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THE CORRELATION BETWEEN VISUAL FIELD DEFECTS AND NERVE FIBER LAYER THICKNESS

measured with optical coherence tomography in glaucoma patients

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Abstract

The diagnostic procedures that are recently included in the basic standards for glaucoma is OCT and other digital devices (HRT, SLP and others). The study is prospective-retrospective and longitudinal, encompassing 100 patients suspected for glaucoma, which were proceeded to the University Eye Clinic for investigation. All the patients were completely check-up in the beginning of the study _and after 6 months. The diagnosis of glaucoma is determined based upon the presence of: increased IOP, glaucomatous disc and a confirmed defect in the field of vision or OCT results. The protocol included visual acuity, IOP, gonioscopy, funduscopy, visual fields, OCT, anamnesis and history of the disease, checkup for risk factors. The aims of the study were: to investigate to correlation between diagnostic findings of OCT and visual fields in new diagnosed glaucoma patients, to correlate the meaning of visual field and OCT in the diagnosis of glaucoma, to correlate the values of AT total, AT superior and AT inferior to correlate the finding of VF and OCT with visual acuity, to correlate the findings of OCT and IOP , to correlate the C/D ratio with OCT and visual field findings.

Conclusions: *average thickness of the retinal nerve fiber layer at glaucoma patients is negatively correlated with the values of intraocular pressure; the relationship between VA and total average thickness in OCT showed significant negative correlation in eyes with glaucoma. Considering the wide variability of structure-visual acuity relationship in glaucoma patients, the clinicians should take this variables into account to predict the visual acuity in advanced glaucoma patients; the mean deviation in visual field testing did not showed correlation with average thickness. The AT total did not show significant correlation with the mean deviation which shows that in the first stadiums of glaucomatous damage there is no predictable values from RNFLT and MD comparing.*

Keywords: *Glaucoma, OCT, Visual field, Average thickness*

Introduction

Once glaucoma is diagnosed, patients are treated and monitored to detect progressionof the disease. Distinguishing change due to glaucoma disease from normal age-related changes or test variability can be challenging. Both the appearance of the ONH and RNFL and the visual function may be followed.

Ageing alone accounts for a loss of approximately 400,000 optic nerven fibres during a 70-year life span (about 25%) with a fairly large difference in then number of optic nerve fibres between individuals.

This physiologic loss of nerve fibresis visible at the ONH and results in a gradual decrease of the mean sensitivity in automated static perimetry over time. Light sensitivity decline in perimetry starts

at the age of 20 years and continues linearly during life with a loss rate of 0.58dB per decade (4). In addition, the upper half of the visual field is influenced to a larger extent by age. Other age-related changes may also be relevant. An age dependent reduction of axial length has been noted and may account for some variability due to magnification differences of images. The physiologic loss of neuronal tissue and visual function is already considered in modern diagnostic instruments.

A direct correlation of the decrease of RNFL-thickness with axon loss is not possible: axons do not present a constant proportion of the RNFL-thickness during life. The concentration of axons in the RNFL decreases with age. Perimetry estimates the visual fieldsensitivity to presented stimuli at a certaintest location. In the widely used Humphrey 24-2 testing algorithm, the threshold value calculated for each of the 54 test points is compared to a data base of healthy individuals of similar age and ethnicity.

Optical coherence tomography (OCT) is a fundamentally new type of optical imaging modality. OCT performs high-resolution, cross-sectional tomographic imaging of the internal microstructure in materials and biologic systems by measuring backs cattered or back reflected light.

OCT images are two-dimensional data sets which represent the optical backs cattering in a cross-sectional plane through the tissue. Image resolutions of 1 to 15 μm can be achieved one to two orders of magnitude higher than conventional ultrasound. Imaging can be performed in situ and in real time. The unique features of this technology enable a broad range of research and clinical applications. This review article provides an overview of OCT technology, its background, and its potential biomedical and clinical applications.

