Review Article

Optical Coherence Tomography Interpretation for Glaucoma

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Abstract:

Structural glaucomatous changes occur more frequently in the earlier stages of glaucoma than functional defects, so we should give special care to optical coherence tomography (OCT) importance as the best current method. The retinal nerve fiber layer (RNFL) change detection is more useful in early glaucoma, the ganglion cell complex (GCC) in moderate to advanced glaucoma, while the visual field test is more useful in advanced stages, but overall, using a combination of RNFL, optic nerve head (ONH), and macular thickness measurement modalities is recommended for glaucoma evaluation because each parameter may be affected earlier than the others so, considering the findings from the RNFL, ONH, and macula enhances early diagnosis of glaucoma.

Keywords: Optical Coherence Tomography; Glaucoma; Optic Nerve.

Article Notes: Received: Apr. 04, 2021; Received in revised form: Apr. 28, 2021; Accepted: May. 30, 2021; Available Online: Sep. 25, 2021.

How to cite this article: Yadgari M. Optical Coherence Tomography Interpretation for Glaucoma. Journal of Ophthalmic and Optometric Sciences . 2021;5(4):61-79.

Section I: OCT evolution and applications in glaucoma

The optic nerve comprising the axons of retinal ganglion cells (RGCs), extends from the lamina cribrosa to the optic chiasm. It is covered by meningeal sheaths so that the nerve space is continuous with that of the brain. The RNFL near the disc is thicker because all the fibers converge there. The lamina cribrosa, as a network-like dynamic structure located in the posterior scleral canal, helps preserve a pressure gradient called the translaminar pressure difference (TLPD) between the extraocular and intraocular spaces, which means the difference between intraocular pressure (IOP) and intracranial pressure (ICP) in subarachnoid space (SAS). The RGC axons at the lamina cribrosa are the most vulnerable to IOP-related stress and strain [1, 2]. The intraocular pressure leads to axonal transport blockade and RGC death [3], so ganglion cell damage occurs at the level of the lamina cribrosa first. The axons and ganglion cell bodies disappear through apoptosis, but this destructive process cannot be detected by clinical examination before exceeding a certain critical threshold [4,5]. Also, these structural damages frequently precede functional damage. For example, standard automated perimetry can remain normal until about 35 % of the RGCs are destroyed [6-8]. So, methods identifying the structural changes are very important in the early diagnosis of glaucoma [5 9, 10].

A confocal scanning laser ophthalmoscopy, Heidelberg retina tomograph (HRT), and scanning laser polarimetry (GDX nerve fiber analyzer) can give us some information about optic disc and RNFL, respectively. However, OCT provides useful information about optic disc parameters, RNFL, and ganglion cell layer simultaneously [11]. So, today OCT has replaced previous devices for detecting early structural glaucomatous damage by evaluating RNFL, macular ganglion cell, and ONH changes with acceptable reproducibility and reliability [12-15].

The OCT is the main test used for early diagnosis of glaucoma and sometimes neuro-ophthalmic diseases. Because OCT evaluates various parameters, such as ONH, RNFL, and inner macular area, it has replaced previous technologies, such as HRT and GDX, for early diagnosis of glaucoma, even years before the visual field defects emerge. The OCT is widely used by ophthalmologists worldwide in daily practice, but the interpretation of OCT print out requires enough experience. A wide range of artifacts and inter-individual variations lead to diagnostic errors if the ophthalmologist is not well educated on this technology.

Optical Coherence Tomography (OCT) is a non-invasive imaging technique that utilizes optical interferometry to produce cross-sectional images of ocular tissue. It has a penetration depth of 2-4 mm and provides images that resemble histological sections. Research on the applications of light interferometry for ocular tissue imaging began in the late 1980s, with the introduction of the first commercial time-domain OCT platform by Zeiss in 1997. The technology has since evolved, with the development of spectral-domain OCT (SD-OCT) technology, which provides faster image acquisition, higher resolution, and advanced segmentation capabilities software, resulting in better performance. Other advances include swept-source optical coherence tomography (SS-OCT), OCT angiography, and adaptive optics optical coherence tomography (AD-OCT) systems.

