

Glaucoma detection for the domiciliary optometrist.

Paper One: Assessment

C 16976 (O)

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GOC Registered Optometrists

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Paper 1: Assessment

Glaucoma describes a group of diseases that share the same common feature of progressive optic neuropathy. Glaucoma results in characteristic damage to the optic nerve head and retinal nerve fibre layer, which can produce characteristic functional vision loss i.e. visual field defects. If progressive this damage is potentially blinding.

Why is glaucoma an important public health issue?

Glaucoma is the leading cause of preventable blindness in the UK, accounting for ~10% of all registrations for both severe sight impairment and sight impairment in England&Wales.¹ The total cost to the UK economy of sight impairment/severe sight impairment is estimated to be £4.1-£8.8 billion annually.²

Glaucoma is principally a disease of ageing, the prevalence increasing with increasing age.³ The UK has a growing elderly population. It is estimated that 25% of the population will be aged over 65 by the year 2034.⁴ The number of people affected by glaucoma is therefore going to increase with this increasingly aged population. There is also likely to be an increase in the number of elderly people living in care-homes or receiving home-care. There are thought to be ~ 1.77 million people in England receiving home-care of some type from their local council of which ~336,000 people are resident in care-homes⁵ ~50% of whom are aged ≥85years.⁶ Domiciliary optometrists will play an increasingly vital role in the detection of glaucoma in this growing population of elderly people.

What is glaucoma? - Definitions & Classifications

Glaucoma is defined by the National Institute for Clinical Excellence (NICE) as:

*"A disease of the optic nerve with characteristic changes in the optic nerve head (optic disc) and typical defects in the visual field with or without raised intraocular pressure."*⁷

A detailed review of the glaucomas is beyond the scope of this article but excellent reviews are widely

available.^{8,9} The glaucomas can be classified as either primary or secondary, where primary glaucoma occurs in the absence of any underlying systemic or ocular condition e.g. Primary Open Angle Glaucoma (POAG). Secondary glaucomas develop as a consequence of ocular or systemic co-morbidity e.g. neovascular glaucoma secondary to a central retinal vein occlusion. Furthermore, the glaucomas can be classified as either open-angle or closed-angle. In open-angle glaucomas the trabecular meshwork of the drainage angle is visible (as determined by gonioscopy) whereas in closed-angle glaucomas there is contact (apposition) between the peripheral iris and trabecular meshwork, which impedes the outflow of aqueous humour.

Primary open-angle glaucoma is the most frequently encountered glaucoma in the UK. It has a prevalence of ~2% in the white European population aged over 40 years. This increases to approximately 10% in the over-75s. POAG is more prevalent in the Afro-Caribbean population, who are at least five-times more likely to develop glaucoma than Caucasians.^{10,11}

A major risk factor for glaucoma is raised IOP.^{10, 12} A raised IOP of >21mmHg (by Goldmann applanation tonometry, GAT) in the presence of an open anterior-chamber angle and the absence of glaucomatous optic neuropathy (GON) is termed ocular hypertension (OHT). The prevalence of OHT is estimated at 2.7% to 7.5%,¹³ higher than the estimated prevalence of COAG.

How do we detect glaucoma?

The detection of glaucoma relies on performing a comprehensive clinical exam, including a thorough history and symptoms, anterior segment examination, gonioscopy, slit-lamp mounted Goldmann applanation tonometry (GAT), standard automated perimetry (SAP) and assessment of the optic nerve by slit-lamp binocular indirect ophthalmoscopy (SLMBIO). The unique circumstances of the domiciliary setting preclude some or

even all of these assessments, so the examination has to be modified accordingly.

Intra-ocular pressure and Tonometry

The normal range of IOP is taken as 10-21mmHg, providing an average of 15.5mmHg. This assumes a normal distribution of IOP in the general population. Studies indicate, however, that the distribution of IOP is skewed more towards higher levels. When used in isolation, tonometry is a poor glaucoma detection test with a sensitivity of just 50% for an IOP cut-off point of >21mmHg. Effective detection is best achieved when a combination of tonometry, visual fields assessment and optic disc evaluation are used.¹⁴ Table 1 summarises the main features of the various forms of tonometer available to practitioners.

