

As a result, the base curve effect is minimised and restrictions of zones, especially in progressive lenses, is greatly reduced. Consequently, the aberration pattern on progressive lenses is more likely to be closer to that intended by the designer as illustrated by the lens shown in Figure 3B. Equally, single vision lenses can be produced with much lower peripheral aberration, reducing barrel or pincushion aberrations (Figure 2).

Compensation

The definition of a compensation is something that counterbalances or makes up for an undesirable or unwelcome situation. With spectacle lenses, compensations are introduced to correct for various reasons including:

Position of wear
During a refraction, the trial lens is held in front of the patient with zero face form angle (FFA), zero pantoscopic tilt (PT) and a specific corneal vertex distance (CVD). When dispensed into a spectacle frame, the angle that the lens now sits at will cause aberrations such as oblique astigmatism. Most modern, freeform lenses will be supplied with a compensated power to counteract this. If frame measurements are not supplied to the manufacturer then standard averages will be used and it is important that the customer

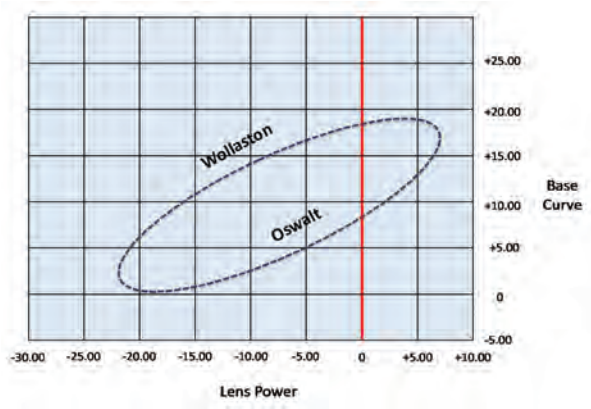

Figure 1.
Tschernings ellipse for 1.5 index material

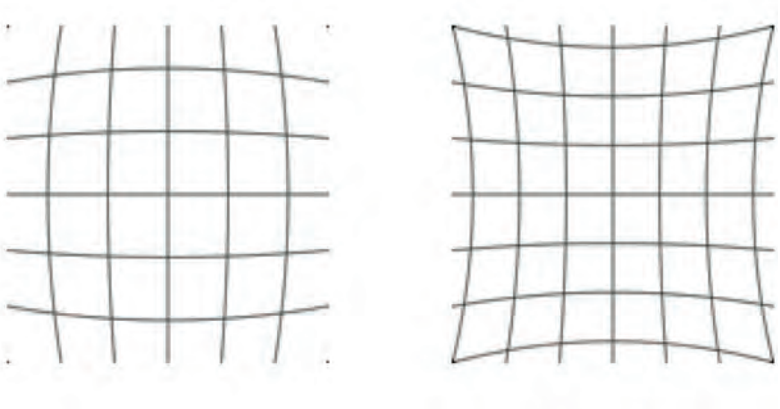

Figure 2.
Barrel and pincushion distortion

knows what standard measurements their lens supplier is using. It is possible to compensate a lens to the actual position of wear measurements and a lens individualised in this way will outperform a lens of standard measurements. Consider Figures 4A and 4B showing the performance of a +2.00 D progressive lens with a +2.00 D add.

The FFA has the largest effect on performance as it effects the congruity of the nasal and temporal vision zones. A FFA of 10 degrees, which is not unusual in the larger frames of today, will cause a drop in performance, including usable corridor width, of 50 per cent with a lens compensated for 'standard frame measurements.'

Likewise, as the PT moves to zero, which is not uncommon with shallow or sports frames, the performance drops off very quickly. The individualised lens shows little effect until measurements are a long way from standard.

It is interesting to note that the performance of the traditional grind lens never equals the performance of the optimised freeform lens types. This is due to the base curve effect.[2]

During eye movements away from the principle axes of vertical and horizontal, the eyes rotate according to Listing's law

During versions, the eyes rotate in the same direction, and since 2000, models produced by physiological research have been used to modify the axis of astigmatism in the periphery of lenses in accordance with Listing's law. Cylinder axis can be altered away from the centre of the lens to match the axis of the rolling eye to improve peripheral clarity.

When converging to near the eyes rotate in opposite directions and recent modelling applies Listing's law to vergences to allow for the changing of the cylinder axis for near. At the same time, the cylinder power can be altered at near in a progressive lens to account for the angle of incidence of light from a near object. (Effective near astigmatism.)

The main effect of including these compensations in the near portion of progressive lenses is to ensure that the correct power is accessed by the eye as it converges. This will increase both clarity and usable corridor width as the corridor is now more symmetrical.[3]

Higher order aberrations (HOAs)

HOAs, such as spherical aberration, coma and trefoil will distort a wavefront of light. The visual effect of these is to reduce contrast and cause blur, halos and glare, especially in low-light levels. For some time, it has been possible to include a compensation for HOA in a spectacle lens. A full correction is impossible due to eye movements across the lens, however, the sphero-cylindrical powers can be compensated at each vision point on the lens. As pupil size influences HOA, compensations have been based on the average pupil size with an average amount of HOA.

It is also now possible to measure a patient's HOA along with pupil size in different light and accommodative conditions and build a compensation into an individualised lens.

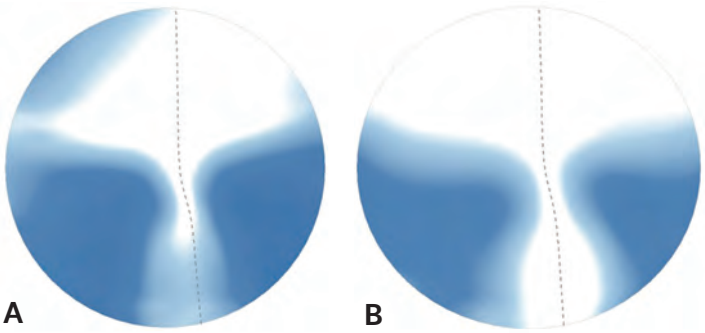

Figure 3.
Restrictions in the vision zones of a traditional grind progressive lens caused by the base curve effect (as shown in Figure 3a).

It is important to note that these compensations need to be considered when checking a lens. For instance, when compensating for position of wear, a lens is produced that will give the patient the same experience as that of a trial lens sitting squarely in front of the eye. However, the verted power of the lens will differ from that ordered. If the PT, CVD or FFA of the dispensed frame differ significantly from the trial situation then the compensated powers may be significantly different.

At this point, it is necessary to point out that a compensated lens can only be checked against the compensated powers. These are usually included either on the lens packets or delivery note from the manufacturer. To accurately check the lens, the vertometer needs to be set to measure in 0.01D steps. If 0.12D or 0.25D steps are used, rounding will invariably lead to the power being incorrectly measured.

There is constant research and development in the lens manufacturing industry to improve the patient's visual experience with spectacle lenses. When considering the physiology of the eye and the way that the brain interprets the visual input, we are just at the beginning of what can be achieved.

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2. Rodenstock GMBH. Tips and Technology July 2019. 6.5
3. Rodenstock GMBH. Tips and Technology July 2019. 6.1.1

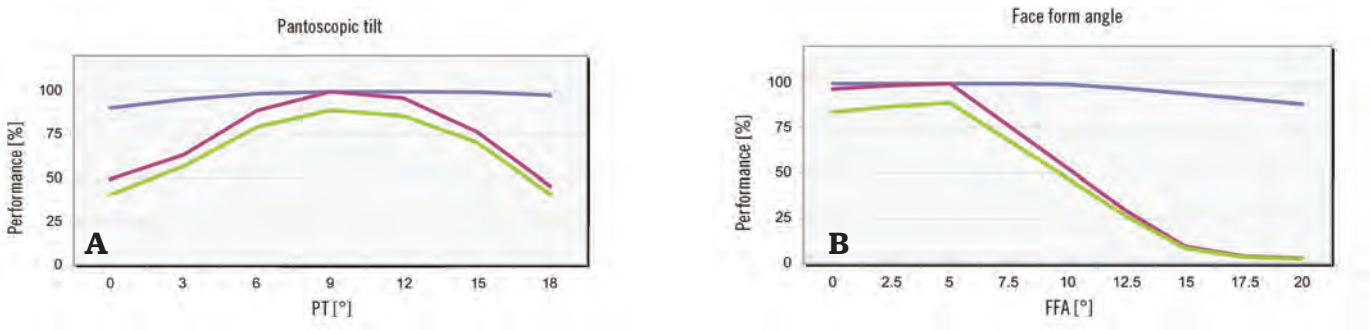

Figure 4
The blue line represents a lens optimized for base curve effect and compensated for actual frame parameters. The purple line: a lens optimised for the base curve effect and standard frame parameters. The green line: a traditional grind lens.

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BOptom GCertOcTher MPH PGDipAdvClinOptom GCertHE FACO
Clinical Editor, *Optometry Connection*

Dr Dan C Chung
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Inherited retinal dystrophies (IRDs) and gene therapy

For years, gene therapy has been called the 'next revolution in medicine' and has inspired researchers to explore its potential for patients who are living with difficult (previously-considered incurable) diseases. Now this research is finally paying off. In August last year, the Therapeutic Goods Administration (TGA) approved Australia's first gene therapy, Luxturna, indicated for inherited retinal dystrophy (IRD) caused by a specific gene mutation. But what is it, and how does it work?

To find out, Clinical Editor Kerryn Hart conducted this interview with Dan Chung. In his role as Therapeutic Area Leader-Ophthalmology at Spark Therapeutics, Dan and his colleagues developed Luxturna gene therapy. Here in Australia, Novartis has worked closely with the TGA to have Luxturna registered, it's not only the first gene therapy for retinal disease, but also the first gene therapy for a genetic disease.

