

GLAUCOMATOUS PARAMETERS IN NORMAL, OCULAR HYPERTENSIVE AND GLAUCOMATOUS EYES USING OPTICAL COHERENCE TOMOGRAPHY

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SUMMARY – The aim of the study was to evaluate optic disk appearance and retinal nerve fiber layer (RNFL) thickness in normal, ocular hypertensive (OHT) and glaucomatous eyes using optical coherence tomography (OCT). This comparative analysis included 62 eyes: 24 normal, 16 OHT and 22 glaucomatous. OCT topographic parameters of cup diameter, cup area, rim area and cup/disk area ratio were significantly greater in OHT eyes than in normal eyes, and significantly greater in glaucomatous eyes than in normal and OHT eyes. RNFL was significantly thinner in OHT eyes than in normal eyes in the inferior quadrant, and in glaucomatous eyes as compared with OHT and normal eyes on an average and in all four quadrants. OCT is a sensitive method for detection of the earliest organic damage in glaucoma, while optic disk parameters and RNFL by use of OCT may prove useful on clinical assessment of glaucoma.

Key words: *Optic disk parameters; Retinal nerve fiber layer thickness; Optical coherence tomography*

Introduction

Glaucomatous optic nerve damage appears not only as a morphological change of the optic disk but also as reduction in the thickness of the retinal nerve fiber layer (RNFL) and defect of the optic nerve axon causes RNFL thinning¹⁻³. It is known to develop earlier than the morphological change of the optic disk and change of vision⁴. In glaucoma patients, such an alteration in the thickness of RNFL may appear prior to vision defects caused by optic nerve defects, and thus the assessment of such an alteration has recently been found useful in the early diagnosis of glaucoma⁵.

The optical coherence tomography (OCT) is a method using ultrared radiation with a resolution of approximately 10 μm to measure the difference in the time of light reflection from different depths of tissue by optical instruments. It measures objectively, without contact and non-invasively for RNFL, giving various param-

eters of the optic nerve disk. In comparison with test results obtained by conventional ophthalmoscopy, the advantages OCT imaging of the optic nerve disk and retinal optic nerve layer are minimizing of determination by the examiners and quantification of the results⁸. This allows for accurate diagnosis, assessment of progression and prognosis.

We used Stratus optical coherence tomography 3.0 (OCT) to measure various parameters of the optic disk of glaucomatous eyes, and thickness of RNFL in normal eyes, ocular hypertensive eyes (OHT) and glaucomatous eyes. We performed comparative analysis of their correlation to assess the clinical usefulness of the data obtained by OCT.

Materials and Methods

The study was performed at University Department of Ophthalmology, Sestre milosrdnice University Hospital, Zagreb, Croatia, from May to December 2006, on 24 normal eyes, 16 OHT eyes and 22 glaucomatous eyes. The definition of normal eyes was the absence of any other eye disease, corrected vision of over 1.0, goniosco-

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Table 1. Patient characteristics

	Normal	OHT	Glaucoma	p
Mean age (yrs)	43.7±6.5	46.5±8.5	56.4±10.4	0.02*
Refractive error (D)	-1.4±1.9	-1.5±2.5	-0.7±1.8	0.96 [†]
Sex (M/F)	14/10	8/8	14/8	0.24*
MD (dB)	1.5±0.3	1.2±0.7	4.1±1.2	<0.0001*
CLV (dB)	1.2±0.5	1.7±1.2	8.5±3.5	<0.0001*

Data are mean±standard deviation; OHT = ocular hypertension; MD = mean deviation; CLV = corrected loss variance; *by analysis of variance; [†]by chi-square.

py result of an open angle, ocular tension measured for a minimum of 2 times lower than 21 mm Hg, the cup/disk ratio less than 0.2, normal results on glaucoma visual field by Octopus automated perimetry performed 2 times, and corrected pattern standard deviation (CPSD) within 95% of normal range.

OHT was defined as ocular tension measurement for more than a minimum of 2 times over 21 mm Hg, absence of any change to the glaucomatous optic disk and absence of any glaucomatous defect on Octopus automated perimetry.

The glaucoma group was defined as an open angle result on gonioscopy, ocular tension measurement of more than 2 times over 21 mm Hg, the cup/disk ratio on ophthalmography, optic disk imaging of over 0.6 and glaucoma visual field on Octopus automated perimetry.

Optic Nerve Head Analysis system was used to measure disk diameter, cup diameter, disk area, cup area, nerve rim area and cup/disk ratio. RNFL thickness average system was used to measure the values of superior, inferior, nasal and temporal RNFL thickness and their averages used as parameters.

On statistical analysis, ANOVA test was used to compare the three groups: normal, OHT and glaucoma.

Results

The three groups differed significantly according to age. There was a statistically significant difference in mean deviation (MD) and corrected loss variance (CLV) on Octopus automated perimetry (Table 1).

Table 2. Mean value of optic nerve head parameter in OCT

	Normal	OHT	Glaucoma	p*	p [†]
Disk diameter (mm)	1.94±0.30	1.93±0.47	1.98±0.33	0.9135	0.7831
Cup diameter (mm)	0.65±0.41	1.12±0.42	1.53±0.34	<0.0001	<0.0001
Disk area (mm ²)	2.47±0.41	2.8±0.64	2.78±0.60	0.7516	0.5611
Cup area (mm ²)	0.76±0.60	1.38±0.64	1.97±0.66	<0.0001	<0.0001
Rim area (mm ²)	1.72±0.51	1.40±0.32	0.81±0.46	<0.0001	<0.0001
C/D ratio	0.29±0.21	0.48±0.14	0.69±0.18	<0.0001	<0.0001

p* = corresponding pairs: normal and OHT; p[†] = corresponding pairs: normal/OHT and glaucoma