	GAT	Perkins	Tonopen	Pulsair	iCare
Contact	✓	✓	✓	x	✓
Non-contact	x	x	x	✓	x
Anaesthesia	✓	✓	✓	x	x
Portability	x	✓	✓	✓ or x	✓
Repeatability /reliability	✓	✓	✓ or x	✓	✓

Table 1: Comparison of different methods of tonometry

Figures 1-3 shows some of the commonly used tonometers currently used in community practice:

Slit-lamp mounted GAT is widely considered to be the “gold standard” method of tonometry, against which all other forms of tonometry are compared. It is clearly impractical for the domiciliary setting. The portable Perkins tonometer is as accurate, but requires a greater degree of manual dexterity from the practitioner and greater co-operation from the patient. The Tonopen (Figure 2) is a highly portable contact device, but as with GAT and Perkins tonometry (Figure 1b) it requires corneal anaesthesia. The Keeler Pulsair range of tonometers are popular in high-street practice for their ease of use and relative portability within the practice setting. They are quite bulky and heavy, and for this reason many of the major domiciliary providers have sought alternative forms of tonometry. One such alternative is the iCare Impact-Rebound tonometer (Figure3). This is also highly portable and has been shown to compare favourably to GAT and the Pulsair NCT.^{15,16} It is also reported to be very comfortable for the patient. Although a contact device, it does not require corneal anaesthesia.

It is important to remember that the IOP measurements of all the tonometers discussed will be influenced by the central corneal thickness (CCT). The CCT can be measured by hand-held pachymetry devices, but this assessment does not form part of a statutory GOS sight-test and is currently not routinely performed by community Optometrists.



Fig 1a The Goldmann Applanation Tonometer (GAT) is slit lamp mounted and although considered the ‘gold standard’ for tonometry measurements, is not practical for use in a domiciliary setting



Figure 1b The principle of the Perkins applanation tonometer is based upon the GAT. It is highly portable and is as accurate, but requires a greater degree of manual dexterity from the practitioner and greater co-operation from the patient.



Figure 2: The Reichert TONO-PEN XL(a) The TONO-PEN AVIA (b). The metal transducer contact tip (c). The OCULO-FILM®+ latex tip covers protect TONO-PEN brand tonometers from dust and fluids, and help protect patients from the risks of cross contamination. The tip covers also feature a textured surface skin to reduce sticking to itself and the metal transducer tip during application