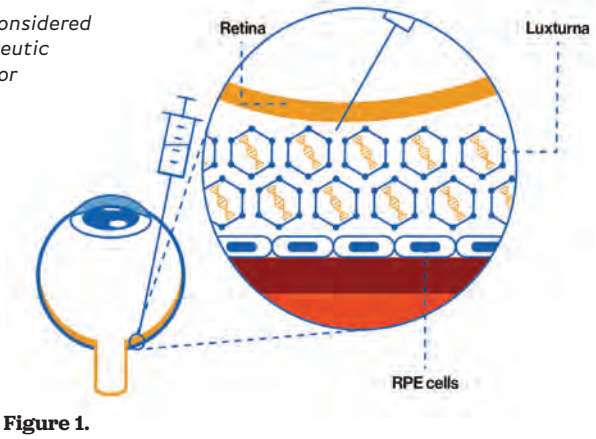

Figure 1.
Luxturna mode of administration

KH **Why are we hearing so much about gene therapy right now and how does it work?**

DC The concept of gene therapy has been progressing for decades, but issues with the vector, or the vehicle we use to deliver the DNA or RNA to a specific target, has had immunogenicity/pathogenicity issues that have caused significant challenges. With the development of a non-pathogenic vector, the adeno-associated virus, more and more investigations into gene therapy have been initiated.

The eye has been a great target for gene therapy, as the eye is a small organ that is immune-privileged, or less likely to elicit an immune reaction. Different segments of the eye can be targeted for gene therapy through various delivery methods, and many ocular issues are caused by a mutation, also known as a variant, in a specific gene, so correcting that specific gene may produce a therapeutic effect.

The basis for gene therapy is the premise that the gene with the mutation is causing the lack of function for that specific cell type, commonly a protein is not being produced, which causes disease. In gene therapy the goal is to add a normal copy of the defective gene to the cell, which then starts producing that missing protein and restores the lost function.

KH **We know that Luxturna is registered in Australia for Inherited retinal dystrophy (IRD); how common are IRDs and are there any specific conditions that Luxturna can treat?**

DC IRDs are rare forms of diseases that affect the functioning of the retina due to mutations that are found in a specific gene. There are over 270 different genes that cause some form of IRD.[1] One of the most common categories of IRD is retinitis pigmentosa; it affects about 1 in 4,000.[2]

Luxturna is indicated for the treatment of patients with IRD caused by pathological biallelic RPE65 mutations and who have sufficient viable retinal cells as determined by the treating ophthalmologist.[3] This IRD may have a clinical diagnosis of Leber Congenital Amaurosis or retinitis pigmentosa. However, the clinical labels can vary, and the definitive method for diagnosis is to get a genetic test through the National Association of Testing Authorities (NATA) Australia or the International Laboratory Accreditation Cooperation (ILAC) accredited genetic testing laboratory to confirm that there are biallelic mutations in the RPE65 gene.*

KH **How would a candidate for Luxturna treatment present to an optometrist and what should the optometrist do next?**

DC One of the most common symptoms is nyctalopia, with a loss of light sensitivity that is progressive over time. This is accompanied by loss of peripheral vision, and central vision can also be affected. In infants and very young children, nystagmus can also be present.

Optometrists should refer patients to an appropriate laboratory for genetic testing, and it is helpful for the patient to speak to a genetic counselor about it as well. Of course, a complete ocular examination and other tests such as optical coherence tomography (OCT), perimetry and light sensitivity testing are also important.

AUSTRALIA'S FIRST APPROVED GENE THERAPY FOR AN INHERITED RETINAL DYSTROPHY[1,2]

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†RPE65-mutation associated inherited retinal dystrophy.

Reference: 1. LUXTURNA® Australian Approved Product Information (5 August 2020). **2.** FDA press release, 18 December 2017. https://www.fda.gov/news-events/press-announcements/fda-approves-novel-gene-therapy-treat-patients-rare-form-inherited-vision-loss (accessed 21/09/2020).

This product is not currently reimbursed.

▼This medicinal product is subject to additional monitoring in Australia. This will allow quick identification of new safety information. Healthcare professionals are asked to report any suspected adverse events at www.tga.gov.au/reporting-problems.

Luxturna® Voretigene neparvovec (recombinant adeno-associated virus 2 vector AAV2-Hrpe65V2).

See approved Product Information before prescribing. Approved Product Information available on request.

Indication: Treatment of inherited retinal dystrophy caused by pathological biallelic RPE65 mutations and who have sufficient viable retinal cells as determined by the treating physician. Pathological mutations of RPE65 should be confirmed by a NATA or ILAC accredited laboratory. **Contraindications:** Hypersensitivity to voretigene neparvovec or the excipients, ocular or periocular infection, or active intraocular inflammation. **Dosage and administration:** Single-use vial for subretinal injections. Luxturna contains genetically modified organisms. Complex dosage and administration – see full PI before prescribing. Please contact Novartis for TGA and OGTR mandated activities prior to administering Luxturna. **Precautions:** •Endophthalmitis may occur following any intraocular surgical procedure or injection. Use proper aseptic injection technique when administering Luxturna. Advise patients to report signs or symptoms of infection or inflammation without delay. Patients should avoid swimming because of an increased risk of infection in the eye. •Permanent decline in visual acuity may occur following subretinal injection of Luxturna. Monitor patients for visual disturbances. •Retinal abnormalities may occur during or following the subretinal injection of Luxturna, including macular holes, foveal thinning, loss of foveal function, foveal dehiscence, and retinal hemorrhage. Do not administer Luxturna in the immediate vicinity of the fovea. Retinal abnormalities may occur during or following vitrectomy including retinal tears, epiretinal membrane, or retinal detachment. Advise patients to report any signs or symptoms of retinal tears and/or detachment without delay. •Increased intraocular pressure may occur after subretinal injection of Luxturna. Monitor and manage intraocular pressure appropriately. •Expansion of intraocular air bubbles: Instruct patients to avoid air travel or travel to high elevations until the air bubble formed following administration of Luxturna has completely dissipated from the eye. A period of up to one week or more following injection may be required before dissipation of the air bubble. Verify the dissipation of the air bubble through ophthalmic examination. A rapid increase in altitude while the air bubble is still present can cause a rise in eye pressure and irreversible vision loss. •Vector shedding: Transient and low level vector shedding may occur in patient tears. Patients/caregivers should be advised to handle waste material generated from dressings, tears and nasal secretion appropriately, which may include storage of waste material in sealed bags prior to disposal. These handling precautions should be followed for 14 days after administration of Luxturna. It is recommended that patients/caregivers wear gloves for dressing changes and waste disposal, especially in case of underlying pregnancy, breastfeeding and immunodeficiency of caregivers. Patients treated with Luxturna should not donate blood, organs, tissues and cells for transplantation. •Cataract: Subretinal injection of Luxturna, especially vitrectomy surgery, is associated with an increased incidence of cataract development and/or progression.•Use in Pregnancy: Category B2: As a precautionary measure, it is preferable to avoid the use of Luxturna during pregnancy. •Lactation: A decision must be made whether to discontinue breastfeeding or to abstain from voretigene neparvovec therapy taking into account the benefit of breastfeeding for the child and the benefit of therapy for the mother. •Safety and efficacy in patients ≥ 65 years of age, hepatic or renal impairment and children< 4 years of age not established. **Adverse effects:** •Very common (≥10%): Conjunctival hyperaemia, cataract, intraocular pressure increased. •Common (1 to 10%): Retinal tear, macular hole, retinal deposits, dellen, eye inflammation, maculopathy, eye irritation, eye pain, retinal detachment, retinal haemorrhage, choroidal haemorrhage, endophthalmitis, macular degeneration, conjunctival cyst, eye disorder, eye swelling, foreign body sensation in the eyes, retinal disorder. Based on TGA approved Product Information dated 5 August 2020 (lux050820m). Novartis Pharmaceuticals Australia Pty Limited ABN 18 004 244 160. 54 Waterloo Road, Macquarie Park NSW 2113. Phone (02) 9805 3555. ® Registered Trademark. AU-13138. McCann Health NOLX19045M. September 2020.

NOVARTIS

KH **How is Luxturna administered and what is the mechanism of action? In other words: how does it work?**

DC The normal copy of the RPE65 gene is placed into a non-pathogenic adeno-associated virus, which is injected into the subretinal space by a vitreo-retinal surgeon (Figure 1).

RPE65 is located in the retinal pigment epithelial cells and converts all-trans-retinol to 11-cis-retinol, which subsequently forms the chromophore, 11-cis-retinal, during the visual (retinoid) cycle. These steps are critical in the biological conversion of a photon of light into an electrical signal within the retina.

KH **Before Luxturna, what options did patients with IRD have?**

DC Luxturna is the first gene therapy for a form of inherited retinal dystrophy. There were no approved effective pharmacologic treatments for this or any other IRD before Luxturna's approval.

KH **For patients, what outcomes can they expect from Luxturna treatment?**

DC The outcomes vary from patient to patient and will depend on the extent and progression of the disease[4] and other factors associated with the delivery of Luxturna to the eye. In our pivotal Phase III trial, subjects treated with Luxturna showed significant improvement in functional vision compared to control, as assessed by the ability to navigate a course at different levels of environmental illumination.
There were also significant improvements observed in full-field light sensitivity threshold (FST) testing. Some patients reported seeing stars for the first time, others were no longer restricted to activities during the daylight hours, but could now perform activities in the evening and other low light settings.[5,6]

KH **What is the likelihood that gene therapy treatments will be available for more common diseases such as glaucoma or AMD in the future?**

DC Diseases such as AMD and glaucoma are not commonly caused by a single gene mutation, commonly referred to as 'monogenic,' as we see in IRD, but are known as 'polygenic.' In other words, there could be several different genes that may be involved, and many times, those genes simply predispose the individual to acquiring the disease. Additionally, environmental factors may also play a role. Therefore, gene therapy is a much more challenging approach to develop treatments for these diseases.

KH **Where can our readers find out more?**

DC Luxturna is only administered at designated gene therapy treatment centres, led by an IRD specialist/ocular geneticist and a vitreo-retinal surgeon. In February last year, the Royal Australian and New Zealand College of Ophthalmologists (RANZCO) published their Guidelines for the assessment and management of patients with IRD. It can be found at ranzco.edu.

We have provided a list of clinical genetic services (below). The list will also be available on the *Optometry Connection* Clinical Resources page of the Optometry Australia website.

*National Association of Testing Authorities (NATA) website: www.nata.com.au
International Laboratory Accreditation Cooperation (ILAC) website: www.ilac.org

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2. NIH National Eye Institute [Internet]. Washington DC: National Eye Institute [cited 2021 Feb 9]. Available from: https://www.nei.nih.gov/learn-about-eye-health/eye-conditions-and-diseases/retinitis-pigmentosa

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This interview was made in collaboration with Novartis (NVS).

