A Refractive Surgery Candidate with Optic Nerve Head Cupping

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CASE PRESENTATION

A 25-year-old female patient was referred for refractive surgery. Corneal imaging revealed no contraindication for surgery. However, having a high cup/disc (C/D) ratio, the patient was referred to a glaucoma unit for further evaluation and whether the cornea surgeon can proceed with refractive surgery.

Table 1 summarizes the results of her baseline ophthalmologic examination. During a two-year follow-up period, the patient was monitored and various imaging studies were performed; intraocular pressure (IOP) was never increased and daytime IOP always remained under 18 mmHg at different hours. Optic nerve head appearance at baseline and final visits, which were carried out within a two-year interval, are presented in Figure 1.

Baseline and final visual field examinations were likewise performed within a two-year interval and are presented in figures 2 and 3, respectively.

The patient underwent optic nerve head imaging studies using Heidelberg retinal tomography (HRT) and optical coherence tomography (OCT) (Figures 4 to 6).

Table 1. Baseline ocular data

	OD	OS
BCVA	20/20	20/20
IOP	16 mmHg	16 mmHg
Refraction	-5.00-1.00×90	-5.50-0.75×85
CCT	520µ	511µ
ORA		
IOPcc	16.6	17.4
IOPg	16.4	16.5
Corneal Hysteresis	10.5	9.9
Corneal Resistance Factor	10.8	10.2

BCVA, best corrected visual acuity; IOP, intraocular pressure; CCT, central corneal thickness; ORA, ocular response analyzer; IOP_{cc}, cornea compensated IOP; IOPg, Goldmann-correlated IOP; OD, right eye; OS, left eye

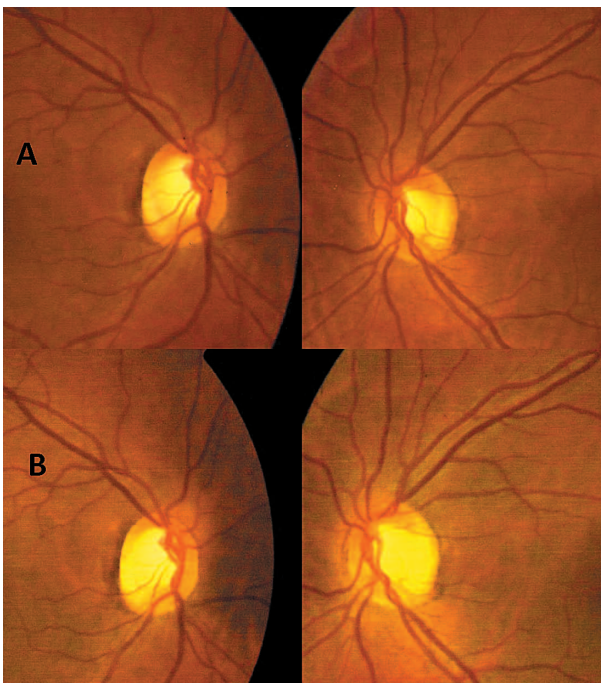

Figure 1. Optic nerve head photography at initial visit (A) and after 2 years (B).

Herein we present the opinions of five glaucoma specialists regarding this case; these experts will address the following questions:

Do you consider this patient a case of glaucoma? Would you recommend laser refractive surgery for the patient?

Ivan Goldberg AM, MD, MB, BS, FRANZCO, FRACS

From the information provided herein, this lady is a glaucoma suspect on the basis of glaucoma-like cupping of her optic discs, myopic refractive status and slightly thinner than average central corneas. It would also be helpful to know whether or not there is a family history of