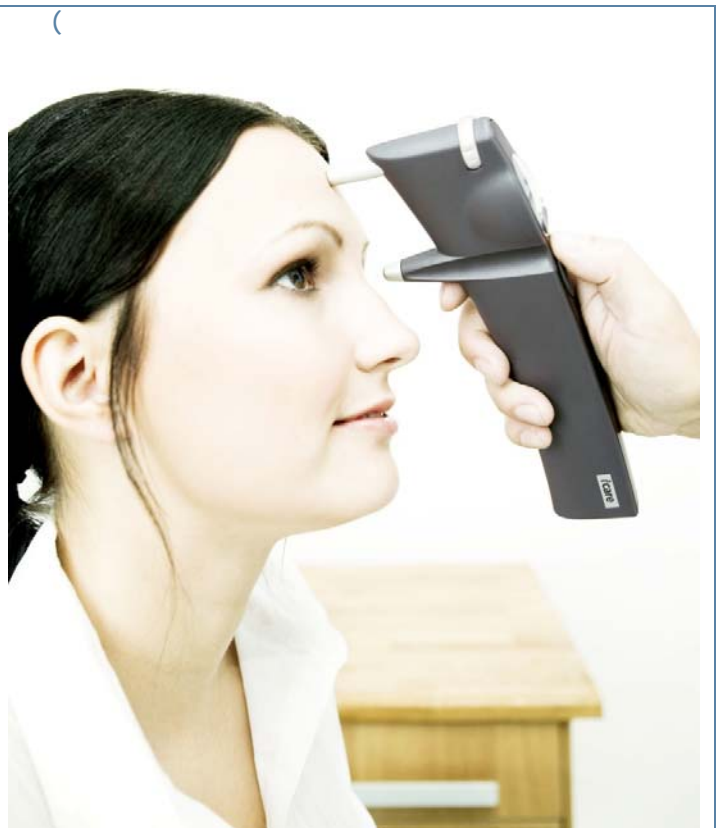


Figure 3: The iCare apparatus from Finland OY gained approval for medical human usage in 2003. The instrument is handheld, lightweight, portable and very non-invasive with no need for anaesthesia making it ideal for use on domiciliary patients.
Photographs Reichert & Tiolt, with permissions)

Optic Disc Assessment -How do we examine the optic disc?

Slit-lamp binocular indirect ophthalmoscopy (SLMBIO) provides the best possible assessment of the disc and fundus. It provides a stereoscopic image, which greatly improves the ability to detect depth and contour, and to detect subtle changes to the optic nerve configuration.

SLMBIO is not practical for domiciliary testing, the majority of internal ocular examinations being conducted with a direct ophthalmoscope. In Scotland, however, it is mandatory to be able to perform an internal examination of the eye using a hand-held SLM and condensing lens.¹⁷ Although a difficult skill to master, the improved view of the disc, macula and peri-papillary area provided is worth the effort. In the author's experience in a hospital setting where patients are unable to be examined at the SLM as it may be unsafe to transfer them from a wheelchair, a hand-held SLM and condensing lens provide a far superior view than the direct

ophthalmoscope. For practitioners without access to a hand-held SLM a good view of the fundus and optic disc can be obtained with the PanOptic direct ophthalmoscope (Welch-Allyn) which claims to provide a 5x larger view of the fundus than achieved by a standard ophthalmoscope through undilated pupils. It has the additional advantage of a longer working distance, which may be more acceptable for patient and practitioner alike. The presence of cataract will make visualisation of the fundus and optic nerve more difficult and so it may be necessary to dilate the pupils. All forms of ophthalmoscopy require good co-operation, which may not be possible for some patients particularly those with severe dementia. It is for each individual optometrist to decide on the most appropriate form of ophthalmoscopy and the need for dilation for each individual patient. In some cases, it may simply be impossible to obtain any meaningful view of the fundus or the optic disc in particular.

What changes to the disc might suggest the presence of glaucoma?

Glaucoma causes characteristic changes to the normal appearance of the optic disc. These changes can often precede detectable glaucomatous visual field (VF) loss. Some of these changes are strongly associated with the presence of glaucoma whilst others are less so. **Table 2** summarises the main features of glaucomatous changes to the optic nerve.

Features strongly suggestive of glaucoma	Features indicating possible glaucoma
NRR changes: <ul style="list-style-type: none"> • Diffuse enlargement of the optic cup • Localised thinning of the NRR • Focal notches in the NRR 	Cup:disc ratio >0.6
	Cup:disc ratio asymmetry >0.2
	Nasal displacement of the blood vessels
Optic disc haemorrhages, without evident secondary cause, e.g. PVD	Bayonetting of the optic nerve blood vessels
Horizontal CDR > vertical CDR	Non-conformity to the ISNT rule
Vertical cup:disc ratio >0.85 (less in small discs)	Prominent lamina cribrosa
	Peripapillary atrophy