Improved software such as adaptive

compensation (AC), enhanced depth imaging optical coherence tomography (EDI-OCT), and swept-source optical coherence tomography (SS-OCT), have significantly enhanced the evaluation of the lamina cribrosa, which includes detection of laminar posterior displacement, lamina cribrosa thickness, focal defects, and micro-architecture changes. AC uses a wavefront sensor to measure ocular aberrations induced by the lens or cornea. A deformable mirror or a spatial light modulator then compensates for aberrations, removes blood vessel shadows, increases tissue contrast, and improves image quality. EDI-OCT has allowed for better visualization and measurement of choroidal thickness and improved cross-sectional lamina cribrosa images by placing the OCT closer to the eye to obtain an inverted image with focused illumination that is more posteriorly located at the level of the choroid and inner sclera. SS-OCT uses Fourier domain principles and combines the advantages of standard TD-OCT and SD-OCT. It does not require a moving mirror like TD-OCT and does not require a spectrometer like SD-OCT. It uses a narrow bandwidth light source that changes the wavelength sweeps across a narrow band of wavelengths in time and frequency variations with time and encodes different echo delay times in the light beam. SS-OCT measures all the light echoes simultaneously, which dramatically improves the speed and detection sensitivity. It has a scan speed of 100,000 A-scans/second, deeper tissue penetration, and wider imaging field compared to SD-OCTs. The diagnostic accuracy of SS-OCT and SD-OCT for RNFL imaging is similar. The Plex Elite 9000 of cirrus OCT, which uses a swept source tunable laser with a wavelength of 1060 nm, can reach a speed scan of 100,000 A-scans/second [11-38].

Section II: Important OCT parameters for glaucoma

Peripapillary RNFL analysis in OCT

The retinal nerve fibers are the ganglion cell axons that eventually enter the optic nerve. Loss of RNFL can be observed grossly in red-free photos and is quantified with OCT. Although macular ganglion cell analysis and ONH help with glaucoma evaluation [39, 40], RNFL is still the most important parameter for glaucoma diagnosis, especially in preperimetric glaucomatous damage [41] and detection of progression by obtaining a circular peripapillary B-scan to measure RNFL thickness measured circularly or RNFL extracted along the circle from a raster cube of data centered over the optic nerve [11, 41, 42]. The RNFL undergoes thinning with age in healthy eyes at a mean rate ranging from -0.48 to -0.60 µm/year. However, glaucoma progression has a faster rate of RNFL thinning ranging from -0.98 to -2.12 µm/year [11]. Apart from age, the risk of faster loss over time in eyes can be associated with thicker baseline RNFL. However, the baseline thickness does not appear to affect the rates of change in GCL + IPL [44].

Previously only a single circumpapillary RNFL scan centered on the ONH was applied for RNFL thickness evaluation and set to about 3.4 mm in diameter. However, according to recent studies, the most common location for RNFL thinning in glaucoma is located at the inferotemporal meridians, approximately 2 mm away from the disc center, which is outside of the 3.4 mm diameter circle, so the RNFL thickness map cube from four SD-OCT devices (Zeiss Cirrus HD-OCT, Topcon 3D OCT 2000, Optovue ((Fremont, CA), and Nidek RS-3000 OCT) and three circle scans of 3.5, 4.1, and 4.7 mm by the GMPE software of spectralis OCT overcome this defect [11]. The

segmentation algorithm of OCT identifies RNFL and measures the RNFL thickness on the circular peripapillary scan. These data are then plotted along the scan circle, usually starting from the temporal quadrant (9 o'clock in a clockwise direction for the right eye, 3 o'clock in a counterclockwise direction for the left eye) as the TSNIT plot. The RNFL calculation circle and TSNIT plots can be presented in different formats, depending on the manufacturer.