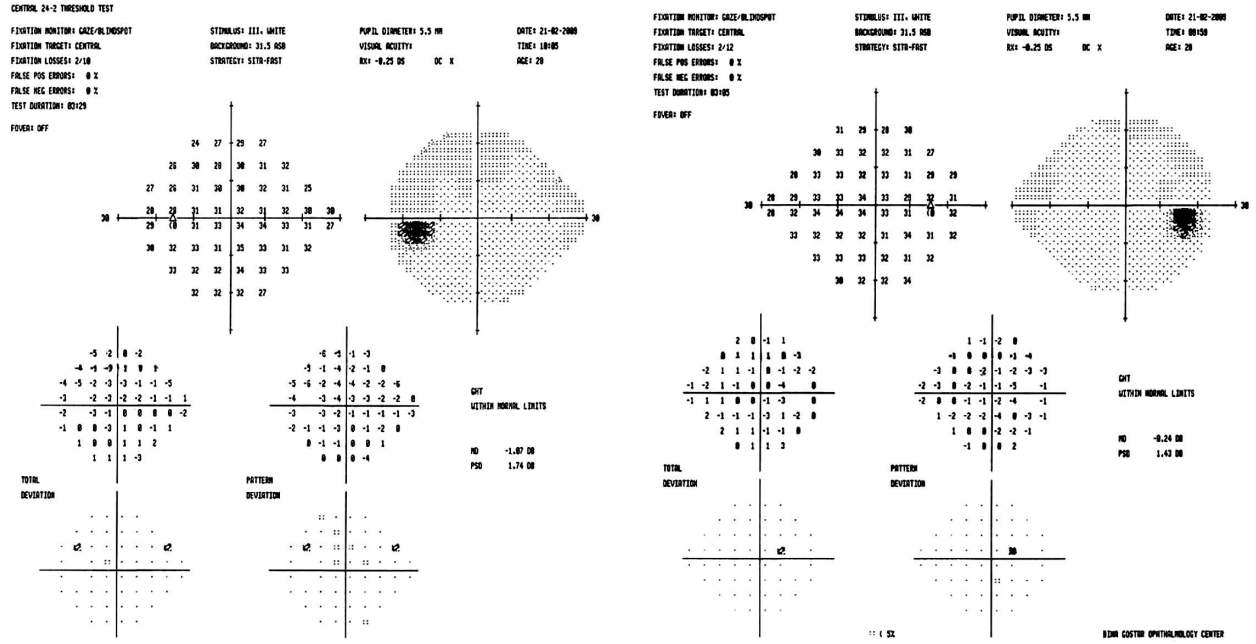

Figure 2. Baseline visual field examination.

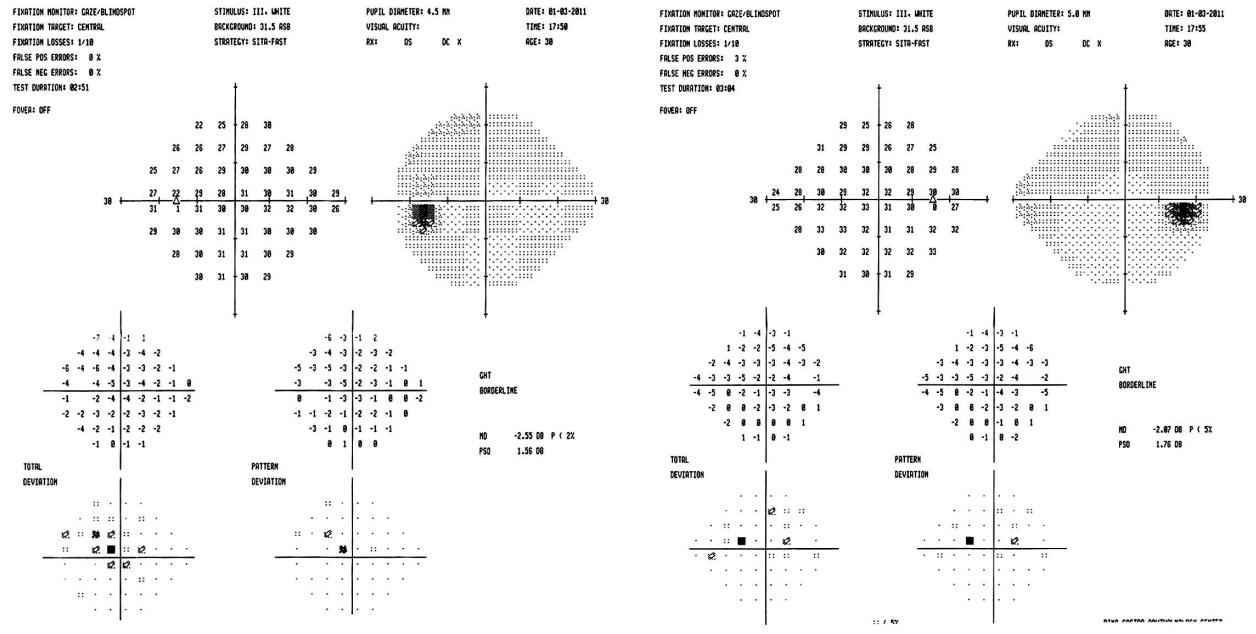

Figure 3. Visual fields two years afterwards.

glaucoma especially among her first-degree relatives, if she herself experiences migraine headaches or suffers from Raynaud's syndrome. Further useful information may include systemic blood pressure levels and any past exposure to steroids, particularly topical types.