Table 2: Typical glaucomatous changes to the optic disc

Neuro-retinal rim changes

The optic cup enlarges in glaucoma due to retinal nerve fibre atrophy. The nerve fibres may be lost diffusely, locally or both. Diffuse loss leads to a generalised enlargement in the CDR over time e.g. from 0.3 to 0.7 (**Figure 4**) Localised loss causes regional changes in the thickness of the the NRR e.g. the ISNT rule is no longer obeyed. Nasal thinning of the NRR can cause a displacement of the disc vasculature nasally, or alternatively the major disc vessels may no longer be apposed to the nasal rim, appearing separated from it by an area of pallor where the rim has been lost. A gross example of localised NRR thinning is the NRR notch where rim tissue is very thin or even absent at a particular location. It is believed that the nerve fibres of the superior and inferior poles are most susceptible to localised damage, and so thinning/notching often occurs in these regions.

Optic disc haemorrhages are a recognised sign of glaucomatous nerve damage and are frequently associated with normal-tension glaucoma (**Figure 5**). Often flame/splinter shaped, indicating their presence in the prelaminar optic nerve head in the superficial retinal nerve fibre layer, they can also occur deep within the disc tissue where they appear more blotchy. Disc haemorrhages often resolve over a period of weeks or months, and so their presence should prompt a referral to an Ophthalmologist for further evaluation.

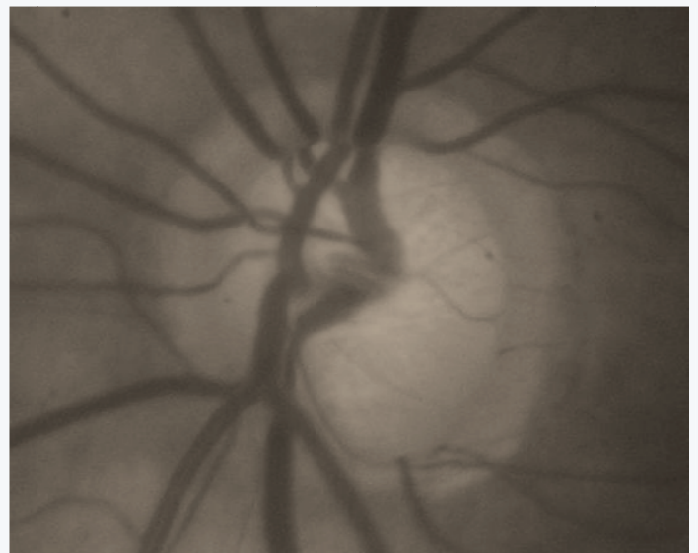
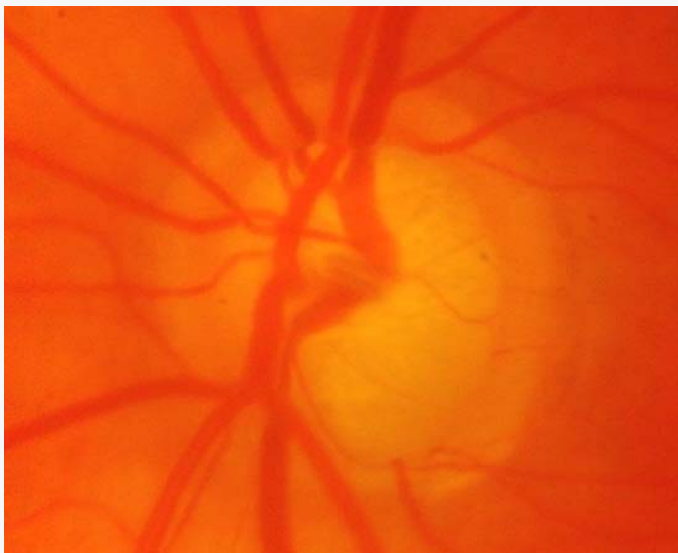


Figure 4 (Left full colour, Right enhanced b/w version)

This advanced glaucomatous disc displays a number of classic features: **i)** increased cup:disc ratio -0.9 (diffuse loss), **ii)** complete loss of the inferior NRR from -3 o'clock to 6 o'clock (focal loss), **iii)** nasal NRR loss and **iv)** vessel bayonetting superiorly (Photograph AT Clarke)