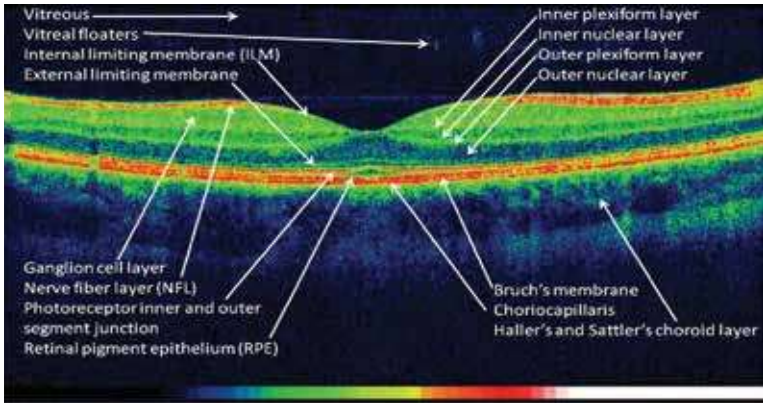


Figure 1.OCT

OCT contributes to our ability to manage glaucoma by providing important quantitative and qualitative data. It enables us to study the morphology and morphometric of the optic disc and the peripapilary nerve fibers. Numerous studies have shown a correspondence between OCT measurements and histological measurements. The OCT scan of the optic disc captures a 6x6mm cube formed from 200 A - scans for each of 200 B-scans. The area within 6x6 mm is segmented for analysis. From this cube of data the machine automatically identifies the center of the disc and creates a 3,46 mm calculation circle around the disc (9). The RNFL normative database helps us to identify the areas of interest by comparing patients' RNFL thickness measurements with the age matched normal subjects. RNFL Thickness map is based on data calculated over the entire cube.

In the next table according to Savin G, there is difference in the RNFL thickness between different populations measured by different OCT.

Study	Sample size(eyes)	Mean RNFL thickness	Ethnicity
Huang et al.	60	101,49	Chinese
Knight et al	29	92	Caucasian
Leung et al.	97	96,8	Chinese
Savini et al	23	95,21	Caucasian
Mansouri et al	65	113,38	Chinese
Nakatani et al	32	111,14	Japanese

Table 1. Population difference of RNFL with OCT

The correlation between RNFL thickness and clinical variables in healthy individuals: progressive tinning with ageing; bigger optic disc shows thicker RNFL (Band Schneider D, Journal of glaucoma, 2010), axial length is in negative correlation with RNFL thickness).
OCT has an important role in the early detection of progression in glaucomatous disease, but has some limitations: quality of signal depends from the optic medias (cataract, corneal macula); artifacts in the picture because of wrong interpretation of software; other eye diseases myopia, age adjusted normative data base, "floor" effect in advanced glaucomatous disease (11).

Aim

To describe two approaches for improving the detection of glaucomatous damage seen with optical coherence tomography (OCT) one, a visual analysis of the high-quality OCT circle scans and two, a comparison of local visual field sensitivity loss to local OCT retinal ganglion cell and retinal nerve fibre layer (RNFL) thinning. To investigate the correlation between diagnostic findings of OCT and visual fields in new diagnosed glaucoma patients; to correlate the meaning of visual field and OCT in the diagnosis of glaucoma; to correlate the values of AT total, AT superior and AT inferior; to correlate the finding of VF and OCT with visual acuity; to correlate the findings of OCT and IOP; to correlate the C/D ratio with OCT and visual field findings;

Materials and methods

We have measured and calculated the correlation between basic parameters: visual acuity (VA), intraocular pressure (IOP), Visual field (VF), Ocular coherent tomography.
Visual acuity in all the patients was checked in the beginning of the study.
Average acuity was 0, 48.
The IOP measurements showed that the average IOP value was 23,3mmHg
The average age of the examined patients was 64, 1year.

OCT RESULTS

The OCT was performed in all 100 patients.
We have statistically examined the values from OCT of RNFL: the average thickness AT (superior, inferior and total) and the values of IOP, which is presented on the following tables and graphics.

AT sup/IOP	r –0,0119
	p –0,881
AT inf/IOP	r=0,0202
	p=,843
Total/IOP	r=-0,2884
	p=,004

