Case 6. Pre-perimetric Glaucoma

Case History:
Mrs H, age 82, had been followed for several years as a glaucoma suspect.

Her ocular history includes:
- Cataract surgery both eyes in 2017
- Bilateral YAG capsulotomy in 2017
- Left early epiretinal membrane, superior to macula

She has a pacemaker for cardiac arrhythmia, hypertension and dyslipidaemia.

Her regular medications are atorvastatin, aspirin, amlodipine, and cilazapril.

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<tr>
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<th>Right eye</th>
<th>Left eye</th>
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<tbody>
<tr>
<td>BCVA</td>
<td>6/6</td>
<td>6/9.5</td>
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<tr>
<td>Refraction</td>
<td>-0.50/-0.50 x 50</td>
<td>+0.25/-0.50 x 101</td>
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<td>Ishihara colour plates</td>
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<td>14/14</td>
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<tr>
<td>Pupils</td>
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<td>Normal</td>
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<tr>
<td>Goldmann IOP</td>
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<td>Slit lamp examination</td>
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<tr>
<td>Anterior segment</td>
<td>Anterior blepharitis 2+, MGD 1+, Clear cornea, Clear PCIOL</td>
<td>Anterior blepharitis 2+, MGD 1+, Clear cornea, Clear PCIOL</td>
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<tr>
<td>Optic nerve</td>
<td>CDR 0.8, Inferior rim notch</td>
<td>CDR 0.7, no focal loss of neuroretinal rim</td>
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<td>Retina</td>
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<td>Epiretinal membrane superior to macula</td>
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<tr>
<td>Gonioscopy</td>
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<tr>
<td>Corneal pachymetry</td>
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<td>567 µm</td>
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Question 1: See the disc photos from 2014 and 2018 (Figure 1). Describe any changes that have occurred in the past 4 years.

Answer 1: The disc appearance does not appear to have changed over the past 4 years. The CDR is approximately 0.8 in the right eye and 0.7 in the left. The zone of peripapillary atrophy is slightly larger in the right eye. The right disc shows inferior rim notching (this was more evident on stereoscopic clinical examination), but the remaining neuroretinal rim appears pink and healthy. There is no disc haemorrhage.

This patient had normal IOP and a normal visual field at the time of initial presentation (visual field not shown). At the time, she was deemed to have physiologically large cups, rather than glaucomatous cupping, based on the disc appearance.

Answer 1 ends
Question 2: Describe her OCT of RNFL (Figure 2).

Answer 2: The OCT RNFL scan has good signal strength. There is a slight asymmetry between the CDR in the two eyes. The right eye has an estimated CDR of 0.77, while the left eye has a CDR of 0.67. The right eye has a large cup volume and average RNFL thickness of 70 µm. The superior and inferior neuroretinal rim of the right optic nerve head is significantly thinned. There is corresponding loss of the RNFL at the 12 and 6 o’clock positions. There may
have been some temporal displacement of the superior and inferior RNFL bundles, based on their position. This could be at least partially responsible for the reduced RNFL thickness at 12 and 6 o’clock. The left eye has average RNFL thickness within the normal range.

OCT shows features of the glaucomatous optic nerve head in the right eye.

Answer 2 ends

Figure 2. Recent OCT of RNFL.
Question 3: See Figure 3 and describe the changes in RNFL thickness over time.

Answer 3: RNFL loss can be seen as diminished light reflection with a red-free filter, but in early glaucoma, subtle attenuation of the light reflection can be difficult to detect. Moreover, drawings of optic disc and disc photography are subject to inter-observer variability (Parrish et al., 2005 and Jampel et al., 2009). OCT overcomes some of these limitations of subjective disc examination and is able to detect RNFL loss before optic disc changes become visible on clinical examination and provide an objective measurement of the RNFL thickness (Alhadeff et al. 2017).

The Guided Progression Analysis (GPA) software computes the difference in RNFL thickness between the average of two baseline scans and the follow-up scan (event analysis) and also calculates the rate of RNFL thickness change over time (trend analysis). If the amount of RNFL loss exceeds the test-retest variability of the system, the change is presented as “possible loss”. If “possible loss” is recognised on two consecutive visits, the software presents the result as “likely loss”. A minimum of two baseline scans and three scans in total are required to generate a GPA printout. Two good quality baseline scans (preferably performed close together, or even on the same day) are important for accurate detection of progression as they act as each patient’s own normative database.