Clinical genetic services in Australia

A partial list of clinics and services for patients with IRDs*

New South Wales

Patients with suspected or confirmed IRDs are managed by the general genetic clinic based in their Local Health District (LHD). For help with specific IRD cases, contact the Genomic Eye Multidisciplinary Team at Westmead Hospital/The Children's Hospital at Westmead.

Queensland

Genetic Health Queensland (GHQ) is based in Brisbane at the Royal Brisbane & Women's Hospital and Queensland Children's Hospital.

Patients with suspected or confirmed IRD from all metro and regional hospitals/GHQ clinics as well as from specialist rooms and GPs can be referred directly to the GHQ ocular genetics clinic via the referral hotline: 1300 364 938.

Victoria

Victoria has a state-wide ocular genetics clinic (OGC) based at the Royal Victorian Eye and Ear Hospital in Melbourne. Adult patients with suspected or confirmed IRD can be referred directly to the ocular genetics clinic.

The Royal Melbourne Hospital, Monash Health and Austin Health services also have limited genetic services for adult IRD patients.

Paediatric patients are usually referred to the Victorian Clinical Genetic Service, which is based at the Royal Children's Hospital in Melbourne. www.vcgs.org.au.

Western Australia

All initial referrals – including IRD referrals – to outpatient public hospital clinics must be processed through the WA Health Central Referral Service (CRS) for triaging, unless it is an emergency. The CRS will then refer IRD patients to Genetics Service Western Australia (GSWA).

https://ww2.health.wa.gov.au/Articles/A_E/About-the-Central-Referral-Service

GSWA clinics

All patients with suspected/confirmed IRD can attend general genetic clinics based in the main GSWA centres in Perth – King Edward Memorial Hospital (adults) or Perth Children's Hospital (paediatric patients).

South Australia

General paediatric genetics: The Women's and Children's Hospital, 72 King William Road, North Adelaide.
Phone: (08) 8161 7375.

General adult genetics: the Royal Adelaide Hospital, Outpatient Department, Level 5E.1, Port Road, Adelaide.
Phone: (08) 7074 2697

For further information on referring patients to the general adult genetics clinic, visit:
www.rah.sa.gov.au/health-professionals/clinical-services/medical/clinical-genetics

Tasmania

The Tasmanian Clinical Genetic Service is based at: the Royal Hobart Hospital, Hobart.

All referrals for patients requiring a genetic service (paediatric and adult) should be addressed to: Tasmanian Clinical Genetics Service, C/O The Royal Hobart Hospital, GPO BOX 1061, Hobart 7001. Phone (03) 6166 8296; Email: tcgs@ths.tas.gov.au

New referrals must conform to the referral standards outlined at: http://outpatients.tas.gov.au/clinics/genetics_statewide.

*Information correct as of February 2021

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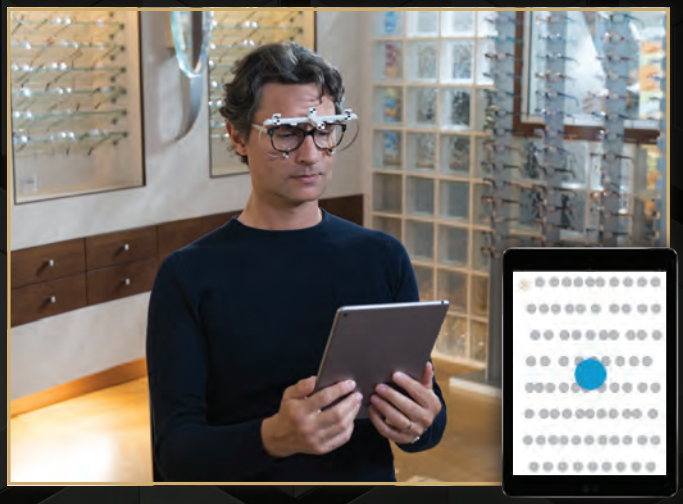

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Analysis of glaucoma referrals

Study investigates glaucoma referrals from primary care and subsequent hospital management in an urban Australian hospital

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Lisa Keay
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Summary and comment provided by

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A typical day in optometric practice likely involves seeing several patients that might be at risk of developing glaucoma. The clinical dilemma that then follows is whether to refer to a public hospital or go through private ophthalmologic care. In the case that the decision is made to refer to a public hospital, a major factor to consider is the lengthy wait periods. The delay in receiving care may be significantly impacted by the quality of the original referral, with the resultant delay impacting the patient's condition in the interim.

Optometry Australia guidelines recommend that referrals include the purpose of the referral, the results of a recent optometric examination, as well as any relevant history. The glaucoma collaborative care guidelines developed by the Royal Australian and New Zealand College of Ophthalmologists go into more detail, adding the following clinical parameters: visual acuity, refraction, central corneal thickness, anterior eye assessment, cornea, anterior chamber, lens, optic disc and fundus assessment, intraocular pressure, clinical imaging and visual field assessment. Other guidelines include the recommendation to include repeat visual fields and intraocular pressures as a measure of disease progression.

In their study published in the November 2020 issue of *Clinical Experimental Optometry*,[1] authors Belinda Ford, Duri Kim, Lisa Keay and Andrew White ask a very important question: is the quality of referrals provided to a public hospital adequate to ensure appropriate care and timely intervention?

The authors studied 200 referrals received at a major Australian hospital over a two and a half-year period, focusing on referrals for glaucoma management. The referral letters themselves were examined for factors such as the referral date, the referrer type, the ophthalmic information provided and the medical information included. Patient hospital records were also examined, including the date of the appointment, diagnosis and management.

The analysis of these patient referrals and records indicated that 72 per cent came from optometrists, 22 per cent from general practitioners, with the remainder coming from other specialties.

The majority of the referrals contained less than 50 per cent of the key clinical and demographic parameters required by the auditing tool created by the authors based on parameters recommended by the Royal Australian and New Zealand College of Ophthalmologists, the Canadian Ophthalmologist Society, and the UK National Health Systems General Ophthalmic Services. That is, useful diagnostic information on the ocular, medical and social risks of glaucoma were missing in the majority of referrals. More than half the referrals included visual acuity information (59 per cent), more commonly reported by optometrists than general practitioners. Less than half the referrals included information on the cup-to-disc ratio (49 per cent), the optic nerve head (35 per cent), the macular (15 per cent), or central corneal thickness (six per cent). Only 14 per cent of referrals included a preliminary diagnosis.

Optometrists were more likely than general practitioners to report on a family history of glaucoma (24 per cent versus five per cent). The median wait time was 400 days (interquartile range 272-451 days). Of the patient records assessed, 59 per cent required surgical or medical management, while 16 per cent did not have glaucoma at all. Of the patients reviewed, 18 per cent were discharged, suggesting that this group contributed to the lengthy wait period. One third of the referred patients were diagnosed with definitive glaucoma, while around half were glaucoma suspects.

The outcomes of this research serve as a timely reminder for optometrists as primary care practitioners to be cognisant of the impact the quality of their referrals may have, particularly when referring for glaucoma management.

Better information will help hospital staff to better triage patients into those requiring more urgent care. One of the recommendations to come from this study was the need for a standardised letter template to facilitate the inclusion of all criteria. The referral letter parameters considered to be key include visual acuity, intraocular pressure and optic nerve head examination. In addition, current referrals rarely included information on family history, or on the social context of the patient. Given that a positive family history is the strongest risk factor for glaucoma, it is critical that this information is included in the referral. Medical history, such as diabetes, hypertension, cataract, myopia, lifestyle factors such as smoking and alcohol consumption must also be included in the referral letter.

The wait periods highlight the need for more streamlined referrals to enable the determination of urgency. Moreover, the inclusion of repeat assessments such as visual fields that indicate disease progression and severity will provide further triage of clinical urgency.

1. Ford BK, Kim D, Keay L, White AJ. Glaucoma referrals from primary care and subsequent hospital management in an urban Australian hospital. *Clin Exp Optom* 2020; 103: 821-829. doi: 10.1111/cxo.13046.

Interview with CXO author Nicole Carnt

Author of: Prevalence and seasonal variation of *Acanthamoeba* in domestic tap water in greater Sydney, Australia. *Clin Exp Optom* 2020; 103: 782-786.

Nicole Carnt is Scientia Senior Lecturer at The School of Optometry and Vision Science, UNSW, Sydney, Australia. She graduated from Optometry at UNSW in 1989 and worked in private practice for 10 years in Australia and the UK before taking a position with the Brien Holden Vision Institute in 1999. She completed a PhD on Epidemiology of Contact Lens Related Infection and Inflammation 2008-2012 and is the recipient of many research awards. She was awarded a NHMRC Research Fellowship in 2012 and spent the first 2.5 years at Moorfields Eye Hospital, London investigating the rare but severe corneal infection in contact lens wearers, *Acanthamoeba* keratitis.

What are the key findings from your research on *Acanthamoeba* in domestic tap water?

In this study of 97 samples of Sydney domestic tap water samples, collected in two periods in 2019—winter and summer—we found around 30 per cent in both seasons were contaminated with *Acanthamoeba*. Three quarters of these samples were phylogenetically classified as 'T4 and T5 genotypes' which are pathogenic for *Acanthamoeba* keratitis (AK).

What do you want optometrists to know about your findings?

The high prevalence of *Acanthamoeba* in Sydney domestic water sends an alert to Australian practitioners to advise contact lens wearers of the dangers of water mixing with contact lenses. This is critical as many contact lens wearers do not understand this risk factor for severe infection with *Acanthamoeba*.

The persistence of *Acanthamoeba* in domestic water across the seasons reinforces that clinicians should be vigilant of AK in contact lens wearers throughout the year. This is particularly important as AK can masquerade as herpes simplex keratitis and we have shown that misdiagnosis occurs in around 50 per cent of cases and is associated with a 5x increased risk of a poor outcome.[1]

What surprised you while conducting this research?