OCT devices offer various thickness measurements and analysis options, such as average, hemifield, quadrant, and clock-hour sector measurements. These numeric data can be displayed on false color maps or pie graphs. Typically, a TSNIT plot displays a double hump pattern, with peak RNFL thickness in the superior and inferior sections. Comparisons are made to the normative database for each age group using any OCT device, with probability levels for abnormality displayed on the TSNIT plot's six-color scale. This scale includes green, yellow, and red in all devices, white in Cirrus OCT, and blue and purple in the newer version of Spectralis OCT. RNFL measurements at or below the 1 % thinnest measurement from the normative database of the specific OCT device fall into the red area, indicating results outside the normal range. Measurements within the 1–5 % thinnest of the normative database are borderline abnormal and displayed in the yellow area. RNFL measurements within the 90 % middle of the normative database are considered within normal limits and marked in green.The RNFL thickness measurements beyond 95 % of the normative database measurements are considered higher than normal. They are seen in the white area in cirrus OCT and the blue or purple area in the spectralis OCT. The Rim Notches match commonly with RNFL defects but averaging can hide focal axonal defects in the sectorial chart, so it is reasonable to evaluate the whole RNFL profile graph meticulously [11]. The average and inferior quadrant peripapillary RNFL thickness values have the best diagnostic accuracy, followed by the superior quadrant RNFL thickness for glaucoma diagnosis [45-47]. The test-retest variability of SD-OCT systems for the average RNFL thickness is below 5 μm [48-53]. It is important to know that peripapillary RNFL may cause changes in diseases, including retinal vein occlusion, diabetic macular edema, retinitis pigmentosa, after peeling the inner limiting membrane, pan-retinal photocoagulation, vitrectomy [54-60]

Optic disc parameter analysis

The bundled axons pass through the lamina cribrosa as the main site of RGC axonal injury within the posterior scleral foramen. The lamina cribrosa is a mesh-work sieve-like structure containing astrocyte-covered, capillary-containing connective tissue beams [61, 62]. The prelaminar neuroretinal tissue obscures the view of the lamina cribrosa on ophthalmoscopy. However, newer types of OCT, such as swept-source OCT and EDI OCT, have given us the opportunity of evaluating it exactly [16, 63, 64]. The minimal neuroretinal rim measure obtained by spectralis OCT is the minimum distance from BMO to ILM, and the resulting parameter is BMO-MRW [11]. Although for more detailed information about lamina cribrosa, we can use some special techniques, including EDI OCT or SS OCT, because glaucomatous eyes have higher mean LCD, greater lamina cribrosa curvature, means lamina cribrosa bowing and sliding larger pores area. Even higher pore diameter standard deviations compared to healthy eyes become more prominent with progression and

occasionally localized posterior displacement of lamina cribrosa (focal lamina cribrosa defects) related to localized RNFL loss and optic disc hemorrhages SS-OCT and adaptive optics technology have made lamina cribrosa visualization better than EDI OCT alone [18,19,65- 67, 71,73-75]. Also, combining adaptive optics with SD-OCT has given 3D in vivo imaging of the lamina cribrosa [76, 77]. Limitations of using lamina cribrosa characteristics for glaucoma evaluation are its characteristics variation in the population, the difficulty of visualizing the peripheral lamina due to blood vessels, scleral shadow, broken images, media opacity or small pupil size, and also the effect of age and axial length on it may limit the ability of lamina cribrosa measurements for glaucoma evaluation [16,28,75,78]. The neuroretinal rim change analysis is included in cirrus HD-OCT GPA software and the new Glaucoma Module Premium Edition (GMPE) of the spectralis OCT [11].

Macular Ganglion cell layer analysis

Macular thickness can be affected in glaucomatous eyes, representing an indicator of possible RGCs damage, since above 50 % of the total RGCs are in the macula and makes up 30- 35 % of the total retinal thickness in the 6-8 layers.[49, 85], but the GCC thickness measurement of the macula is superior to total macular thickness in detecting glaucoma [9, 14, 84, 86-90]. A macular inner retinal layer is more reliable in people with small or large optic discs, peripapillary atrophy named optic discs, or high myopia situations presenting unreliable PPOCT reports [92]. Also, ganglion cell analysis in advanced glaucoma is more helpful than RNFFL because it remains above the measurement floor range longer than peripapillary RNFL thickness . Although there are several advantages to ganglion cell analysis, it is necessary to remember that retinal pathologies can affect the posterior pole thickness map analysis [85, 96, 97].