The patient’s GPA of RNFL and optic nerve head shows a progressive decline of the average RNFL thickness of the right optic nerve head over the past 6 years (Figure 3). The rate of RNFL loss was -4.47 μm/year. The right eye has thin superior and inferior neuroretinal rims and RNFL loss (both inferiorly and superiorly over time, with greater loss in the inferior quadrant). The CDR (measured by OCT) and cup volume has increased, and the rim area decreased concurrently. The left optic nerve head has not undergone noticeable thinning. The rate of RNFL thinning in healthy people without glaucoma is estimated to be -0.24 to -0.365 μm/year (Celebi et al., 2013; Peng et al., 2017). Our patient’s rate of RNFL thinning (-0.93 μm/year) is higher in the left eye than the average rate in normal eyes.

Answer 3 ends
Question 4: What are the causes of progressive RNFL thinning?

Answer 4: Glaucomatous optic neuropathy typically causes progressive RNFL thinning. A retrospective study of 294 glaucoma suspects showed that 8.8% of patients developed a visual field defect during a mean follow-up of 2.2 years, and that the rate of RNFL thinning was significantly faster in eyes that developed visual field defects than the eyes that did not (-2.02 µm/year vs -0.82 µm/year) (Miki et al., 2014). People with glaucoma showed an even faster rate of RNFL thinning, ranging from -1.2 to -15.4µm per year (median loss of -3.3 µm/year) (Leung et al., 2010).

In glaucomatous optic neuropathy, thinning is predominantly found at the inferotemporal and superotemporal disc regions (Jonas et al., 2000). The inferior and superior poles of the lamina cribrosa have larger pores and less connective tissue support for the axon bundles. This structural alteration at the inferior and superior poles may account for the vulnerability of the axon bundles in those regions. The RNFL thinning subsequently involves temporal, then nasal inferior and lastly nasal superior. The sequence of axon fibre loss correlates with the progression of visual field defects from an early nasal step to a last island of vision in the inferotemporal central visual field.

Other types of optic neuropathies cause progressive RNFL thinning, but the pattern of thinning and associated symptoms are distinct from glaucoma.

Ischaemic optic neuropathies initially cause disc swelling, then RNFL thinning. Severe ischaemia in arteritic anterior ischaemic optic neuropathy may cause disc cupping comparable to that seen in glaucoma. In arteritic ischaemic optic neuropathy, however, the pallor of the neuroretinal rim is in excess of cupping. In non-arteritic ischaemic optic neuropathy, the contralateral disc has a small CDR (disc at risk). Unlike glaucoma, ischaemic optic neuropathies cause sudden loss of vision and may be accompanied by systemic complaints, such as headaches, jaw claudication, joint pain, rash, weight loss and night sweats.
Patients with compressive optic neuropathies show progressive RNFL thinning but thinning is more pronounced in the temporal and nasal sectors. Open angle glaucomas produce larger cups, and cup volume and less rim volume with OCT measurements (Danesh-Meyer et al., 2014). In compressive optic neuropathies, optic nerve pallor is in excess of cupping and bitemporal hemianopia, cecocentral scotoma or decreased acuity may occur, which are uncommon in glaucoma.

Demyelinating optic neuritis results in RNFL thinning after each episode of optic neuritis. RNFL thinning can occur in multiple sclerosis in the absence of episodes of inflammation, and the degree of thinning is correlated with the duration of the disease (Noval et al., 2011). In the absence of previous optic neuritis and multiple sclerosis, our patient is unlikely to have the demyelinating form of optic neuropathy.

Toxic, nutritional, congenital and post-traumatic optic neuropathies can be distinguished from history and usually do not cause marked superior and inferior quadrant thinning seen in glaucoma.

**Question 5: See her visual fields (Figure 4). What is the diagnosis?**

Answer 5: Her visual fields are essentially normal and have not changed over the past 3 years.

Her disc appearance is suspicious for glaucoma and she has progressive loss of RNFL without corresponding changes in the visual field. There were no signs or symptoms to suggest causes other than glaucoma. Her diagnosis is most likely pre-perimetric open-angle glaucoma in the right eye (glaucoma suspect in the left eye). Perimetry is not sensitive enough to detect a visual field defect until at least 25-35% of retinal ganglion cells are lost (Kerrigan-Baumrind et al., 2000).