The prevalence of *Acanthamoeba* in Sydney domestic water was higher than what we expected. In fact, it was similar to what we found in the UK, using the same sampling strategy. In the UK, the water quality and delivery systems have been traditionally more likely to harbour *Acanthamoeba*. We also expected a lower proportion of positive samples in winter as *Acanthamoeba* flourishes in hot conditions and some studies have found that increased number of cases of AK occur in summer. However, this may be due to greater participation in water sports in summer. In any case, our results show that the level of *Acanthamoeba* in Sydney water is high and it persists throughout the year.

What drew you to this area of research?

During my NHMRC Research Fellowship at Moorfields Eye Hospital in London, I met a patient with severe AK, who was so motivated about the lack of knowledge among contact lens wearers of the danger of mixing water with their lenses, that she designed a 'no water' symbol to be placed on contact lens packaging. Through an industry-funded research project, we have shown that the use of these symbols reduces water exposure in contact lens wearers and case contamination with water borne microbes.

These 'no water' stickers for contact lens packaging are available in the UK, USA and Australia (through CCLSA). My research on water, inspired by this patient campaigner, reinforces the important safety message of not mixing contact lenses with water.

What are you currently working on?

This research has led to a collaboration with Dr Con Petsoglou at Sydney Eye Hospital to determine similarities between isolates of *Acanthamoeba* cultures from corneal scrapes of patients and environmental water samples. We have also teamed-up with Water NSW to collect samples from water catchments and will correlate water factors such as turbidity and mineral content with *Acanthamoeba* presence. We will also collect samples from AK patients' homes and see how these relate to the *Acanthamoeba* causing the infection as well as the source water. An interesting fact about *Acanthamoeba* is that it can host intracellular bacteria, viruses and fungi. Around 20 per cent of AK patients suffer concurrent microbial keratitis, so we are not only looking at the *Acanthamoeba* organism itself, but also its microbiome.

1. Carnt N, Stapleton F: Strategies for the prevention of contact lens-related *Acanthamoeba* keratitis: a review. *Ophthalmic Physiol Opt* 2016, 36: 77-92. doi: 10.1111/opo.12271

This original case report was submitted by Optometry Australia member Anthony Tran in response to our call for papers.

Anthony Tran
BOptom (Hons), BSci, FAAO
Visiting Clinical Supervisor
UNSW Optometry Clinic

Normal tension glaucoma

Managing systemic risk factors to improve patient prognosis

Glaucoma is an irreversible progressive optic neuropathy, characterised by optic nerve changes with possible visual field defects.[1] Although normal tension glaucoma progresses slowly compared to other forms of glaucoma, correct diagnosis and management is essential as normal tension glaucoma has been associated with deeper, more paracentrally involved visual field defects.[1] Current management involves reducing intraocular pressure to lower the risk of progression. First-line therapy involves the use of a prostaglandin analogue due to its potency and good safety profile. However, normal tension glaucoma can continue to progress even with conventionally adequate intraocular pressure control due to vascular risk factors affecting proper optic nerve perfusion.

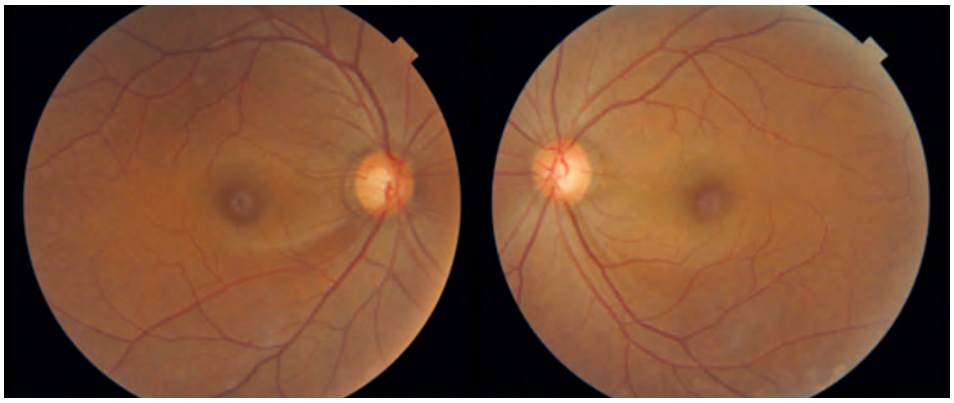

Figure 1.
Fundus photos illustrating inferior notching of neuroretinal rim (OD > OS) with inferior RNFL defect (OD)

As optometrists begin to take a more active role in glaucoma management, it is important to collaborate with other health-care providers to ensure any undiagnosed systemic risk factors are properly addressed to ensure the best outcome for patients. This report outlines a case of normal tension glaucoma in a patient with systemic hypotension.

Case study

A 46-year-old Southeast Asian female presented for a routine eye examination and had no conspicuous symptoms. Her last eye examination with her local ophthalmologist six years prior was unremarkable. She was not taking any medications. Upon questioning, she reported possible hypotension. She did not report any diabetes, hyperlipidaemia, asthma, chronic obstructive pulmonary disease, or heart disease. Her family history was unremarkable. There was no history of ocular injuries or surgeries. She had no drug allergies.

Her corrected visual acuities with a mild myopic script were 6/6 OU.

Intraocular pressures by Goldman applanation tonometry were 13 mmHg OU at 9:59am. Central corneal thickness (CCT) was 510 µm in OU, thinner than average.

Slitlamp biomicroscopy was unremarkable. Gonioscopy revealed open angles to the ciliary body OU with no pigment, exfoliative material, angle recession, or abnormal vessels noted. Dilated fundus examination revealed optic nerves with vertical C/D ratios of 0.7 and horizontal C/D ratios of 0.4. Inferior notching of the neuroretinal rim and visible nerve fibre layer thinning were noted OU, OD greater than OS. No pallor or drance haemorrhages were noted. Maculae were unremarkable OU (Figure 1).

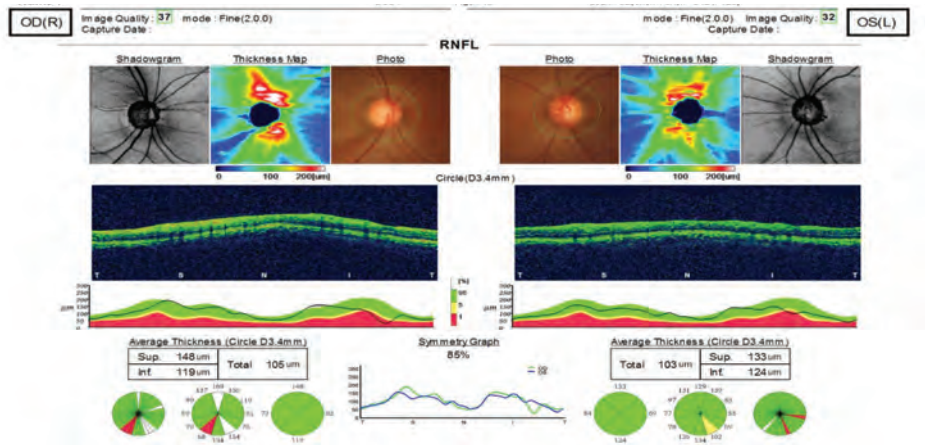

Figure 2.
RNFL thinning at 7 o'clock OD and 5 o'clock OS, corresponding to inferior neuroretinal rim notching and RNFL defects noted on clinical examination

Tentative diagnosis

This patient was tentatively diagnosed as a high-risk NTG suspect OU (OD > OS) and was advised to follow-up in two weeks for visual fields (VF) and OCT.

Follow-up 1 (two weeks later)

Best corrected visual acuities were 6/6 OU. IOPs were 14 mmHg OU at 5:44pm. Optic nerve head examination remained unchanged. OCT scans revealed retinal nerve fibre layer thinning at 7 o'clock in the OD and borderline thinning at 5 o'clock in the OS that corresponded with clinical findings (Figure 2). Ganglion cell layer analysis also

showed thinning inferiorly (OD > OS). VFs revealed early superior paracentral arcuate VF defects OD.

Diagnosis: Normal tension glaucoma (NTG)

The patient was diagnosed with NTG due to corresponding optic nerve head appearance, OCT and VF findings in the context of normotensive IOPs. Dilation and gonioscopy ruled out any secondary-open angle glaucoma, angle-closure glaucoma, and other forms of optic neuropathy. This patient had thin CCTs, suspected hypotension, and myopia which are common risk factors for developing NTG.

Management

The patient was referred to her previous ophthalmologist for co-management of her glaucoma. This referral was made as the ophthalmologist had access to the patient's previous records and would be able to assess her rate of progression. Referring this patient also facilitated investigation of her systemic hypotension which may have contributed to her glaucoma.

Her treating ophthalmologist prescribed latanoprost 0.005% eye drops OU to be instilled at night. She also underwent 24-hour blood pressure monitoring to confirm her hypotension and was found that her nocturnal blood pressure reading dropped to as low as 80/50. A referral to her general practitioner for further management of her hypotension was made.

Discussion

Glaucoma is a progressive and irreversible optic neuropathy that is the second leading cause of blindness in the world.[1] In 2020, it was predicted that about 79.6 million individuals globally will be affected by glaucoma[2] and 30-40 per cent of this population would be diagnosed with NTG.[3,4] NTG is differentiated from primary open-angle glaucoma by initial presenting IOPs (IOP less than 21 mmHg).[1] Both conditions exhibit open anterior chamber drainage angles and glaucomatous optic neuropathy with possible visual field changes. However, NTG tends to exhibit deeper paracentral VF defects and a higher incidence of drance haemorrhages.