Table 2. Correlation between IOP versus AT sup, AT inf and AT total

AT sup/MD	r=0,1847
	p=,067
AT inf/MD	r=0,1425
	p=,159
Total/MD	r=0,0817
	p=,421

Table 3. IOP and AT

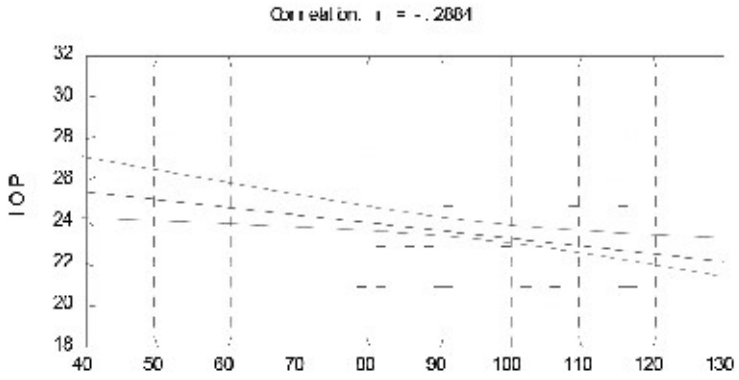


Figure 2. IOP and AT

We have registered statistically significant negative average correlation between IOP and the values of AT total. Other values (superior, inferior average thickness has not showed statistically significant correlation (table 2).
The other parameter that we have examined was mean deviation (MD) from the visual field and compared with the average thickness (superior, inferior, total) in OCT results.

AT sup/visus	r=0,0691
	p=,497
AT inf/visus	r=-0,0385
	p=,705
Total/visus	r=-0,2070
	p=,040

Table 4. MD versus AT sup, AT inf, AT total

There is no statistically significant correlation between MD and AT values

III. Visual acuity (VA) was correlated with AT superior, inferior and total. It is registered

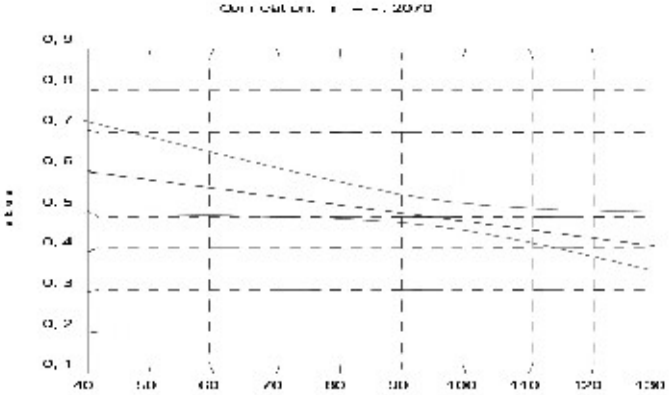


Figure 3. VA versus AT superior, AT inferior and AT total

AT sup/CD	r= 0,0982
	p=0,334
AT inf/CD	r=-0,1928
	p=0,056
Total/CD	r=-0,1892
	p=0,061

Table 5. VA versus AT superior, AT inferior and AT total

statistically significant negative correlation between VA and values of total AT, and there is no statistically significant correlation with the values of superior and inferior thickness. We have correlated the C/D ratio with AT sup, inf and total and the results are presented in the table 5.
Table 5. C/D versus AT sup, inf and total
There is no statistically correlation between the cup disc ratio and C/D values of average thickness.
We have examined the relation between IOP and VA which is presented in the following table and graphic (figure).

	vizus
IOP	0,2193
	p=0,028

Table 6. IOP and VA

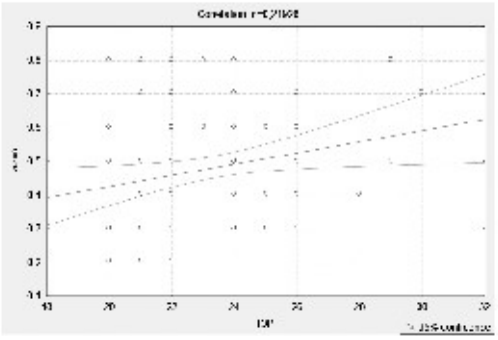


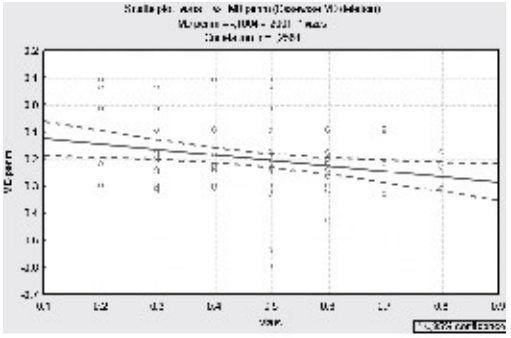
Figure 4. IOP and VA

It is registered mild positive statistically significant correlation between IOP and VA.
We have calculated that there is a mild correlation between mean deviation and visual acuity presented in the following table and graphic.

	MD perim
vizus	-0,2561
	p=0,010

Table 7. MD and visual acuity

Figure 5. MD and visual acuity



We have registered mild negative statistically significant correlation between MD and visual acuity.