With moderately severe myopia, this patient's optic disc appearance is difficult to categorize with certainty. Her optic nerve head appearance is certainly "glaucoma-like" but not pathognomonic for glaucoma while being compatible with her refractive status. Nevertheless, these features might be considered "normal" for her. In situations like this, objective structural imaging devices often cannot assist the clinicians differentiate "refractive discs" from

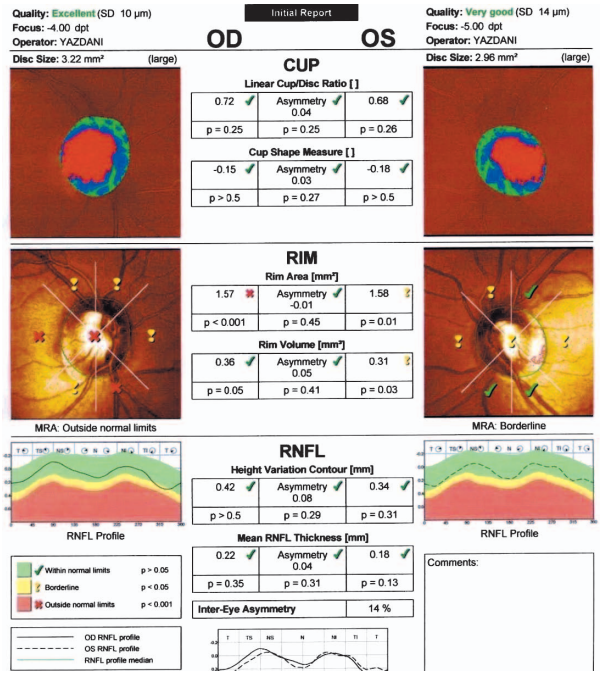

Figure 4. Heidelberg retinal tomography.

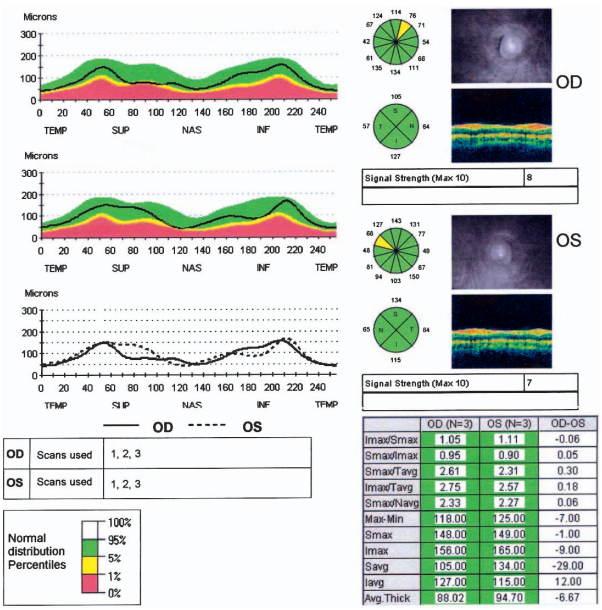

Figure 5. Optical coherent tomography using a Stratus machine.

"glaucomatous discs" on the first examination. Similar to photographs, these modalities provide a structural baseline to allow intelligent use over time.

Baseline visual fields seem quite normal in both eyes, bearing in mind this is a standard automated perimetry which has poor sensitivity for early glaucomatous loss. Other perimetric methods such as frequency doubling perimetry, short wavelength automated perimetry (blue-on-yellow perimetry) or Heidelberg edge perimetry might be useful if arcuate loss were to be identified, especially if it correlates with the thinnest parts of the neural rims.

According to provided photographs and OCT images, it appears that there has been no change over two years of follow-up. Similarly, from the standard automated perimetric analyses, no definitive nerve fiber related loss can be identified. These are all reassuring.

It seems that it was impossible, at the time of the first assessment, to say with confidence whether or not glaucoma was present. With careful review over time and analysis of findings, currently possible after two years of follow-up, one would be able to be a little more confident that active glaucomatous damage is not present. Ongoing assessment of the patient remains vital to detect any early changes and to offer protection when needed without treating unnecessarily.