Various OCT systems utilize diverse macular measurements to assess the diagnosis and progression of glaucoma. For instance, Cirrus HD-OCT evaluates the GCL + IPL (ganglion cell layer + inner plexiform layer), whereas RTVue OCT and Nidek OCT measure the ganglion cell complex (GCC; mRNFL + GCL + IPL). The Topcon OCT generates a variety of combination maps for these three layers. Spectralis OCT, on the other hand, assesses the overall macular thickness and the segmentation of each individual retina layer, including mRNFL, GCL, and IPL [11, 93, 98]. The earlier version of the Heidelberg Engineering Spectralis OCT Posterior Pole Asymmetry analysis could only measure the overall thickness of the macula's retinal layer, without the ability to differentiate between its various sub-layers. However, a newer version of this technology (GMPE) now permits the segmentation of these different layers for more detailed analysis.[99, 100]. Topcon DRI-OCT Triton can simultaneously measure GCC and GCL + IPL thickness. The inferior temporal sector of ganglion cell analysis is the most important in the macula for glaucoma evaluation, consistent with inferior sectors of the peripapillary RNFL area [101-104]. The GCL + IPL values decrease faster with aging than circumpapillary RNFL thickness measures [105].

Altogether for evaluating glaucoma, it seems that GCC thickness defect is more accompanied by paracentral scotoma frequently seen in NTG, and pRNFL thickness defect is more significant in eyes with advanced or peripheral VF defects. The RNFL change detection is more useful to show progression in glaucoma suspects, preperimetric glaucoma, early

glaucoma, and GCC trend analysis in eyes with moderate to advanced glaucoma. In contrast, functional change is a better indicator as the disease progresses to advanced stages . Overall, a combination of RNFL, ONH, and macular thickness measurement modalities is recommended to increase the chance of identifying early glaucomatous damage. Each of these parameters may be affected earlier than the others, so considering the findings from RNFL, ONH, and macula enhances early diagnosis of glaucoma [11].

Section III: Available OCT devices for glaucoma

Although each OCT device has its advantages and disadvantages, their thickness measurements are not interchangeable, so there is no significant difference between their protocols concerning diagnostic value [108-110].

Heidelberg spectral glaucoma scanning protocol

Heidelberg Engineering (Heidelberg Engineering Inc., Heidelberg, Germany) manufactures Spectralis OCT systems that use an 870 nm wavelength diode laser as a light source with a first-generation scanning speed of 40,000 scans/second up to 85,000 scans/second in new versions with a scan depth of 1.9 mm, the axial resolution of 3.87 μm, and transverse resolution of 14 μm [11, 111]. Two hundred-one normal Caucasians (111 men and 90 women) were registered in the normative database of this device between 18 and 78 years [40]. For glaucoma, the basic original module was the RNFL analysis and Posterior Pole Asymmetry analysis software. GMPE software for spectralis OCT has allowed some upgrades to the RNFL analysis, such as an automated anatomic positioning system, detailed ONH analysis, and possible evaluation of each level of macular thickness separately for ganglion cell analysis. Multimodal imaging with fundus photographs, fluorescein angiography, and OCT images in a single output is another capability of the spectralis system [11].

1. RNFL thickness profile

Standard original RNFL imaging algorithm

A 12 ° diameter peripapillary circular scan, equivalent to a 3.46 mm retinal diameter in eyes with average corneal curvature and axial length, is performed with a 0 ° degrees temporal point. For the right eye, the scan is counted in a clockwise direction, while for the left eye, it is counted in a counterclockwise direction. RNFL measurements are taken and compared to the normative database for each sector, including temporal (90 °), temporal superior (45 °), nasal superior (45 °), nasal (90 °), nasal inferior (45 °), and temporal inferior (45 °). **The Glaucoma Module Premium Edition**