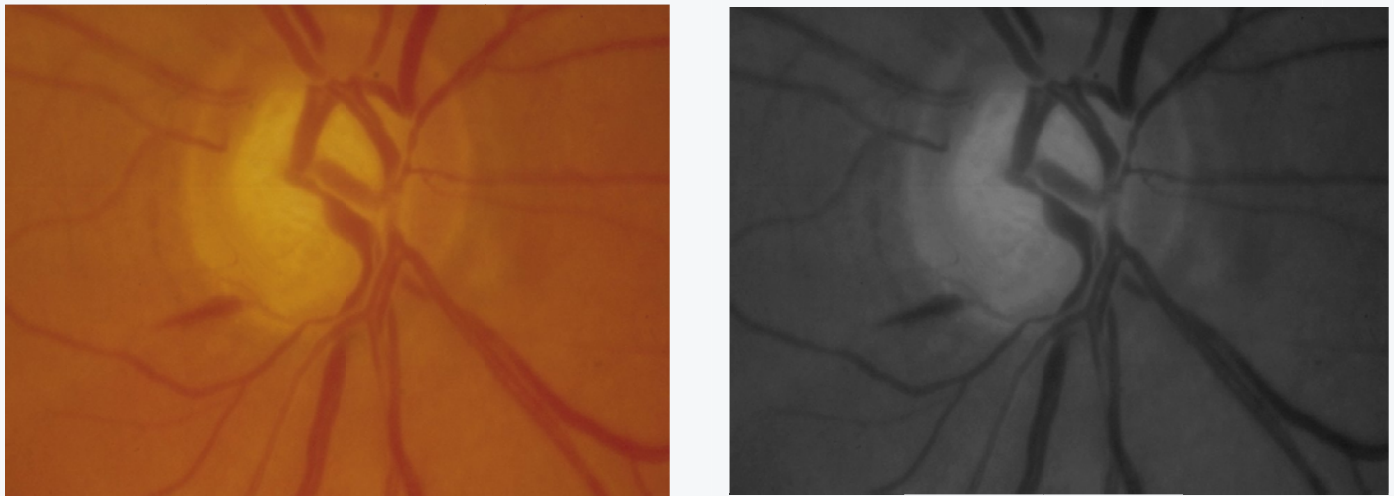


Figure 5 (Left full colour, Right enhanced b/w version) Optic disc haemorrhage (photograph, Kanski, with permissions).

Vessel changes

Changes to the disc vasculature can also be an indication of glaucomatous nerve change. As discussed above, increased cupping of the nasal rim will lead to a displacement of the disc vessels and an increase in the horizontal:vertical CDR. Localised notching of the NRR may cause “bayonetting” or undercutting of the vessel, causing an apparent shift in the position of the vessel as it crosses the edge of the disc and drops into the cup. A subtle glaucomatous sign is “baring” of the circumferential blood vessels. These small vessels often tightly follow the margin of the cup. As cupping increases, NRR tissue is lost and an area of pallor appears between the vessel and the cup margin. This sign can also be observed in large optic discs with large cups. Fly-over vessels occur when there is loss of rim tissue underlying vessels that cross the disc margin. The blood vessel often appears “suspended” in mid-air.

Peripapillary atrophy

Atrophy of the chorioretinal tissue surrounding the optic disc is termed peripapillary atrophy (PPA). It is a common finding in many eyes, especially myopes. It is usually classified into two distinct areas, an outer α -zone and inner β -zone PPA. Alpha-zone PPA represents thinning of the choriocapillaris with areas of hyper- and hypo-pigmented retinal pigment epithelium (RPE). Alpha-zone PPA is a common finding in normal eyes. Beta-zone PPA represents atrophy of the neuroretina and RPE, which exposes the underlying choriocapillaris. Beta-PPA is a recognized feature of glaucoma, and its location can correspond with the site of GVFL (glaucomatous visual field loss). Peri-papillary atrophy is uncommon in the nasal sector of the disc, and so its presence here

should arouse suspicion about possible glaucomatous NRR loss.