As to whether refractive surgery would be wise, I believe the glaucoma suspect status does not interfere with the choices available for the patient. Now that structure and function have been documented and follow-up is assured, if corneal status permits laser refractive surgery and the fully-informed patient wishes to have it, there appears to be no specific contraindication to it.

L. Jay Katz, MD, FACS

The dilemmas posed in this case are whether a myopic patient with moderate optic nerve cupping has glaucoma and secondly, whether laser refractive surgery is safe to be performed.

Myopia together with large globes is often associated with large discs and corresponding large cups. This appears qualitatively on optic nerve photographs and is confirmed quantitatively on HRT with the area of the discs being around 3mm^2 classified as "large". In addition, OCT documents normal double-hump retinal nerve fiber layer (RNFL) profiles without any suggestion of loss. On Humphrey perimetry, there is no defect of note on two

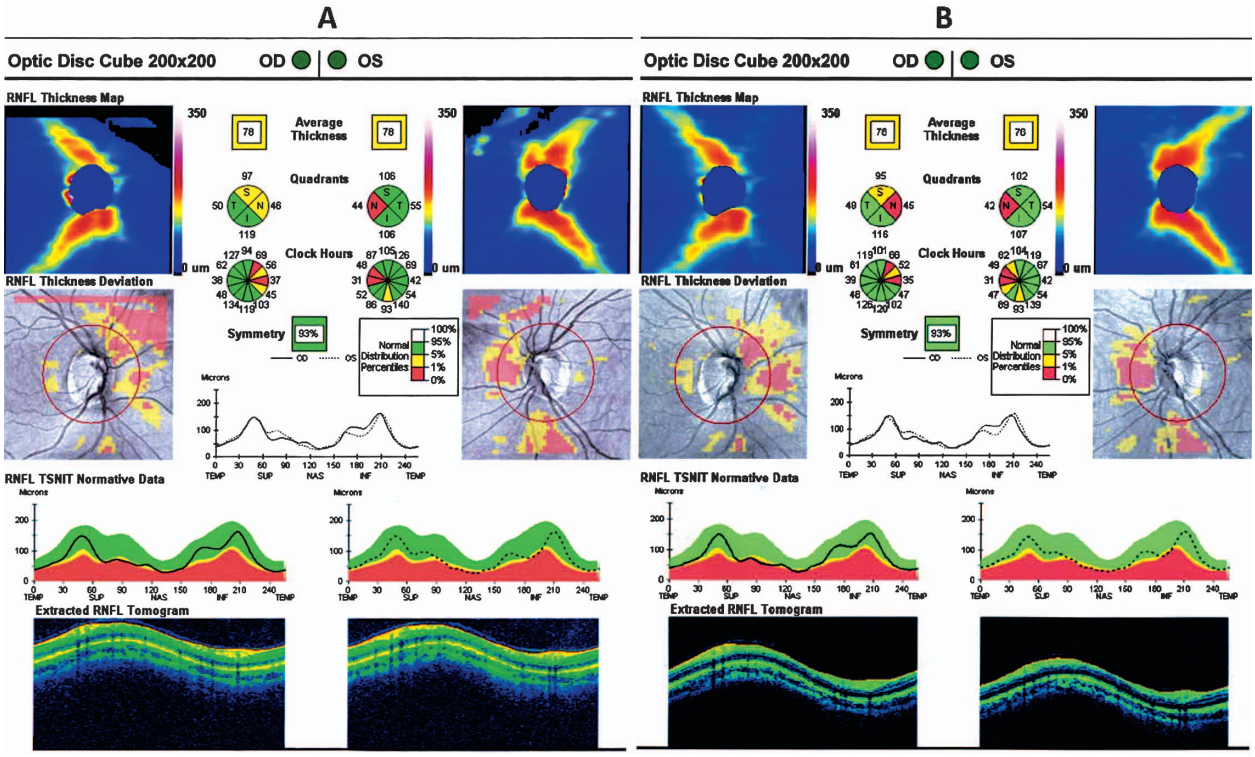

Figure 6. Optical coherent tomography imaging using the Cirrus machine at initial visit (A) and after 2 years (B).

consecutive tests. There is also no apparent asymmetry when comparing the optic nerves or intraocular pressures. Although pachymetry measured corneal thickness as slightly thin, the patient never had IOP above 18 mmHg. There is no mention of family history of glaucoma. Based on the optic nerve appearance alone, the diagnosis would be glaucoma suspect (low suspicion). Some would consider myopia and moderate cupping as risk factors for glaucoma but the patient is only 25 years old. Careful follow-up would be recommended and perhaps a diurnal IOP curve to denote peak IOP level and the time of day it occurred.