Answer 5 ends
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Figure 4. Visual field in the past three years
Question 6: See GCC analysis (Figure 5). What is the role of macula GCC analysis in this case scenario?

Answer 6: The right macula shows superior and superotemporal thinning of the GCC, less than 1% range of normative data. The left macula has normal GCC thickness. The GCC thinning in the superior region matches the RNFL thinning, but inferior RNFL thinning is not reflected in the GCC analysis.

Both RNFL and GCC thicknesses (average and in all quadrants) in pre-perimetric glaucoma patients are significantly reduced compared with normal, and significantly higher compared with perimetric glaucoma patients (Begum et al., 2014; Kim et al., 2014). Begum et al. showed that the superior and superotemporal ganglion cell-inner plexiform layer parameters had the highest predictive power for detecting pre-perimetric glaucoma. However, GCC analysis appeared to be no more sensitive at detecting pre-perimetric glaucoma than RNFL analysis. The GCC thickness may be less sensitive to glaucomatous changes because the GCC thickness includes the inner plexiform layer which is not the primary structure damaged by glaucoma; and the peripheral retinal ganglion cells located outside the macula are excluded from analysis.

At present, GCC analysis in the glaucoma assessment and monitoring is complementary to OCT of RNFL but cannot replace it. Longitudinal assessment of macular GCC parameters may be more useful than RNFL parameters in patients with disc anomalies, such as high myopia (although GCC can also be thinned in high myopia), tilted disc, significant peripapillary atrophy, or optic nerve hypoplasia. However, GCC analysis is not meaningful in patients with any macular pathology (eg. AMD, ERM) as this will confound results.

Answer 6 ends
Question 7: What percentage of patients with pre-perimetric glaucoma eventually develop visual field defects and what are the risk factors for perimetric progression?
Answer 7: Jeong et al. investigated the time course of disease progression in normotensive pre-perimetric glaucoma patients who were taking IOP-lowering medications. More than half (57.7%) of the patients showed statistically significant progression in structural or functional evaluation over an average follow-up period of 6.6 years (Jeong et al., 2010). Over the same period, 26.8% of the patients developed glaucoma with visual field defects. Disc haemorrhage and IOP reduction of less than 20% from the baseline were significant risk factors for the progression of pre-perimetric glaucoma.

Recently, impaired peripapillary perfusion has been proposed as an important risk factor for visual field progression in pre-perimetric glaucoma patients. Shiga et al. monitored patients with normotensive pre-perimetric glaucoma for a minimum of 16 months (Shiga et al., 2018). All the participants were on topical IOP-lowering medication. In this study, superior visual fields showed the most progression. The authors measured the blood flow in each quadrant of the optic nerve head using laser speckle flowgraphy. There was a significant linear correlation between the rate of superior visual field progression (dB/year) and the baseline optic nerve head blood flow in the inferior quadrant. When comparing perimetric progressive and non-progressive eyes, baseline IOP, visual field sensitivity, age, refractive error, systemic conditions and RNFL thickness were not different between the two groups. The baseline optic nerve head blood flow (overall and in all quadrants), however, was significantly lower in the perimetric progression group.

OCT angiography is a non-invasive technique that can provide a detailed view of peripapillary microvasculature, blood flow index and vessel density. Cennamo et al. demonstrated that the peripapillary flow index and vessel density were significantly lowered in the eyes with pre-perimetric glaucoma compared with normal eyes. Their findings support the vascular theory of glaucoma development in which reduced ocular blood flow leads to axonal damage and functional loss. Although OCT angiography is a promising tool in glaucoma, it is not currently used in the routine clinical evaluation of glaucoma patients.

Answer 7 ends
Question 8. What are the treatment options for this patient?

Answer 8: The pathogenesis of pre-perimetric glaucoma is unclear. As yet, there is no agreed upon diagnostic or treatment guidelines for pre-perimetric glaucoma. Therefore, frequent monitoring is important to detect progression of structural and/or functional losses, and development of any risk factors, such as high IOP or disc haemorrhage. Our patient had a high rate of progressive RNFL thinning, which increased suspicion and lowered the threshold for initiating treatment.