Visual Field Assessment - How do we assess the visual field for glaucoma?

Standard automated perimetry (SAP) is the gold-standard assessment of the central visual field. It is essentially a differential light sensitivity test using white light on a white background. Many different programmes and algorithms exist including suprathreshold and full threshold strategies. For glaucoma assessment and monitoring the Humphrey Field Analyzer (HFA) 24-2 full threshold SITA standard algorithm is considered the reference standard method of perimetry.⁷

Clearly the HFA is not suited to the domiciliary setting. Furthermore, many patients in care-homes will be unable to perform SAP because of physical and/or cognitive limitations. Full-threshold VF testing can be time-consuming, fatiguing and extremely stressful for patients, even for those who have capacity. Other methods of visual field assessment, therefore, need to be employed in the domiciliary setting.

Assessment of the Visual Field

Gross perimetry/confrontation perimetry

Gross perimetry and confrontation perimetry are both qualitative forms of visual field analysis. They do not quantify the state of the visual field but instead provide a qualitative assessment as to its overall integrity. Many domiciliary optometrists will be familiar with these two forms of visual field assessment, it being the most

popularly employed method in the domiciliary setting¹⁸ Several excellent articles have been written about gross/confrontation perimetry¹⁹ but as they are not specific to glaucoma detection they will not be covered further here.

The Damato Campimeter

This is a portable screening device that provides a quantitative measure of the central 30° of the visual field (Figure 6) It is glaucoma specific, but it can also detect altitudinal, quadrantic and hemianopic defects. Three versions of the campimeter are available with either 20, 30, or 60 light blue numbers arranged in a specific spiral-pattern around a central target on a white hand-held card. The 20 and 30-point tests are considered ideal for glaucoma visual field screening.

Damato campimetry has been evaluated against automated perimetry in normal and glaucoma patients. A recent study involving a clinical population of patients found an optimal sensitivity of 81% and specificity of 72% based on comparison with a HFA 24-2 programme.²⁰ The same study also found that only 6.5% of patients were unable to perform the test, mainly due to lack of understanding. This study population is not representative of the patients found in the domiciliary setting, many of whom have dementia. Unfortunately, for some patients, even a simple test such as the Damato campimeter will be impossible to perform.

Electronic visual field analysis

The OT survey found that ~18% of domiciliary practitioners have access to electronic VF analysers (eVFAs). Popular eVFAs include the Henson 7000, Oculus Easyfield and the Zeiss Frequency Doubling Technology (FDT) screeners. Table 3 summarises the main features of these three eVFAs.

The FDT perimeter (Humphrey Systems, Dublin, CA and Welch-Allyn, Skaneateles, NY) uses frequency doubling to assess the visual field. Frequency doubling technology (FDT) perimetry uses a low spatial frequency sinusoidal grating which undergoes high temporal frequency flicker i.e. rapid reversal of the light and dark bars. When this occurs the stimulus appears to have double the number of light and dark bars than are actually present, the “frequency doubled” illusion. It is thought that the spatio-temporal characteristics of this stimulus are detected by the magnocellular division of the retinal ganglion cells, which account for only 10-15% of the total retinal ganglion cell population. The FDT stimulus may, therefore, detect retinal ganglion sensitivity loss earlier than SAP. Most patients can perform the FDT test but in the author’s experience a significant minority have great difficulty either understanding the test or appreciating the presence of the stimulus. Where a patient is unable

to perform the FDT reliably an alternative assessment of the visual field should be attempted e.g the Damato Campimeter.