From the perspective of optic nerve injury, I believe that laser refractive surgery poses a low risk for this patient. As to whether her thin cornea, pupil size, tear film, and previous problems with contact lenses among other factors may play a role in this situation, it is the refractive surgeon who should decide whether the patient is a good candidate for surgery or not. The patient should be alerted that IOP measurements will be falsely lowered after surgery, as a result of thinner corneas following laser ablation and her ophthalmologist should take that into consideration in future examinations.

Kaweh Mansouri, MD, MPH

IOP measurements have been in the statistically normal range (<21 mmHg) in the presented case, however higher outside office values cannot be excluded due to the static nature of Goldmann applanation tonometry.[1,2] Myopic optic discs are particularly challenging in evaluating glaucoma. This young patient has large optic discs (3.22 mm^2 and 2.96 mm^2 in the right and left eyes respectively, based on HRT) with typical myopic appearance and the presence of bilateral beta-zone parapapillary atrophy without a visible defect of the RNFL. OCT imaging, performed with two different instruments, reveals bilateral signs of structural anomaly of the optic nerve head ("red-disease "). Notably, the presence of high myopia may have put this patient outside the normative database of these imaging instruments, limiting their automated interpretation. Subsequent imaging with Cirrus-

OCT did not demonstrate any sign of structural change. Two visual field examinations within a two-year interval do not exhibit any reproducible defects and should therefore be considered as "borderline normal"; this would recommend repeating the visual field examinations. The low central corneal thickness (CCT) and presence of myopia are further risk factors for glaucoma. Given the test results, and in the absence of other risk factors, family history for example, I would consider this patient a glaucoma suspect at low risk, requiring initial annual follow-up examinations for glaucoma.

There is no consensus among ophthalmologists and even glaucoma specialists on the appropriateness of laser refractive surgery in patients at risk for glaucoma. I personally consider the presence of established or suspect glaucoma as a relative contraindication for performing refractive surgery, especially for laser in situ keratomileusis (LASIK), for the following reasons:

Firstly, there is a transient but dramatic rise in IOP associated with the microkeratome during LASIK surgery, which may put an at-risk patient in further danger of glaucomatous damage or retinal vein occlusion.[3]

Secondly, IOP is the only treatable risk factor for glaucoma and its accurate measurement is essential for managing this condition. IOP measurements with current tonometric techniques would become inaccurate after laser refractive surgeries, particularly after LASIK, due to alterations in CCT and corneal curvature.[4] Dynamic contour tonometry measurements may be less affected by refractive surgeries, however this device is not widely available to practicing ophthalmologists.[5]

In addition, topical and sometimes oral steroids are frequently used at high doses for postoperative management of refractive procedures. Patients with glaucoma are at higher risk of developing steroid-induced IOP elevation. Several reports of steroid-induced glaucoma and its progression after refractive surgeries have already been reported.[6,7]

Moreover, imaging studies of the optic nerve head and RNFL are increasingly becoming integral components of a comprehensive glaucoma evaluation.[8] Although there are sparse data related to the effects of refractive surgery on imaging studies, it seems that these procedures may somehow affect the imaging techniques.[9,10] Furthermore, refractive surgery may pose detrimental effects on the accuracy of visual field examinations. It has been reported that a blur zone in the cornea may degrade visual fields after photorefractive keratectomy (PRK).[11]

Finally, the presence of flap interface fluid, a relatively common event after LASIK, may mask a dangerously high IOP.[12]

I would advise the patient to wait another year or two before deciding to undergo refractive surgery in order to exclude any change consistent with glaucoma. If the patient is adamant on undergoing surgery earlier, I would try convince her to consider PRK as an alternative to LASIK.

Suggested Readings

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Mohammad Pakravan, MD

The patient described herein is a 25-year-old female with moderate myopia seeking refractive surgery who has suspicious cupping in both eyes. During her two-year follow-up, IOP remained under 18 mmHg but some changes appeared in her clinical and paraclinical data. Considering the provided information, it now should be clarified if the patient is a case of glaucoma and whether to proceed with laser refractive surgery or not. There are some points about this case we are unaware of; further knowledge about them could be valuable at this point. For example, we are not informed whether the myopia has progressed within two years of follow-up or not.