Risk factors of glaucoma are multi-factorial whereby vascular factors and IOP may play a larger role. Vascular risk factors include migraines, Raynaud's phenomenon, vasospastic disorders, diabetes, sleep apnoea, systemic hypotension, and increased blood viscosity due to poor perfusion of the optic nerve.[5–7] Other risk factors include age, race (predominantly Japanese), family history, thin CCT and myopia.[2,4,5,8,9] While patients with NTG present with IOPs within the statistically normal range, it has been observed that further reducing a patient's IOP may slow progression.[10]

Systemic hypotension was flagged as a risk factor for glaucoma in this patient. The association between vascular risk factors such as hypotension and ocular perfusion pressure with open-angle glaucoma is well established. Ocular perfusion pressure (OPP) is defined as the difference between a patient's blood pressure and IOP. It is suspected that low blood pressure results in low perfusion of the optic nerve, depriving the optic nerve of oxygen and nutrients and resulting in cell damage and death.[11] Patients with low diastolic OPP are at 2-4 times more likely to develop glaucoma.[11,12] The Barbados Eye Study showed that patients with systolic perfusion pressures less than 101 mmHg and diastolic perfusion pressures less than 55 mmHg were at greater risk of developing open-angle glaucoma[11] Additionally, the Thessaloniki Eye Study concluded that patients who experienced diastolic blood pressures of less than 90 mmHg after taking anti-hypertensive medication were associated with increased cup-disc ratios and decreased neuroretinal rim areas of the optic discs.[13] NTG patients with well-controlled IOPs may still progress due to significantly lowered blood pressure during the day and night.[11,13–16] Additionally, patients may experience a nocturnal elevation of IOP due to the diurnal variation of IOP.[17] Therefore the maximal IOP exhibited by patients may occur outside typical office hours leading to a misleading diagnosis of NTG in certain patients.[18] Increasing OPP may be achieved by reducing IOP and ensuring blood pressure is not further reduced significantly through medication. Reducing the occurrence of IOP peaks and BP troughs would increase OPP and reduce the risk of further glaucomatous damage. Considering the heightened risk of progression with lower OPP, it was important in this case to refer this patient out for co-management of her systemic hypotension.

Latanoprost 0.005% once at night OU was initiated by her ophthalmologist to reduce IOPs and risk of progression. Latanoprost was chosen due to its good safety profile and efficacy. Beta-blockers were avoided in this patient due to the patient's systemic hypotension. There have been cases in the past in which NTG still progresses in patients with systemic hypotension despite good IOP control. This patient already demonstrated early VF loss at a young age and her low systolic blood pressure was a clear risk factor for the progression of NTG. Thus, referral to her primary care physician to discuss further options for managing her blood pressure was essential in the management of her condition.

Conclusion

This case study outlines the management of a patient with normal tension glaucoma and systemic hypotension. Although patients with NTG tend to progress more slowly than other forms of glaucoma, visual field loss is often concentrated more centrally and may result in earlier symptoms. While the pathophysiology of the disease is not well known, IOP reduction is an effective measure in lowering the risk of progression. Some patients continue to progress despite adequate IOP control. Thus, systemic risk factors and associations must also be investigated and managed accordingly to ensure improved prognosis for these patients.

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18 Lee YR, Kook MS, Joe SG, et al. Circadian (24-hour) pattern of intraocular pressure and visual field damage in eyes with normal-tension glaucoma. *Invest Ophthal Vis Sci* 2012; 53: 881-887.

Optos Daytona Plus

Comprehensive retinal examination with ultra-widefield retinal scanning

Sally O'Brien
BAppSc(Optom) (Hons) GradCertOcTher

Principal Optometrist
Clacher & Hook Optometrists
Wynnum QLD

Our practice has been family owned and operated in Brisbane's bayside suburb of Wynnum since the 1950s, and I am now, in partnership with my sister Emma Richardson, the proud third-generation owner.

Our practice's preceding owner, my father, Mac Hook, prided himself on being ahead of the game when it came to investing in cutting-edge diagnostic technology, and I am eager to follow this precedent. As a result, my colleagues and I enjoy an array of diagnostic technology; slitlamp biomicroscope camera, non-mydriatic fundus camera, visual field analyser, corneal topographer, and in 2013, our practice became one of the first in Queensland to procure an Optos optomap ultra-widefield (UWF) retinal scanner.

In late 2020, it came time to upgrade our UWF scanner, and the right choice for the needs of our practice was the Optos Daytona Plus.

The process of swapping the old for the new machine was straightforward. We set aside half a day for the Optos technicians to remove the old instrument, and for the new unit to be installed and set-up.

Our existing patient database was able to be transferred from the previous server without issue. The patient profiles were available to us that day, so by that afternoon, we were able to access existing patient profiles and capture images straight away. The considerable image database took longer to transfer, around two weeks, so previous images were unavailable for this time. However, due to our usual process of attaching optomap images to the patient's file in our practice management software, this was only a minor inconvenience.

Case number one

A 54-year-old female was referred to our practice for Optos imaging by a local optometrist. She had been found to have a pigmented lesion in her temporal right fundus. Imaging with the Daytona Plus revealed a 10.8 x 6.1 mm Congenital Hypertrophy of the Retinal Pigment Epithelium (CHRPE) in the temporal periphery of the right fundus.

Figure 1.
The colour composite image, with ruler measurements

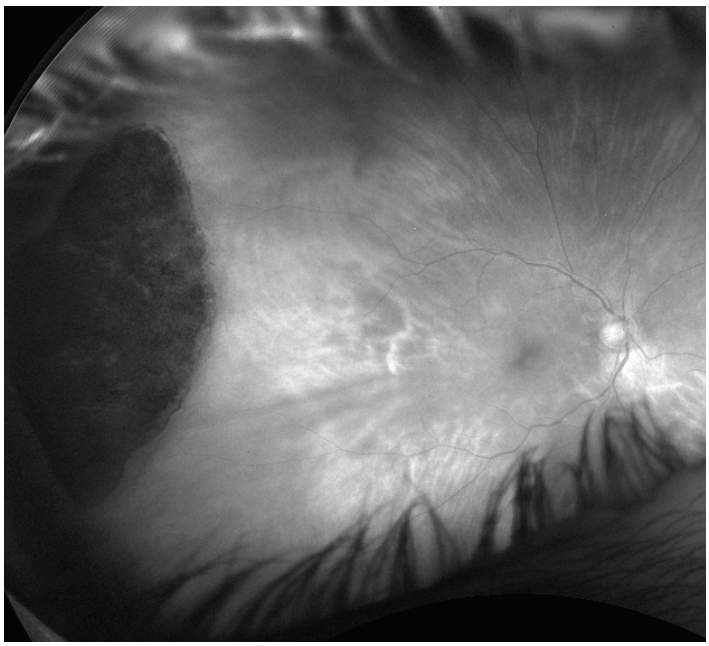

Figure 2.
The red laser (green-free) view, which nicely highlights the lesion in the RPE

The benefits of the new unit were apparent straight away. The footprint of the Daytona Plus is smaller, freeing up much-needed space. The new unit is a lot quieter, due to it not having the internal fans. Images are captured with a single touch of the screen, or alternatively, I have been enjoying the auto-capture function, which leaves both hands free to help position the patient against the head rest. The 200-degree image is captured within half a second, allowing for instantaneous, simultaneous viewing of the posterior pole and peripheral retina. Eye steering extends the field of view even further, by taking subsequent images while directing the patient's gaze up, down, left, or right. I have detected many a small retinal tear or hole far into the periphery using this feature over the years. There is a noticeable improvement in the definition of the images, especially at the posterior pole, when compared to our previous model.

The Daytona Plus takes non-mydriatic, high-resolution images through a pupil as small as 2 mm. We offer imaging with this technology to every patient, from paediatric to geriatric. When compared to my standard non-mydriatic fundus camera, the Daytona Plus is far superior at capturing images through small pupils, especially when there is a cataract. This often means the difference between being able to capture a quality image for a patient with miotic pupils at the initial visit and having to bring them back for a dilated fundus examination (DFE) at a second visit.

The Daytona Plus uses 3-in-1 Colour Depth Imaging; low power laser wavelengths that scan simultaneously, which allows for review of the retinal substructures in their individual laser separations:

- → Composite colour
- → Sensory view (green-laser): from the sensory retina to pigment epithelial layers
- → Choroid view (red-laser): from the RPE to the choroid

Autofluorescence with green laser light displays lipofuscin in the RPE, to aid in the diagnosis of conditions such as certain retinal dystrophies, optic disc drusen, central serous chorioretinopathy (CSC) and geographic atrophy, to name a few.

Daytona Plus comes with OptosAdvance browser-based software, which allows for simple documentation and monitoring. optomap Auto Montage enables a series of images to be montaged to show over 95% of the retina.[1] Measurement software allows quick and easy distance and area measurements, which I find particularly useful for measuring the size of naevi and other retinal lesions.

Our Optos Daytona Plus is only new to our practice, but I am already impressed, and I look forward to continuing to explore and learn, to become more adept at using the software and its many features. Optos ultra-widefield retinal scanning is certainly technology that I would not want to be without in optometry practice. It gives me confidence that, in conjunction with our other diagnostic equipment, we provide our patients with a comprehensive retinal examination every time.

1. Nagiel et al. Ultra-Widefield fundus imaging. *Retina* 2016; 36:4.

Case number two

A 57-year-old female presented to our practice with a four-day history of flashes and floaters in her right eye. The patient had been noted to have a large choroidal naevus in the right eye at the posterior pole at her first presentation in 2013, with documented growth between 2016 and 2020. A second, smaller naevus, with drusen, was noted in the superior fundus. Figure 3 shows the colour composite auto-montage image. There were no retinal holes or tears detected. Figure 4 shows the fundus autofluorescence (FAF) image, which shows the absence of hyper-fluorescence. The patient had been under the care of a local ophthalmologist, but due to the location of the larger naevus and the increase in its size, the patient was referred to an ophthalmologist with interest in ocular oncology. The lesion was flat, with no orange pigment or subretinal fluid. The naevus was deemed stable, and a review in 12 months was recommended, unless any earlier symptoms arose.