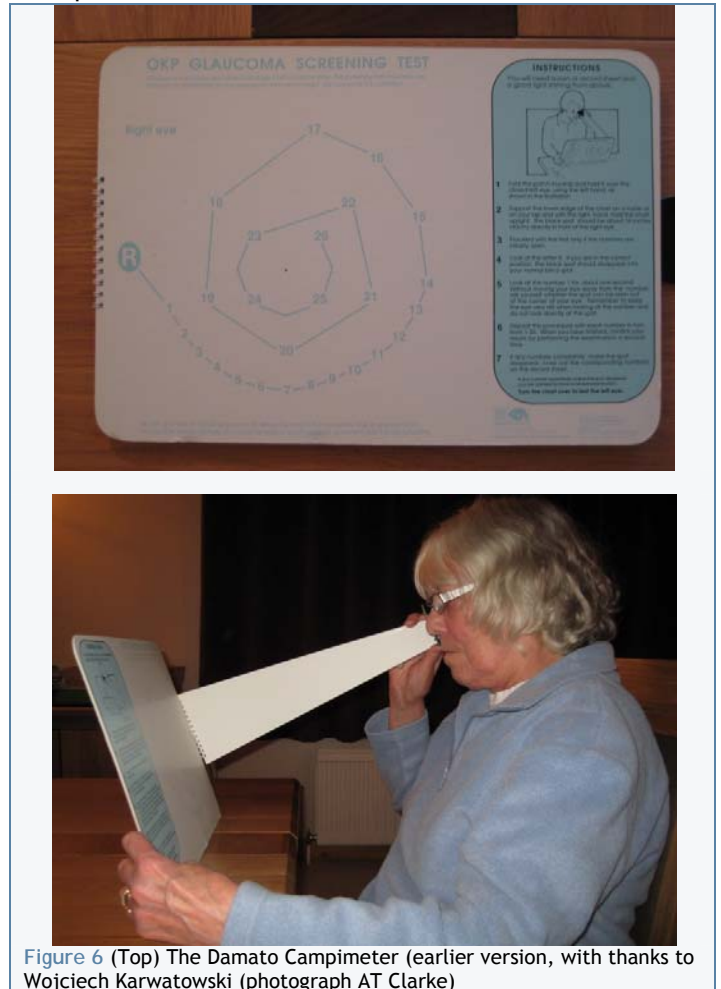


Figure 6 (Top) The Damato Campimeter (earlier version, with thanks to Wojciech Karwatowski (photograph AT Clarke))

	Henson 7000	Oculus Easyfield	Zeiss FDT
Stimulus	W-W	W-W	Sinusoidal grating
Flat/bowl screen	Flat	Bowl	Flat
Portability	✓ (5Kg)	✓ (1.3Kg)	✓/× (8.6Kg)
Extent VF test	Central 30°	Central 30°	Central 20°/30°
Test programmes	Screening/FT	Screening /FT	Screening/FT

Table 3: electronic visual field screeners suitable for domiciliary sight-tests W-W=white-on-white; FT=full threshold

As mentioned earlier, visual fields assessment is difficult even for capable patients. It is interesting to note that, in the same OT survey on visual fields assessment in the domiciliary setting, 50% of respondents felt that 10% or fewer of the patients they examine would be capable of performing a meaningful VF test, and only 3.5% of respondents felt that over half their patients would manage such tests. However, it is important to have access to a central VF test and to at least attempt an assessment for those patients who appear capable of doing it.

What type of defects do we see in glaucoma?

The characteristic visual field defects seen in glaucoma reflect the organised arrangement of the retinal nerve fibre layer. These defects respect the horizontal midline because the superior and inferior retinal nerve fibres do not cross over, forming a natural line of demarcation, the horizontal raphé. The typical VF changes observed in glaucoma can be summarised as:

- Generalised reduction in sensitivity - difficult to differentiate from normal ageing changes e.g. cataracts and pupil miosis
- Isolated focal paracentral defects - as disease progresses these areas coalesce
- Nasal focal loss - differential sensitivity either side of horizontal midline, “nasal step” defect
- Contiguous nasal step and paracentral loss - the classic “arcuate scotoma”
- “Double arcuate” - seen in advanced/end-stage glaucoma, the presence of arcuate defects in both the superior and inferior hemifield create a ring scotoma with a central island of remaining vision