Noting the available daytime IOP results (probably measured by Goldmann applanation tonometry) which were all below 18 mmHg and considering CCT slightly lower than average and thinner on the left side, and also ocular response analyzer parameters (normal IOP_{cc}, IOP_{g}, corneal hysteresis and corneal resistance factor), it may be concluded that intraocular pressures are within the normal range.

Fundus photography reveals apparent thinning of the neuroretinal rim and an increase in vertical C/D ratio, bilaterally. Additionally, some rim pallor, as compared to the baseline fundus photographs, can be observed provided that the level of illumination was the same in both sessions. Baseline visual fields were normal, but after 2 years, mean deviations have increased and some central depressions are visible in both eyes, more prominent in the left one.

Altogether, three types of peripapillary RNFL thickness measurement data are available for this patient: HRT, and Cirrus and Stratus OCTs. There is a big controversy surrounding the agreement upon employing these three techniques to assess RNFL thickness. In general, due to differences in measurement algorithms, RNFL thickness results obtained by each of these instruments may not be entirely compatible and should not be used interchangeably.

Cirrus OCT, as the only modality employed through initial and follow-up examinations, reveals reductions in average thicknesses together with severe thickness loss in both nasal quadrants, although the signal strengths are not visible on the printouts and the baseline tests have black artifacts in the thickness maps. There are also two new clock-hours of borderline thickness in the left eye. Overall, I consider these findings as bilateral progressive thinning of the peripapillary RNFL.

I assume this is a case of bilateral progressive optic neuropathy and further evaluations are necessary to thoroughly address the case. First, a detailed systemic history focusing on medications, anemia or cardiac arrhythmias, collagen vascular diseases and Raynaud's disease, infectious conditions and sleep disorders should be taken, all of which have to be followed by appropriate systemic evaluations. Secondly, any possible progression of myopia should be evaluated, which of course must be considerable enough to justify these changes. Careful slit lamp examinations and gonioscopy should also be performed to detect any signs of pigment dispersion; IOP control in supine position is also required and helpful. Color vision testing is another beneficial tool which usually drops sooner and to a greater extent than visual acuity. Finally, neuroimaging studies are recommended and compressive lesions are to be ruled out.

If no cause is revealed subsequent to these evaluations, it is prudent to follow the case for another year or two while periodically repeating

all clinical and paraclinical tests to reach a more specific diagnosis. I would advise the patient to wait for the time being.

Shahin Yazdani, MD

The patient presented herein fits a common scenario in everyday practice: a young myopic individual with "suspicious discs". The presence of myopia per se probably increases the risk of glaucoma based on a considerable number of studies, regardless of other risk factors such as intraocular pressure (IOP), family history, age, race, central corneal thickness, etc. Some of these risk factors (speaking about the patient of interest) are unknown to us; there is no hint on family history of glaucoma which may be interpreted as negative. I personally rely on this risk factor very much and consider a positive family history as one indication to initiate treatment in borderline cases.

CCT in this patient is below average (considering 540-550 microns as the normal range). Biomechanical properties including corneal hysteresis (CH) and corneal resistance factor (CRF) based on ORA are normal in the right eye leading to very close cornea compensated pressure (IOPcc) values to those measured by the Goldmann device. However, biomechanical parameters in the left eye are slightly less than normal leading to a 1.4mmHg higher IOPcc value as compared to conventional applanation tonometry. We can therefore consider the corneas in this patient to be structurally thin in both eyes, biomechanically normal in the right eye, and slightly "weak" in the left one. Apart from well-known issues on thin CCT in underestimating IOP and as a risk factor for glaucoma, thin CCT has also been associated with larger discs (as observed in this patient) and suggested to reflect greater deformability of the lamina cribrosa, hence greater susceptibility to glaucomatous damage. These theoretical issues may serve as a red flag in this particular patient.