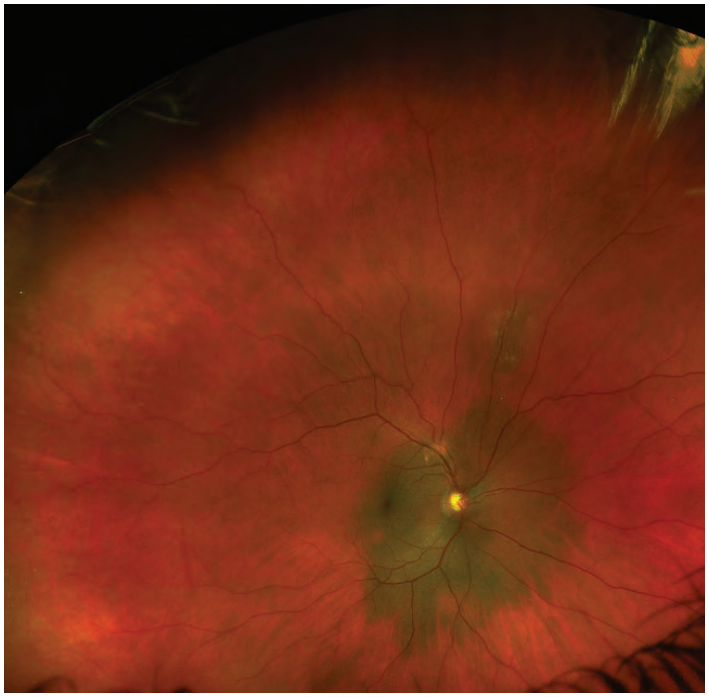

Figure 3.
Colour composite auto-montage image

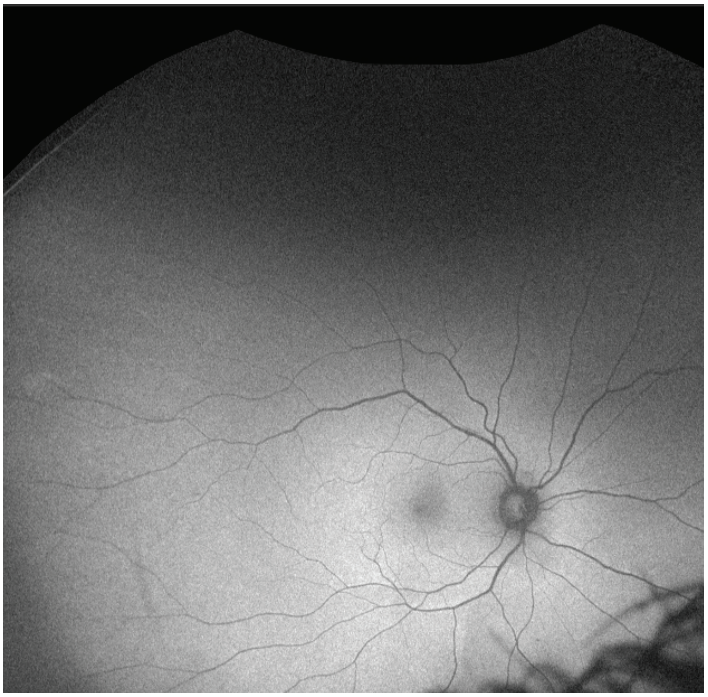

Figure 4.
Fundus autofluorescence (FAF) image

Pupil anisocoria

A clinical approach

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Anisocoria or asymmetrical pupils is a common clinical finding associated with conditions ranging in severity from benign to life-threatening. The dysfunction typically lies within the efferent pupillary pathway of either the sympathetic or parasympathetic nervous system causing the dilator or sphincter muscle of the iris to respond poorly to differing levels of illumination.[1]

Adopting a practical and efficient evaluation process for anisocoria, including pharmacological testing, can expedite the decision to reassure a patient of a benign cause or urgently refer them for further investigation.

Clinical approach to anisocoria

Before establishing aetiology, the optometrist must determine which pupil is abnormal. Pupil reaction to bright or dim illumination is a simple technique to ascertain which pupil is impaired. The abnormal pupil will either fail to constrict or dilate, identifying the dysfunction is either in the iris itself or within the sympathetic or parasympathetic neural pathway.

Information about the duration of the condition can establish its severity. Acute presentations are more likely associated with life-threatening conditions than long-standing anisocoria. Careful history taking, reviewing old photographs or assessing the iris for the presence of heterochromia—a characteristic of congenital Horner's Syndrome—may confirm a long-standing case.

Anisocoria with normal light-reactive pupils

Differential diagnoses

The most common differential diagnoses of anisocoria with normal light-reactive pupils include physiological anisocoria and Horner's Syndrome.[2] Physiological anisocoria is typically present at birth and is found in approximately one in five people. Patients are generally asymptomatic, have less than 1 mm difference in pupil size, good visual acuity, no ptosis, normal ocular movements and both pupils react normally to bright or dim illumination.[3]

Horner's Syndrome is a rare condition occurring from damage to the oculo-sympathetic pathway. Various levels can be affected along this long pathway with central and preganglionic Horner's Syndrome classified as a disruption to the first order and second order neurons respectively and postganglionic Horner's Syndrome a disruption of the third order neuron (Figure 1).[4]

A myriad of clinical signs are associated with Horner's Syndrome but the classic triad includes ptosis, miosis and anhidrosis (loss of sweating on the side of the Horner's pupil). The miotic pupil reacts normally to light but exhibits a dilation lag in the dark compared to the normal pupil. There may also be an upside-down ptosis, a slight elevation of the lower lid due to reduced sympathetic supply, giving rise to an apparent enophthalmos. The presence of iris heterochromia suggests a congenital or long-standing lesion with birth trauma being the most common cause of Horner's Syndrome in children.[4]

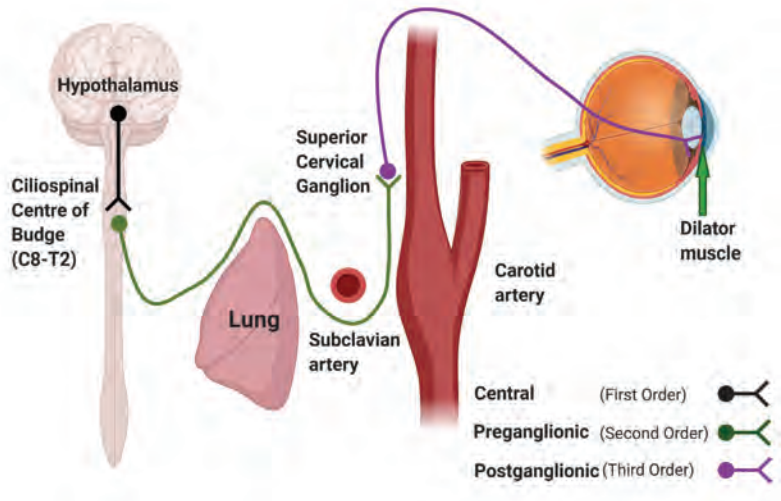

Figure 1.
Three neuron oculo-sympathetic pathway

Anisocoria with one pupil that is poorly reactive or non-reactive to light

Differential diagnoses

Disruption to the parasympathetic pupillary fibre pathway often produces a poorly reactive or non-reactive pupil to light (Figure 2). Clinically, this results in a dilated pupil due to the unopposed action of the

sphincter muscle. Iris sphincter damage, Adie's tonic pupil, third nerve palsy, pharmacologic blockade and intermittent unilateral pupillary mydriasis caused by conditions such as migraine are common differential diagnoses that must be considered when evaluating the cause of iris sphincter dysfunction.[1]

Adie's tonic pupil is mostly idiopathic but can be caused by infections, trauma and tumours. It is more common in woman aged between 30 and 50, with the mean age around 32.2 years and is unilateral in 80 per cent of presentations but can become bilateral over time.[5] The dysfunction typically occurs at the site of the ciliary ganglion affecting the postganglionic parasympathetic supply innervating the ciliary body and iris.

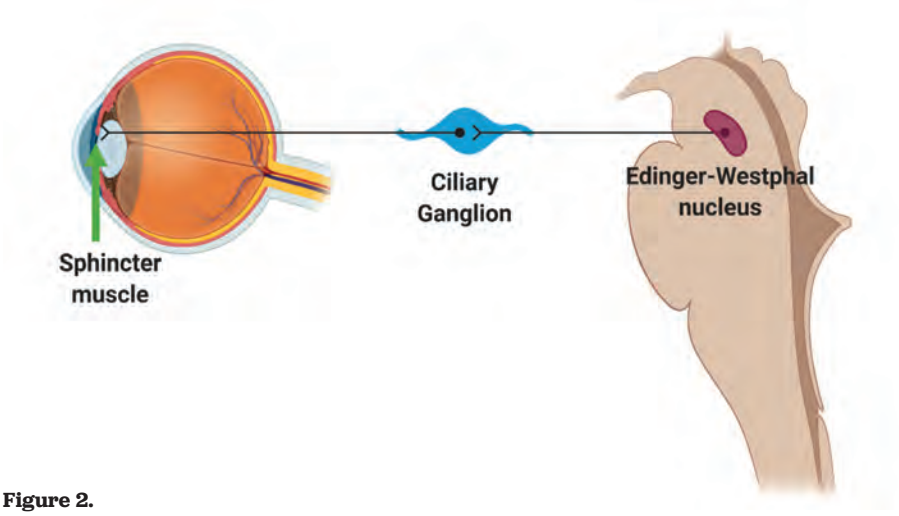

Figure 2.
Parasympathetic pupil pathway

Diagnostic features of Adie's tonic pupil include a dilated pupil with poor or no light reaction but increased pupillary constriction - due to accommodation - to a near target. Tonic near constriction remains with slow re-dilation upon returning to distance gaze. Ninety-four per cent of patients will exhibit segmental denervation of the iris sphincter and vermiform 'worm-like' movement of the pupillary border.[6] The tonic pupil over time (months to years) can become smaller often referred to as 'little old Adie's pupil.'[7] Patients can present with symptoms such as photophobia, blurred vision at near and headaches due to accommodative dysfunction.

Pharmacological evaluation of anisocoria

Pharmacological evaluation can be an important clinical test when trying to differentiate the various causes of anisocoria. It can be especially useful for assisting in obtaining a diagnosis for Adie's tonic pupil and Horner's syndrome as well with localising the dysfunction.

Adie's tonic pupils have a reduced rate or no acetylcholine release at the iris sphincter neuromuscular junction causing upregulation of the postsynaptic muscarinic receptors. As such, low concentrations of a cholinergic agent produces a pupillary response that would usually be ineffective in a normal pupil. Pilocarpine 0.1%, a 10% diluted form of the commercially available 1% pilocarpine, is the agent of choice for testing Adie's tonic pupils. This low concentration will markedly constrict the sphincter muscle of an Adie's tonic pupil whereas the normal pupil will remain unchanged.[1]

Horner's Syndrome similarly sees an upregulation of alpha-1 receptors on the dilator muscle when there is a decrease in sympathetic nerve activity anywhere from the first-order neuron to the third. Pharmacological testing for Horner's Syndrome serves a dual purpose; to establish a diagnosis and localise the lesion.