Summary

The ageing population and number of patients with or at risk of glaucoma are going to increase significantly over the next 20 years. Inevitably the demand for domiciliary sight-tests will also increase. The domiciliary optometrist is uniquely placed to identify those at risk of glaucoma and to refer those patients suspected of having the disease. The unique circumstances of the domiciliary environment and the more challenging patients encountered mean that the optometrist has to be flexible in approach and use different methods of assessment than would normally be used in practice. Equipment is available to help the optometrist provide the best possible assessment of the optic disc, visual field and intra-ocular pressure. The greatest sensitivity is achieved when a combination of all three tests are used, but in many cases it may not be possible to achieve this. In all cases, acting in the best interests of the patient is paramount.

The next article will discuss the medical management of the glaucomas and how the domiciliary optometrist can help with patients’ ongoing care.

Anthony T Clarke BSc(Hons) MCOptom DipGlauc completed a degree in Physiology & Anatomy in the mid-1990s before going on to study Optometry at Aston University, qualifying as an Optometrist in 2000. Since 2003 he has worked in a specialist Consultant-led glaucoma clinic at the Leicester Royal Infirmary and is also an accredited Optometrist for the Peterborough Community Glaucoma Screening programme. He is also the Lead Assessor (Glaucoma) for the Leics & Rutland LOC.

Multiple Choice Questions

Question 1

Which of the following statements regarding the epidemiology of the UK population is FALSE?

- A. There is approximately 1.77 million in England receiving home care from their local council
- B. There is approx one third of a million people living in residential care homes
- C. 35% of the population will be aged over 65 by the year 2034
- D. Half of people living in residential care homes are over the age of 85

Question 2

Which of the following statements regarding the prevalence of glaucoma is FALSE?

- A. Afro-Caribbeans are five times more likely to develop POAG than Caucasians
- B. POAG has a prevalence of 2% in the white European population.
- C. The prevalence of Ocular Hypertension is estimated at approximately 5% higher than the estimated prevalence of COAG
- D. POAG has a prevalence of 10% in the white European over 75 years of age.

Question 3

Which is of the following statements regarding IOP / Tonometry is TRUE?

- A. The normal range of IOP is 10-21,Hg providing an average of 16.5 mmHg
- B. Tonometry is a good glaucoma detection test with a sensitivity of 5%
- C. Increased central corneal thickness results in an over estimation of IOP
- D. The iCare Impact-Rebound tonometer takes central corneal thickness into consideration when measuring IOP.

Question 4

Which of the following is/are *not* a recognised sign of optic disc glaucomatous changes?

- A. Optic disc haemorrhages
- B. Diffuse enlargement of the optic cup
- C. Cup:Disc asymmetry of >0.2
- D. Alpha-zone peripapillary atrophy

Question 5

Which statement regarding visual field analysis is FALSE?

- A. Standard automated perimetry is not suitable for domiciliary setting
- B. Gross arc perimetry can only provide a qualitative assessment of the visual field
- C. The Damato Campimeter provides 18% sensitivity and 72% specificity based on comparison with a 24-2 (HFA)
- D. The FDT perimeter uses frequency doubling to assess the visual field.

Question 6

You examine an 80 year old-female patient who informs you that her older sister had glaucoma. She has intra-ocular pressures by iCare of 21mmHg RE and 16 mmHg LE. Look at the fundus/optic disc photos and Damato Campimeter visual field print-outs obtained from this patient.

What would be the most appropriate action for this patient?

- A. See routinely in one year
- B. Re-examine in 6 months
- C. Refer urgently to HES via GP - to be seen within the week.
- D. Routine referral for suspect normal tension glaucoma

To receive your CET point for this article, complete the
Multiple Choice Questions
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Only one attempt is permitted

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