The ONH appearance is the next issue to tackle. Fundus images taken 2 years apart have been obtained with almost the same level of magnification, but the second set of images have been acquired with slightly more illumination which may cause an impression of increased pallor. In my opinion, the images are comparable and no evidence of structural change can be seen, at least as much as non-stereoscopic viewing allows. The most striking feature is the amount of cupping, however one should always judge cupping in the context of disc size and in conjunction with other ONH findings. I believe the appearance of the disc, considering the neural rim in particular, is overall healthy and no significant focal neural rim notching or saucerization is present. RNFL reflectance is not adequate to judge its integrity, the peripapillary area is unremarkable in terms of atrophy or hemorrhage, and there is only a mild pigmented crescent at the temporal margin of the disc which is of no significance. We have no data on vertical disc diameter which seems large (the disc has also been categorized as large on HRT). Therefore these features suggest the presence of physiologically large cups in large myopic discs. Examination of first degree relatives especially siblings and parents would also be helpful; should this disclose similar findings, one could be more comfortable with labelling this patient as "normal".

Stratus OCT had shown no clinically significant RNFL dropout. The dates of the OCT examinations have been omitted from the printouts but I assume that the Stratus OCT had been performed earlier on, while the Cirrus OCTs are more recent. One should be cautious when comparing the printouts of different OCT machines because different OCT generations and even different company products belonging to the same generation of technology are not comparable. Stratus is a time domain OCT machine with readings known to be higher than the more recent spectral domain OCT machines such as Cirrus; this discrepancy is evident on quadrantic comparison of RNFL thickness values in this case. Having said this, the pattern of RNFL loss on cirrus OCT is most prominent on the nasal side of the discs, a location not typical for glaucomatous damage. I would also like to stress the presence of some artifacts (black areas) on the Cirrus printout which are outside the scan circle and probably do not affect the measurements, however quite commonly such artifacts may fall

within the area of interest, making measured values unreliable. The Cirrus images taken two years apart show no significant change in RNFL thickness in quadrants or clock hours. The other issue in interpreting OCT scans in this patient is the presence of myopia and large optic discs. Non-glaucomatous moderate and high myopic eyes have been reported to have thinner RNFL based on OCT and this should be considered when one is evaluating a myopic glaucoma suspect. The effect of optic disc size on OCT-based RNFL thickness is debatable, some studies have reported no effect while others have stated thicker values due to closer proximity of the scan circle to the disc margin.

The HRT has yielded several sectors of abnormality based on Moorfield regression analysis (MRA) which are more severe in the right eye. The HRT is known to be less accurate in eyes with large discs and reported to produce high false positive results suggesting glaucomatous abnormality due to high sensitivity but low specificity. This matter is also reflected in this case in whom the right eye, which has larger disc area based on the machine's categorization (the HRT classifies discs with areas more than $3mm^2$ as large), also has more severe abnormal sectors as compared to the left eye. The only set of HRT data available to us are the MRA results, it could have been helpful if the glaucoma probability score (GPS) data had been available, however GPS is also notoriously unreliable in large discs. The advantage of GPS over MRA is lack of dependence on the contour line which is drawn by the operator, however this analysis still depends on the arbitrary reference plane used to separate optic nerve tissue into "rim" and "cup". In my opinion, the best analysis available in the HRT machine is the topographic change analysis (TCA) which is independent not only from the contour line but also the reference plane. However this analysis is best used for long term follow-up to detect areas of height variation, it has no utility in discriminating normal form glaucomatous discs.

The final piece of information is functional data, standard achromatic perimetry (SAP) has been performed twice, 2 years apart for this patient using the SITA fast strategy and 24-2 program, personally I would have requested a SITA standard 24-2, but this is not much of an issue. Both visual fields are reliable and well performed as far as reliability indices, gaze tracker and test duration show. However in both tests the patient seems to have been over-corrected for near; considering more than 5 diopters of myopia, even with complete relaxation of accommodation, the patient is still 2 diopters myopic for the test, necessitating correction which has been ignored during the second test and received only -0.25D correction in the baseline test. The astigmatic error has also been overlooked and this may affect the outcomes of the test. The baseline VF can be considered as normal in both eyes (ignoring the insignificant areas of depression in the superior field on the pattern deviation plot of the left eye). The second VF shows very mild but significant generalized depression in both eyes which may be due to optical blur from inadequate correction as described above. The second SAP however has no significant focal defects based on Andreson's criteria.

In summary, I do not believe that the patient described herein has glaucoma, but she can be classified as a glaucoma suspect which is not a contraindication to laser refractive surgery. I do not think additional/repeat imaging modalities such as OCT or HRT are useful in this particular case. Still I would be cautious in performing/recommending surgery in this case until a properly performed VF with appropriate optical correction is obtained and family history is probed for glaucoma; provided both investigations are cleared, I would recommend refractive surgery.

Conflicts of Interest

None.

Consultants

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