The goal of treatment is to lower the IOP by more than 20% of baseline IOP. The first line options are the same as for primary open angle glaucoma; usually a prostaglandin analogue (eg. Latanoprost) or selective laser trabeculoplasty (SLT). In SLT, a green, 532nm Nd:YAG laser is applied to the trabecular meshwork, selectively targeting pigmented cells. The mechanism by which SLT reduces the IOP is unclear. It is thought to increase outflow facility through a series of inflammatory changes in the trabecular meshwork. The proposed biological changes include secretion of cytokines that increase the permeability of drainage components, remodelling of extracellular matrix by activated matrix metalloproteinases, recruitment of monocytes and increased cell division.

Our patient opted to start with eye drops first. She was started on latanoprost 0.005% (Hysite) at night. At her six-week follow-up, IOP had reduced to 11 mmHg in the RE, and 12 mmHg in the LE. This indicates a clinically significant reduction from baseline (39% reduction in the RE and 33% reduction in the LE). Answer 8 ends

Question 9: She has marked anterior blepharitis and meibomian gland dysfunction. What advice would you give to her before she starts using Hysite?

Answer 9: Hysite is a prostaglandin analogue and has pro-inflammatory properties. Long-term use of Hysite has been associated with ocular surface disease and chronic alteration in meibomian gland morphology and function
(Arita et al., 2012). Normotension glaucoma patients with meibomian gland dysfunction had significantly lower compliance with prostaglandin analogues than those without (Lee et al., 2018). It is, therefore, important to treat blepharitis and meibomian gland dysfunction at the same time as commencing ocular antihypertensive medication. Our patient was given instructions for hot compresses, and lid wipes, and lubricating eye drops. A significant improvement in clinical signs of blepharitis was seen at follow-up.

References and recommended reading


Question number: 1
Question text: What is the estimated average rate of RNFL thinning in normal, healthy eyes?
Answer A: +0.3 µm/year
Answer B: -0.25 µm/year
Answer C: -0.6 µm/year
Answer D: -1 µm/year
Answer E: -3 µm/year

Question number: 2
Question text: What is the estimated average rate of RNFL thinning in glaucoma suspect eyes that eventually develop a visual field defect (Miki et al 2014)?
Answer A: +0.2 µm/year
Answer B: No significant change
Answer C: -2 µm/year
Answer D: -4 µm/year
Answer E: -6 µm/year

Question number: 3
Question text: What is least likely to be a feature of a glaucomatous disc?
Answer A: CDR asymmetry
Answer B: Disc haemorrhage
Answer C: Peripapillary atrophy
Answer D: Well-perfused neuroretinal rim
Answer E: Temporal pallor

Question number: 4
Question text: The patient discussed in the case history had unilateral progressive RNFL thinning. What features made diagnosis of glaucoma more likely?
Answer A: CDR of 0.7 in the contralateral eye
Answer B: Preserved visual acuity
Answer C: Absence of systemic complaints
Answer D: More pronounced thinning in the superior and inferior quadrants
Answer E: All of the above
Question number: 5
Question text: The Heidelberg retinal tomograph is able to differentiate compressive optic neuropathy from normal discs (Danesh-Meyer et al 2014). True or False?

Question number: 6
Question text: Which of the following conditions is least likely to show a bowtie atrophy of the disc?
Answer A: Multiple sclerosis
Answer B: Traumatic optic neuropathy
Answer C: Primary open angle glaucoma
Answer D: Pituitary adenoma
Answer E: Optic tract glioma

Question number: 7
Question text: Approximately what proportion of retinal ganglion cells are lost before visual field loss can be detected?
Answer A: 1-5%
Answer B: 5-10%
Answer C: 10-20%
Answer D: 25-35%
Answer E: 80-90%

Question number: 8
Question text: Choose an option that is not a diagnostic requirement for pre-perimetric normotensive glaucoma.
Answer A: Normal IOP
Answer B: Normal visual field
Answer C: Evidence of progressive structural loss
Answer D: Open angles on gonioscopy
Answer E: Physiologically large cups

Question number: 9
Question text: Which retinal layers make up the ganglion cell complex on the Cirrus OCT?
Answer A: Retinal nerve fibre layer, inner plexiform layer
Answer B: Inner plexiform layer, ganglion cell layer
Answer C: Photoreceptors, retinal pigment epithelium
Answer D: Photoreceptors, retinal pigment epithelium, Bruch’s membrane
Answer E: Inner plexiform layer, inner nuclear layer

Question number: 10
Question text: GCC analysis is superior to OCT of RNFL in detecting preperimetric glaucoma.
True or False?