For diagnosis, cocaine or apraclonidine topical drops are applied. Cocaine (not available in Australia) blocks the reuptake of noradrenaline at the sympathetic nerve synapse with the iris dilator muscle.[1] In eyes that have normal sympathetic innervation, cocaine will cause pupillary dilation due to an increase in noradrenaline accumulating in the synaptic cleft (Figure 3). Conversely, with sympathetic denervation it will have no effect on the dilator muscle regardless of the lesion location as little or no noradrenaline is being released by the postganglionic neuron.

Apraclonidine 0.5%, a strong alpha-2 and weak alpha-1 adrenergic receptor agonist causes the abnormal miotic pupil to dilate due to upregulation of the alpha-1 receptors on the dilator muscle but no response in normal eyes.[8] Studies have shown this response occurs in both preganglionic and postganglionic lesions thus is not useful in localising the lesion.[9] Paediatric patients should be excluded from apraclonidine testing due to side effects such as lethargy and bradycardia.[10]

Localisation of the oculo-sympathetic dysfunction in Horner's Syndrome is important as first and second order lesions are considered to be associated with a higher incidence of malignancy.[4] Hydroxamphetamine and phenylephrine are the two most common pharmacological agents used to help localise central and preganglionic lesions from postganglionic.

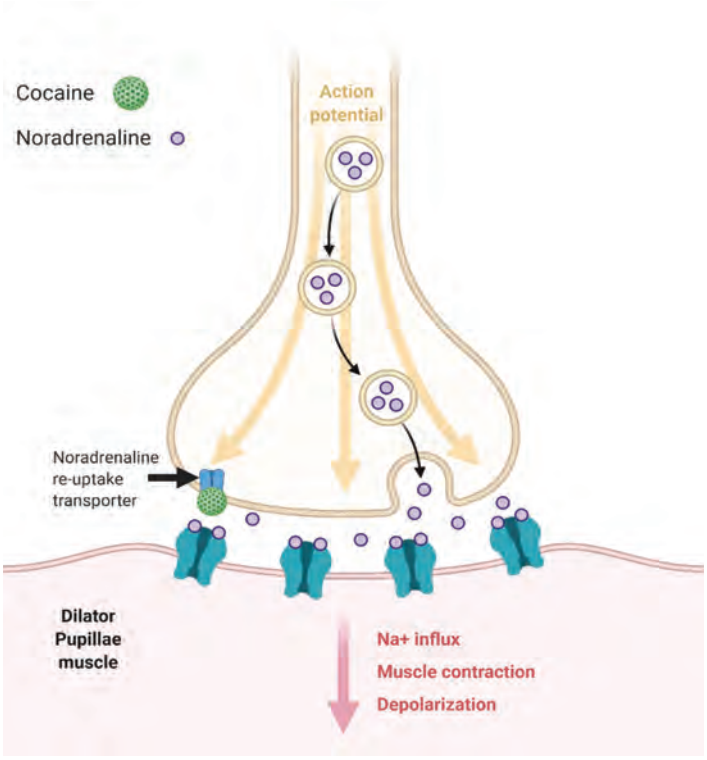

Figure 3.
Blockage of noradrenaline re-uptake from cocaine

Hydroxyamphetamine, also not available in Australia, stimulates the release of noradrenaline (NA) from the postganglionic neuron. This results in dilation of a normal pupil and a central or preganglionic Horner's pupil. In a dysfunctional postganglionic neuron stores of noradrenaline will be depleted so there will be no pupil response.

Phenylephrine, an alpha-1 agonist, has been found to have excellent sensitivity (81 per cent) and specificity (100 per cent) in identifying post-ganglionic Horner's Syndrome.[11] Phenylephrine 2.5% is diluted by 10% to 0.25% and instilled in both eyes. A postganglionic Horner's pupil will dilate with low-dose phenylephrine due to denervation hypersensitivity but a central or preganglionic Horner's pupil as well as a normal pupil will have no response. A summary of the different pharmacologic agents used for diagnosis and localisation can be seen in Table 1.

	For diagnosis		For localisation	
Site	Cocaine (Blocks reuptake)	Apraclonidine (Activates receptor)	Hydroxyamphetamine (Stimulates noradrenaline (NA) release)	Phenylephrine 0.25% (Activates receptor)
Normal	Dilates	No change	Dilates	No change
Central/Pre-ganglionic	No/minor change	Dilates	Dilates	No change
Post-ganglionic	No change	Dilates	No change	Dilates

Table 1.
Summary of pharmacologic testing for Horner's Syndrome

Clinical diagnostic algorithm

A clinical diagnostic algorithm can be a useful tool for optometrists when trying to differentiate between possible aetiologies. Using a step-by-step approach can narrow down the clinical diagnosis and aid optometrists in making expedient and possibly life-saving diagnostic decisions (Figure 4).[12]

Conclusion

Anisocoria has a wide range of causes and requires a methodical evaluation, including pharmacological testing, to rule out serious conditions associated with mortality. While long-standing cases are most likely benign, acute cases of anisocoria may require urgent referral for further investigation.

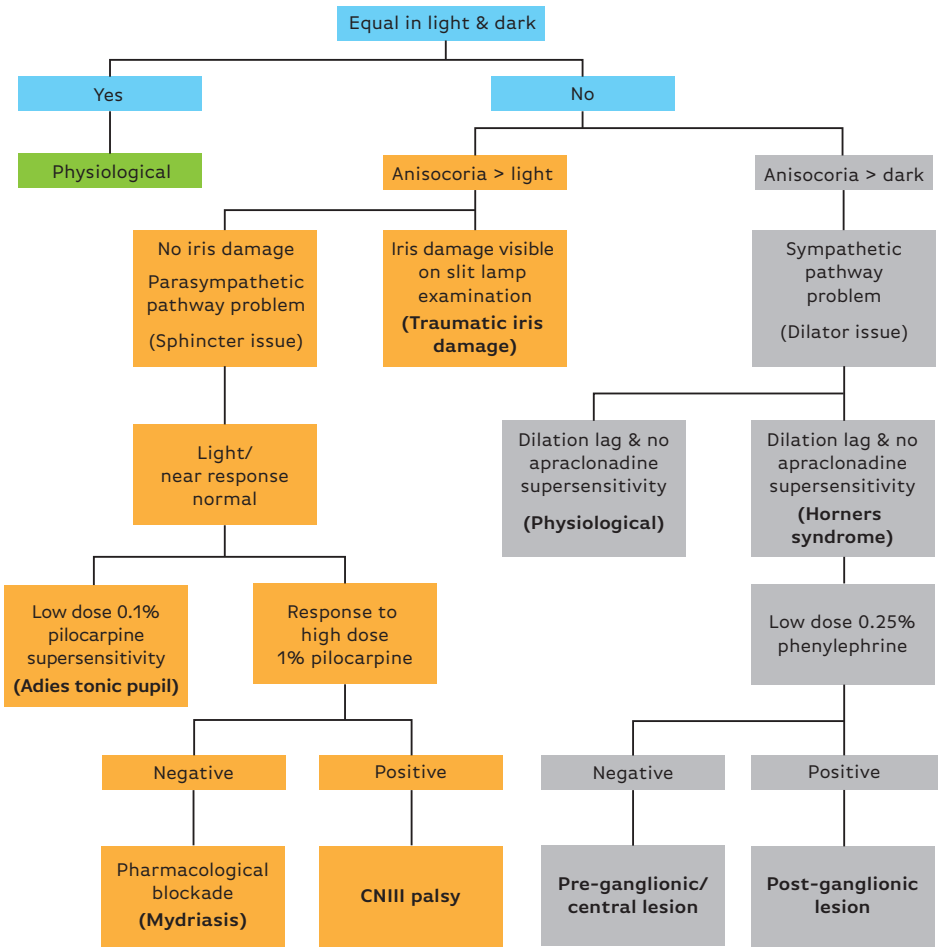

Figure 4.
Anisocoria Clinical Diagnostic Algorithm

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This original case report was submitted by Optometry Australia member Hayley Birch in response to our call for papers.

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Acute visual field loss:

Could a cotton wool spot cause that?

Cotton wool spots (CWSs) are grey-white retinal lesions with fluffy margins of 0.1-1 mm in diameter[1] and are found at the level of the innermost retinal layer. CWSs are composed of localised accumulations of axoplasmic debris within adjacent bundles of unmyelinated ganglion cell axons.[2] They occur after arterial occlusion at the borders of large ischemic areas but should not be regarded as a retinal nerve fibre layer infarct.[2] A discussion by McLeod argues that CWSs are better defined as cotton wool 'sentinels' or indicators of vascular insufficiency to a particular area within the retina, rather than retinal infarcts.[2]

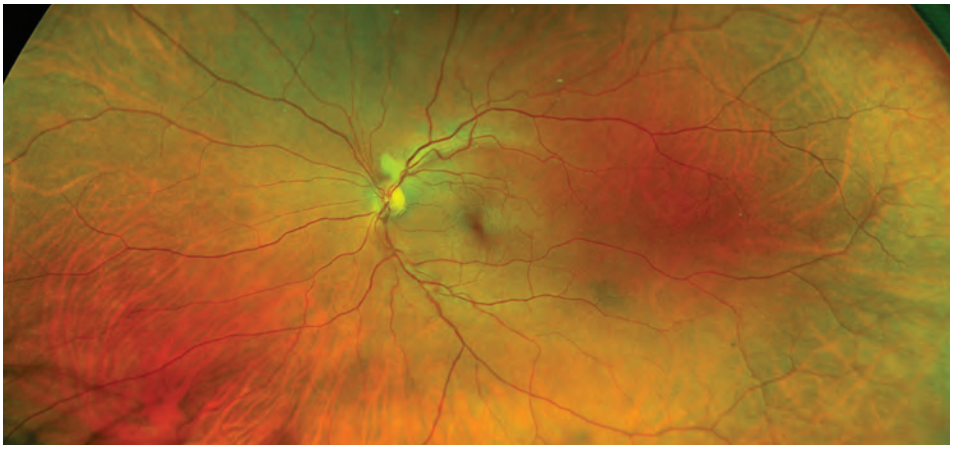

Figure 1.
CWS superior to the left optic nerve head

CWSs are uncommon in healthy patients, and therefore should be considered a 'red flag' for further investigation of systemic health. They are often seen in patients with diabetes, hypertension, retinal artery or vein occlusion and ischaemic optic neuropathy and often coexist with other features of retinopathy such as haemorrhages, exudates or oedema.[3,4] However, the presence of CWSs has also been reported in cases of systemic infection such as human immunodeficiency virus (HIV), immune and collagen vascular disorders, embolisms and malignancy.[3]

One study attempted to differentiate types of CWSs by their aetiology with a focus on CWSs caused by HIV compared to those seen in hypertension, diabetes and central retinal vein occlusions (CRVO). The study found that CWSs are smaller in size in HIV patients and the number of CWSs was higher in patients with CRVO.[3] There were no other significant differences reported.