Disscusion

Previous studies reported that the thickness of retinal nerve fiber layer showed good diagnostic ability for detecting glaucoma. However, its impact on the progression of visual field loss in primary open angle glaucoma (POAG) is unknown. The purpose of this study was to assess whether baseline RNFL thickness is associated with the progression of visual field loss in POAG. One hundred patients suspect for POAG were included in the study. All patients were examined for baseline optical coherence tomography (OCT) measurements. They had two reliable Optopol visual field tests with glaucoma standard tests during the follow-up period. Factors compared between the groups were as follows: age, baseline intraocular pressure (IOP), mean IOP during the follow-up, refraction, baseline MD and baseline OCT measurements (3). Our study registered statistically significant negative average correlation between IOP and the values of AT total, with r=-0, 2884 and p=0,004. Superior AT with p=0,884 and inferior average thickness with p=0,843 have not showed statistically significant correlation. This leads to conclusion that baseline AT total thicknessis negatively correlated with the IOP value and can be predictive of glaucomatous damage.

The other parameter that we have examined was calculating the average mean deviation (MD) from the visual field and compared with the average thickness (superior, inferior, total) in OCT results. We compared the rates of retinal nerve fiber layer (RNFL) thickness in patients suspected of having glaucoma who developed visual field damage (VFD) with those who did not develop VFD and to determine whether the rate of RNFL loss can be used to predict the development of VFD. Global and quadrant RNFL thickness (RNFLT) were measured with optical coherence tomography and MD from visual field tests was compared using multivariate linear mixed-effects model. The AT total with p=0,421 AT superior with p=0,067 and AT inferior with p=0,159 did not show significant correlation with the mean deviation which shows that in the first stadiums of glaucomatous damage there is no predictable values from RNFLT and MD comparing. The examination group with suspected patients for glaucoma is not homogenous to predict the visual field progression with OCT results. The mean deviation from perimetry did not showed correlation with average thickness, due to the total sensitivity loss in glaucoma patients.The preperimetric glaucoma where OCT is an important examination was confirmed only in small number of patients, that is why we did not get any correlation (5).

We assessed the relationship between retinal structures measured by optical coherence tomography and visual acuity in open-angle glaucoma (OAG) patients. The participants underwent OCT for measurement of retinal nerve fiber layer thickness. The correlations between best-corrected visual acuity and optical coherence tomography (OCT) parameters were evaluated using regression analysis. Among RNFL parameters, average total thickness showed the highest correlation with BCVA, and the superior with r=0,0691 and p=0,497 and inferior r=-0,0385 and p=0,705 did not show statistically significant correlation with the values of superior and inferior thickness. The visual acuitu vallues showed negative correlation with the average thickness, wich can be explaned with the fact that we have found early glaucoma stage in new patients with glaucoma while the acuity is still good.

Conclusion

Average thickness of the retinal nerve fiber layer showed in ocular coherent tomography at glaucoma patients is negatively correlated with the values of intraocular pressure. The relationship between VA and total average thickness in OCT showed significant negative correlation in eyes with glaucoma.

Considering the wide variability of structure-visual acuity relationship in glaucoma patients, the clinicians should take other variables into account to predict the visual acuity in advanced glaucoma patients. Mean values of the basic diagnostic parameters (C/D, VF and OCT) in primary open-angle glaucoma patients, primary open - angle glaucoma suspects, and healthy subjects differed significantly. They are an important diagnostic tool in glaucoma diagnosis. What limits the diagnostic value of these parameters is their wide span and overlapping in populations of primary open-angle glaucoma patients and healthy patients. Analyzing of OCT and visual field together with measuring the intraocular pressure we used the methods to verify the diagnosis of glaucoma. Because very often those patients have also beginning or advanced cataract or age related macular degeneration we used this important ophthalmological tools to discover those diagnosis in potential glaucoma patients. The OCT instruments offer both high sensitivity and high specificity, and all eyes with advanced disease were correctly classified

as glaucomatous in this evaluation. However, although these instruments are still expensive they are very suitable as a screening tool for glaucoma. The OCT parameters differed in the distinct optic disc appearance and initial glaucomatous damage pattern.
Clinicians should be aware that the diagnostic capability of OCT parameters could differ according to the type of optic disc damage in early glaucoma. To improve the sensitivity and specificity of OCT imaging, high-quality images should be visually scrutinised and topographical information from visual fields and OCT scans combined. A close visual analysis of a high-quality circle scan can help avoid both false positive and false negative errors. Similarly, to avoid these errors, the location of abnormal visual field points should be compared to regions of abnormal RGC and RNFL thickness.

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