Question number: 11
Question text: What is the disadvantage of GCC analysis in the detection of glaucoma?
Answer A: It includes a retinal structure not affected by glaucoma.
Answer B: It requires considerable patient cooperation.
Answer C: Peripheral retina ganglion cells are not included in the analysis.
Answer D: A and C
Answer E: A, B and C

Question number: 12
Question text: What percentage (approximately) of medically treated patients with pre-perimetric glaucoma showed progression in functional or structural evaluation in the study by Jeong et al?
Answer A: 5%
Answer B: 25%
Answer C: 60%
Answer D: 80%
Answer E: 100%

Question number: 13
Question text: In the above study, what percentage of the patients developed perimetric glaucoma?
Answer A: 5%
Answer B: 25%
Answer C: 60%
Answer D: 80%
Answer E: 100%

Question number: 14
Question text: Which of the following was a risk factor for the progression of pre-perimetric glaucoma in the above study?
Answer A: Disc haemorrhage
Answer B: Baseline visual acuity worse than 6/12
Answer C: IOP reduction of less than 20% from the baseline
Answer D: All of the above
Answer E: A and C

Question number: 15
Question text: Guided progression analysis of the peripapillary RNFL is essential in detecting pre-perimetric glaucoma. True or False?

Question number: 16
Question text: Macula GCC parameters may be more helpful than RNFL parameters in detecting preperimetric glaucoma is patient has;
Answer A: Diabetic maculopathy
Answer B: Macular degeneration
Answer C: Large zone of peripapillary atrophy
Answer D: Dense cataract
Answer E: Corneal scar

Question number: 17
Question text: Choose the correct statement regarding OCT macula GCC parameters.
Answer A: Reduction in GCC thickness can precede perimetric changes.
Answer B: GCC thicknesses are significantly reduced in preperimetric glaucoma, but there is no significant difference between preperimetric and perimetric glaucoma.

Answer C: GCC parameters are not correlated to OCT angiography parameters.

Answer D: GCC parameters are linearly correlated with IOP.

Answer E: None of the above.

Question number: 18
Question text: A prospective study of normotensive preperimetric glaucoma (Shiga et al 2018) showed most visual field progression in which sector?

Answer A: Superior
Answer B: Inferior
Answer C: Temporal
Answer D: Nasal
Answer E: Superior and inferior

Question number: 19
Question text: Shiga et al identified which of the following as a risk factor for perimetric progression in patients with preperimetric glaucoma?

Answer A: RNFL thinning
Answer B: Baseline IOP
Answer C: Advanced age
Answer D: Reduced optic nerve head blood flow
Answer E: Migraine

Question number: 20
Question text: Impaired peripapillary blood flow may precede the visual field defect in glaucomatous optic neuropathy.

True or False?

Question number: 21
Question text: Choose the incorrect statement regarding OCT angiography.

Answer A: Able to detect vessel density of the microcirculatory network
Answer B: Has potential to aid in the detection early glaucoma
Answer C: Requires intravenous administration of dye
Answer D: Able to provide rapid qualitative and quantitative information about optic disc perfusion
Answer E: Extremely motion-sensitive and requires patient co-operation

Question number: 22
Question text: Which of the following is not a proposed mechanism of action of selective laser trabeculoplasty?
Answer A: Secretion of cytokines
Answer B: Recruitment of monocytes
Answer C: Induction of matrix metalloproteinases
Answer D: Thermal burns and contracture of trabecular meshwork
Answer E: Increased cell division

Question number: 23
Question text: Selective laser trabeculoplasty uses which type of laser?
Answer A: Carbon dioxide laser
Answer B: Argon blue-green laser
Answer C: Krypton red laser
Answer D: Excimer laser
Answer E: Green Nd:YAG laser

Question number: 24
Question text: What is the usual choice for first line medical treatment for pre-perimetric glaucoma, assuming that there are no contraindications?
Answer A: Betaxolol
Answer B: Latanoprost
Answer C: Combigan
Answer D: Pilocarpine
Answer E: Dorzolamide

Question number: 25
Question text: Meibomian gland dysfunction can affect compliance of prostaglandin analogue therapy.
True or False?