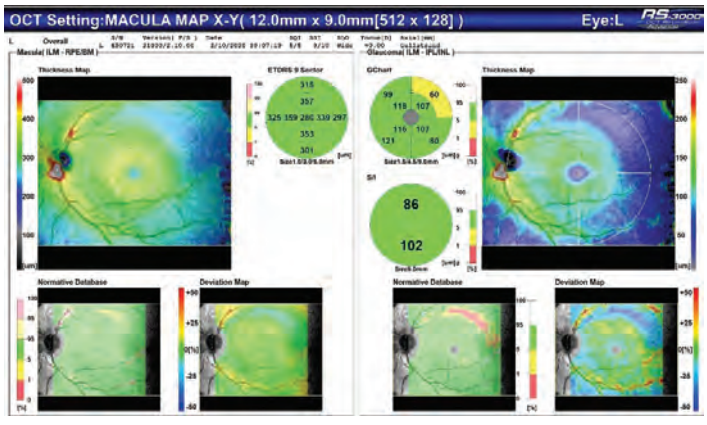

Figure 2.
OCT shows thickening of the inner retina at the location of the CWS

Due to the number of associated conditions, and the difficulty identifying a specific aetiology, both systemic and ocular differentials must be considered when CWSs are found on ophthalmoscopy. Ocular differentials for CWSs include any retinal lesion that appears white or yellow-white such as myelinated nerve fibre layer, commotio retinae, hard exudate, astrocytic hamartoma, retinal necrosis, active posterior uveitis, retinitis or vasculitis.[4]

Most patients with CWSs will be asymptomatic unless the cotton wool spot involves the central retina or fovea.[5] Reported symptoms include relative or absolute arcuate scotoma and/or blurred vision.[6] Following ophthalmoscopic resolution of the CWS, visual function does not always recover.[7] Differential diagnoses for these symptoms of CWSs include, but are not limited to, amaurosis fugax, migraine with aura, retinal detachment, optic neuritis and glaucoma.

Case report

Initial appointment

A 47-year-old male presented urgently to the practice reporting sudden, painless loss of his inferior visual field in his left eye. He did not have any recent trauma, photophobia or blurred vision. His prior ocular history showed a recent diabetic eye examination at the same practice a few months ago which showed no diabetic retinopathy of the left eye but a small isolated CWS in the right eye. At that time, the attending optometrist advised he quit smoking which the patient was successful in doing.

Vision was 6/6 in both eyes. Undilated fundus biomicroscopy showed resolution of the CWS in the right eye, but the presence of a new, larger CWS superior to the left optic nerve head (Figure 1).

Optical coherence tomography (OCT) demonstrated thickening of the inner retina at the location of the CWS. This is consistent with

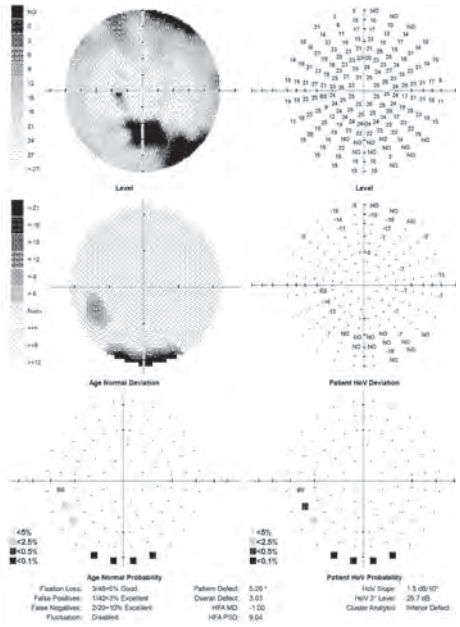

Figure 3.
inferior arcuate defect shown

the theory of accumulation of axoplasmic debris at the level of retinal ganglion cell axons,[2] visible with fundus biomicroscopy, as a CWS. There was also an adjacent area of arcuate shaped retinal thinning evident on the retinal thickness map (Figure 2). This could also be appreciated with the red-free filter on both slitlamp and on the ultra-widefield retinal image.

Medmont monocular full field testing showed an inferior arcuate defect in his left eye (Figure 3).

The patient was reassured that vision loss was related to the presence of the CWS with expectation of improvement over the next few weeks. A six-week review appointment was made and the patient was referred to see his general practitioner for a cardiovascular work-up (blood pressure measurement) and full blood test to rule out other underlying systemic causes including both vascular (hypertension, diabetes, hyperlipidaemia) and infectious causes of CWSs.

Review appointment

The patient returned for a review after six weeks reporting return of his left inferior visual field after approximately one week. Vision remained excellent at 6/6, undilated fundus biomicroscopy showed 90 per cent resolution of the CWS in the left eye (Figure 4). OCT was consistent showing reduced inner retinal thickening at the location of the CWS and no further thinning of the arcuate retinal defect. Medmont monocular full field testing showed significant improvement.

The patient reported he was undergoing further testing of his systemic health with his general practitioner. A three-month review was scheduled to check for complete resolution of the CWS.

Discussion

In patients with CWSs and no known medical history of diabetes, 20 per cent are found to have elevated blood glucose level and 50 per cent have an elevated blood pressure measurement (diastolic blood pressure of 90 mmHg or greater).[5]

Expected resolution of CWSs is relatively dependent on the underlying cause and size of the CWSs, as well as age of the patient. Most CWSs disappear within 4-12 weeks, however some studies have found that CWSs in diabetic patients can persist up to 8.1 months in those < 40 years old, and 17.2 months in those > 40 years old.[8] One study found that the small CWSs associated with HIV have a significantly shorter resolution time within an average of 6.9 weeks.[9] CWSs in hypertensive patients show similar resolution times to those seen in HIV patients. Overall, CWSs associated with hypertension or HIV resolve quicker than those associated with diabetes.

This case highlights the usefulness of OCT in giving optometrists not only a better understanding of the full extent of retinal pathology, but also enabling them to predict a visual outcome. OCT in the context of CWS will demonstrate retinal thickening at the location of the CWS on a retinal thickness map and generalised retinal thinning adjacent to the CWS. OCT radial scans show the location of the thinning extending from the ganglion cell layer to the outer plexiform layer.[7,10]

In this case, we saw a CWS with adjacent superior arcuate retinal thinning with a corresponding inferior arcuate visual field defect. We can use OCT technology in this same way to also predict visual field loss based on correlating retinal thinning in other cases such as glaucoma or stroke.[11]

Every CWS will leave a permanent inner retinal defect most easily appreciated with OCT due to the permanent change to the innermost retinal layers. Symptomatic vision loss due to CWSs is most likely caused by a CWS in the location of the posterior pole or fovea with the most common aetiology being underlying diabetes or hypertension.[5]

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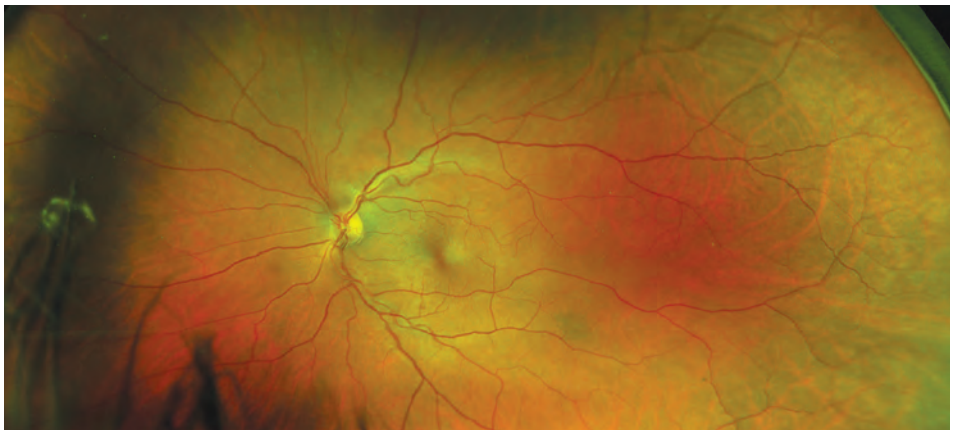

Figure 4.
A 90 per cent resolution of the CWS in the left eye

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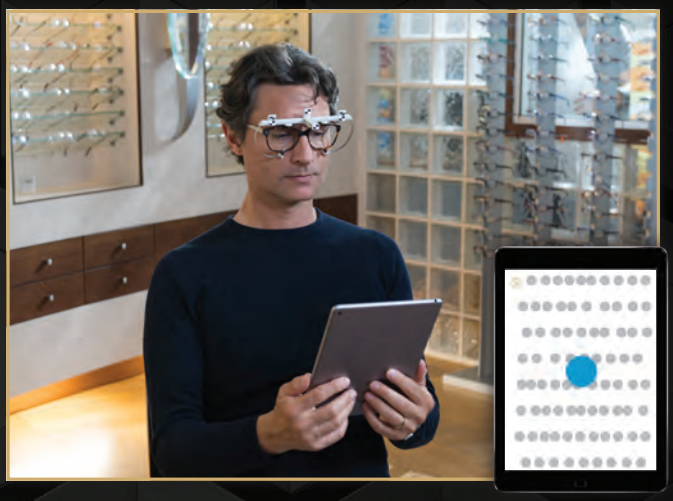

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