During RNFL analysis with GMPE software, three circle scans of 3.5, 4.1, and 4.7 mm automatically are centered around the BMO centroid 24 radial equidistant scans for ONH analysis [11]. Also, the automated anatomic positioning system is applied to make the test more reliable. The angle between the fovea-to-BMO centroid (FoBMO) axis and the horizontal axis ranges from − 17 ° to + 6 ° with a mean of - 7 °[112]. The OCT databases incorrect for the FoBMO alignment have wider confidence intervals, and even a slight head tilt can change this angle and result compared to a normal database with high test-retest variability. So the automated anatomic positioning system is applied for GMPE to allow FOD axis to start the scan circle as the most temporal point instead of horizontal line applied in the previous versions. FoBMO

alignment is critical to ensure anatomical alignment of all eyes with healthy control eyes (normative database), thereby enhancing measurement accuracy. The blue line in the figure denotes the fovea to Bruch's membrane opening (FoBMO) axis of two eyes with different anatomical positions (a and b) of the fovea relative to the BMO center. The GMPE of Spectralis OCT scan orientation is automatically aligned along the FoBMO axis of the eye. [11, 97, 112-114] The OCT output shows the RNFL thickness classification around the papillary with six standard pie charts consisting of temporal (90 °), temporal superior (40 °), nasal superior (40 °), nasal (110 °), nasal inferior (40 °), and temporal inferior (40 °) [40], according to structure-function map explained in [115].

2. Optic disc parameters analysis

BMO is a useful landmark in glaucoma imaging due to its relative stability under various conditions, such as large IOP changes caused by glaucoma surgery [11]. The previous version of spectralis OCT had no analysis and presented no information about ONH parameters. However, in GMPE, we can analyze the optic disc through Bruch's membrane opening-minimum rim width (BMO-MRW) and Bruch's membrane opening-minimum rim width area (BMO-MRA) as a neuroretinal rim thanks to the ease of identifying the highly reflective Bruch membrane and the internal limiting membrane. However, we should know that these parameters may be affected by IOP. For example, it becomes greater after lowering IOP while RNFL thickness remains constant (reversal of glaucomatous optic disc cupping) [116-118]. So, BMO-MRW is considered in each ONH radial scan as alternative measurements for the number of axons entering ONH [120-123].

3. Ganglion cells analysis:

Posterior pole analysis software can calculate the total retinal thickness of the entire posterior pole retinal in a central 8 x 8 grid as a colored thickness map with warmer colors for the thicker area and visible average total retinal thickness area at the center of each pixel. Additionally, inter-eye thickness asymmetry analysis for comparing the right and left macula and intra-eye thickness asymmetry analysis for comparing the inferior and superior half of the macula are performed [47, 53, 99, 100, 124-129]. The newer spectralis OCT (GMPE) can segment macular layers separately but with no statistical analysis [11]. The posterior pole vertical-oriented scan (PPoleV) algorithm in the newer spectralis versions is a previous alternative. So, 19 vertical B-scans, involving a 30 ° × 15 ° scanning area perpendicular to the FoBMO axis with clear macular layer segmentation, are shown as a heat map on a circular grid (an ETDRS grid format), including average thickness in µm and average volume in mm^3 of ganglion cell layer in each sector [11, 130, 131].

4. Glaucoma Progression Analysis:

Chapter 2: Carl Zeiss Meditec

Carl Zeiss Meditec (Dublin, CA) is the manufacturer of a diagnostic SD-OCT device called ZEISS Cirrus HD-OCT, which entered the market in 2007 and made the first commercial OCT system as the OCT-1 in 1997. FastTrac is an eye-tracking system available on the Cirrus 5000 HD-OCT model, which tracks the patient's eye movements to reduce motion artifacts compared to the previous Cirrus 500 model [11]. The normative database of the Cirrus HD-OCT involves 282 people equal to or older than 18 years with a refractive error within −12 to +6 diopters and axial length of 22- 28 mm without known ocular pathologies.

On the RNFL and macular ganglion cell deviation maps, at each superpixel, suspect data as measurements between 1 % and 5 % of the normative database are highlighted in yellow, and 1 % of the normal database is highlighted in red. The 5 % (largest) of measurements is in the white area, and the grey color is not applicable because data gained is not comparable with normal database due to some of its characteristics, such as very large or small disc or cup-to-disc ratio of less than 0.25. About 90 % of measurements fall in the green area (5 % < green ≤ 95 %). The 5 % (worst) of measurements fall in the yellow area outside the normal limit if the measurement is worse than 1 % of the normal database. The 5 % (largest) of measurements is in the white area, and the grey color is not applicable because data gained is not comparable with normal database due to some of its characteristics, such as very large or small disc or cup-to-disc ratio of less than 0.25 [11, 40].

1. RNFL thickness profile

The optical disc is evaluated in a 6x6 mm cube consisting of 200-B mode scans, each consisting of 200-A mode scans, so each A-scan corresponds to 30 μ^2 of the retina in an emmetropic eye. The device automatically detects the center of the optical disk. It forms a 3.46 mm circle around the disk, analyzes the thickness of RNFL around the disc, and compares it with the normative database. The signal strength value is between 0 and 10 for the whole scan, indicating better value in higher numbers and unacceptable with a signal strength of 5 or less [11]. The RNFL thickness map is shown on all scanned cube data in which cool colors indicate thinner areas.

In comparison, warm colors indicate thicker areas, so the RNFL thickness (from 0 as blue to 350 µm as white) is visible in all 6x6 mm areas [40]. In this manner, the observer may better detect RNFL loss than a single 3.46 mm circumpapillary RNFL scan [44, 48, 101]. The TSNIT thickness profile shows the RNFL thickness for each point across the sircle around the disc, compares these values with the age-matched normative database and shows them with color codes (white, green, yellow, and red) [40]. Through a deviation map, patient RNFL thickness in the cube, which consists of 2500 superpixels, is compared with aged-matched normative data via deviation map with the mentioned color coding way [11, 40].

2. Optic disc parameters analysis

The OCT device automatically measures several ONH parameters, including disc area, rim area, vertical rim thickness, horizontal rim thickness, cup-to-disc area ratio, vertical cup-to-disc ratio, horizontal cup-to-disc ratio, and cup volume. [132].

3. Ganglion cells analysis

To aid in the diagnosis and monitoring of glaucoma, it is essential to scan the macular region, with a particular focus on ganglion cell analysis. The device generates a 6 x 6 mm macular cube data centered on the fovea. The Cirrus HD-OCT offers two scan options for the macular cube, including a default 512 x 128 grid with 128 horizontal B-scans, each with 512 A-scans, totaling 65,536 A-scans. Alternatively, a 200 x 200 macular scan algorithm is available, consisting of 200 horizontal B-scans with 200 A-scans each, including 40,000 A-scans with higher vertical resolution and shorter acquisition time, making it useful for patients with less optimal fixation. The ganglion cell analysis algorithm calculates the average, minimum, and sectoral thicknesses (superotemporal, superior, superonasal, inferonasal, inferior,

inferotemporal) of the ganglion cell-inner plexiform layer (GCIPL) and provides a thickness map as a color-coded topographic image and deviation map [98, 133, 134].

4. Glaucoma Progression Analysis

To analyze glaucoma progression, Cirrus HD-OCTGPA utilizes at least four scans to examine two sections of the eye: the RNFL and ONH area, as well as the macular region. For the event analysis (GPA), the first two scans selected by the user serve as baseline data, and up to six subsequent scans are compared with these baseline images, independent of the normative database. In normal subjects, the average GCIPL thickness is 82.1 ± 6.2 µm, with the superonasal sector being the thickest and the inferior sector being the thinnest. The thinning rate due to aging is around -0.31 µm/year. An average GCIPL thickness change of more than 4 µm is considered normal and typically indicates an arcuate defect on the thickness change and progression maps. While the floor effect can affect macular parameters, this tends to happen later in the disease progression than in the RNFL.

For GCIPL progression analysis using GPA, a minimum of four high-quality macular scans (two baselines and two follow-ups) are necessary. If there is a decrease in thickness in the first follow-up, the pixel is coded as yellow. However, if this decrease is repeated, the pixel is coded as red 40. The Cirrus HD-OCT GPA evaluates RNFL thickness map progression for focal changes, RNFL thickness profile for broader focal changes, average and inferior/superior hemifield RNFL thickness for diffuse progression, and average cup-to-disc ratio for ONH changes over time [11].

PanoMap Analysis

The PanoMap analysis combines the macular cube and the 200 × 200 optic disc cube involving RNFL in a single report as a wide-field view accompanied by a macular full-thickness map, providing a more precise spatial relationship between the parapapillary and macular areas to simplify the diagnosis making [11].

Chapter 3: Optovue-RTVue 100

Optovue achieves a scan rate of 70,000 A-scans/second with a 5 µm axial and 15 µm transverse resolution. There are 1,600 eyes in the database; 600 are from the United States and 1,000 from around the world. For comparison with other people in the same age group, it uses green (normal), yellow (suspicious), and red (abnormal) [40].

1. RNFL thickness profile

The optical disc is calculated using a 6x6 mm cube of 101 lines. Nine radial and 13 circular scans with a diameter of 1.3-4.9 mm are performed around the optic disc defined by the pigment epithelium border [40]. The average RNFL thickness in four 3.45 mm diameter circular scans are calculated in 0.16 seconds, and the result is compared with normative parameters.

2. Optic disc parameters analysis

The RTVue-100 puts the cup plane at 150 mm above the defined disc plane between RPE tips for getting cup-to-disc horizontal and vertical ratios, optic disc area, cup area, rim area, cup-to-disc area ratio, disc volume, cup volume, rim volume, and cup-to-disc volume ratio.

3. Ganglion cells analysis

The GCC is defined as the sum of RNFL, GCL, and IPL thickness with a scan pattern centered 0.75 mm temporal to the fovea, as a square grid of 7×7 mm consisting of 15 B-scans gives

us three color-coded maps, the GCC thickness map for a healthy eye on the left side with a thick band surrounding the macula, the GCC thickness map for a glaucoma patient on the right side with a decrease in the thickness of this band around the macula, and the deviation map [86, 135]. The deviation map shows the percentage loss from the normal database at each pixel in the map, so green and yellow are nearly normal areas, blue represents GCC thinning from 20-30 % relative to normal, and black in the deviation map represents a 50 % loss or greater, red represents 20-40 % thicker than normal and white represents 50 % increase in the GCC thickness or greater relative to an age-matched normal. The significance map (normal database reference map) shows regions where the change from the normal database reaches statistical significance, so green represents normal (P value 5 %-95 %), yellow indicates borderline results (1 % ≤ p-value < 5 %), and red represents a normal outside limit (P value < 1 %). In summary, the significance map shows how significant the difference of each area of the macular ganglion cell complex is compared to the normal value. The circular mask in the center of the deviation and significance maps macula shows impossible calculation because of the absence of ganglion cells in this region, the thickness, deviation, and significance maps for a glaucoma patient [136]. Pattern-based parameters, such as focal loss volume (FLV) and global loss volume (GLV), have been found to have better diagnostic values than mean GCC loss alone. FLV represents the average amount of focal ganglion cell complex (GCC) loss, while GLV is the sum of negative fractional deviation. Mean GCC loss alone may overlook focal GCC loss in eyes with above-average GCC thickness, highlighting the importance of pattern-based parameters [39, 40, 86, 135, 137-141].

4. Glaucoma Progression Analysis

The RTVue progress analysis compares RNFL thickness measurements and the GCC map over time and determines whether the changes are statistically significant [142].

Summary

Following the demographic data quality scan of patients, which is important, physicians who interpret these reports should review them systematically so that they do not miss small details that may be important for the final decision, as well as for identifying artifacts or anatomical changes that could lead to misdiagnosis. The physician must determine whether the patient's ocular condition is worthy of comparison with a normative database of the available type of OCT.

Conclusion

The OCT is an excellent method for diagnosing and following up patients with glaucoma, considering nerve fiber layer thickness, ganglion cell analysis, and optic disc characteristics.

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Footnotes and Financial Disclosures

Conflict of interest:

The authors have no conflict of interest with the subject matter of the present manuscript.