Table 3. Retinal nerve fiber layer thickness in normal, OHT and glaucomatous eyes according to quadrant

	Normal	OHT	Glaucoma	p*	p [†]
Superior (μm)	127.0±14.2	125.9±10.7	85.8±27.7	0.4964	<0.0001
Inferior (μm)	134.6±21.6	126.8±19.2	74.1±22.2	0.0450	<0.0001
Nasal (μm)	71.4±16.3	74.4±17.3	54.5±20.2	0.2316	<0.0001
Temporal (μm)	83.7±17.9	78.2±15.9	55.0±14.6	0.1726	<0.0001
Mean (μm)	104.3±10.7	101.4±8.6	67.4±15.6	0.1138	<0.0001

p* = corresponding pairs: normal and OHT; p[†] = corresponding pairs: normal/OHT and glaucoma

Table 2 shows mean values of optic nerve head measured by OCT: disk diameter, cup diameter, disk area, cup area, rim area and cup/disk area ratio. On comparison between the normal and OHT groups, a significant difference was detected in all parameters of the optic nerve disk except for diameter of the optic nerve disk and disk area. Similarly, comparison between OHT and glaucoma groups yielded significant differences except for diameter of the optic nerve disk and disk area.

Considering RNFL thickness in the normal group, the inferior quadrant was thickest, followed in order by the superior, nasal and temporal quadrants. In OHT group as compared with normal eyes, the inferior quadrant RNFL was thinned significantly, with no significant differences detected in other quadrants. In the glaucoma group as compared with OHT group, significant reduction was detected in all areas, and thinning was particularly more significant in the superior and inferior quadrants (Table 3).

Discussion

In this study, a significant difference was detected in the parameters of the optic nerve disk between the normal and OHT groups, except for diameter of the optic nerve disk and disk area. Comparison between OHT and glaucoma groups showed significant differences except for diameter of the optic nerve disk and disk area. In other studies, differences between normal, OHT and glaucoma groups are reported. Zangwill *et al.*⁷ report that in OHT the measurement of optic nerve disk parameters by confocal scanning laser ophthalmoscopy showed a value between normal and glaucoma, while a significant difference was detected in the optic nerve disk area, nerve rim area and mean contour height. Schuman *et al.*⁸ report that the thickness of the temporal nerve fiber layer decreased with increasing age. Bowd *et al.*⁹ report that measurement of RNFL thickness by OCT showed significant reduction in all four quadrants in OHT cases as compared with normal eyes, and RNFL was thinned by 15% on an average. Similarly, although the test method was different, Schwartz and Takamoto¹⁰ report an approximate RNFL thinning of 18% as measured by stereophotogrammetry. In the report by Quigley *et al.*³ preceding RNFL defects were detected in 57% of OHT patients during the process of developing visual field defect, and the preceding RNFL defect was detected in 35% of OHT patients even if it was not in the process of developing visual field defects.

According to the report by Bowd *et al.*⁹, the RNFL inferior quadrant in OHT was significantly thinner than normal and was associated with damage to the ocular nerve initiated in the inferior pole. In our study, similarly to the report by Bowd *et al.*⁹, a significant difference was recorded in the inferior quadrant between normal and OHT, but no such difference was observed in other quadrants, possibly because of difference in the sensitivity of measuring equipment and size of the study population.

Conclusion

According to our results, assessment of the optic nerve disk parameters by OCT to determine RNFL thicknesses may be useful in the diagnosis of glaucoma patients and on assessment of its progression in the future.

References

1. QUIGLEY HA, KATZ J, DERRICK RJ, *et al.* An evaluation of optic disc and nerve fiber layer examinations in monitoring progression of early glaucoma damage. *Ophthalmology* 1992;99:19-28.
2. SOMMER HA, QUIGLEY HA, ROBIN AL, *et al.* Evaluation of nerve fiber layer assessment. *Arch Ophthalmol* 1984;102:1766-71.
3. QUIGLEY HA, ADDICKS EM, GREN WR. Optic nerve damage in human glaucoma. III Quantitative correlation of nerve fiber loss and visual field defects in glaucoma, ischemic neuropathy, papilloedema and toxic neuropathy. *Arch Ophthalmol* 1982;100:135-46.
4. TUULONEN A, LEHTOLA J, AIRAKSINEN PJ. Nerve fiber layer defects with normal visual fields. *Ophthalmology* 1993;100:587-98.
5. AIRAKSINEN PJ, ALANKO HI. Effect of retinal nerve fiber loss on the optic nerve head configuration in early glaucoma. *Graefes Arch Clin Exp Ophthalmol* 1983;220:193-6.
6. SOMMER A, D'ANNA SA, KUES HA, GEORGE T. High-resolution photography of the retinal nerve fiber layer. *Am J Ophthalmol* 1983;96:535-9.
7. ZANGWILL LM, Van HORN S, De SOUZA LIMA, M *et al.* Optic nerve head topography in ocular hypertensive eyes using confocal scanning laser ophthalmoscopy. *Am J Ophthalmol* 1996;122:520-5.
8. SCHUMAN JS, HEE MR, PULIAFITO CA, *et al.* Quantification of nerve fiber layer thickness in normal and glaucomatous eyes using optical coherence tomography: a pilot study. *Arch Ophthalmol* 1995;113:586-96.
9. BOWD C, WEINREB RN, WILLIAMS JM, ZANGWILL LM. The retinal nerve fiber layer thickness in ocular hypertensive,

- normal and glaucomatous eyes with optical coherence tomography. Arch Ophthalmol 2000;118:22-6.
10. SCHWARTZ B, TAKAMOTO T. Measurement by nerve fiber layer thickness and its functional correlations with the visual field. Bull Soc Belge Ophthalmol 1992;244:61-72.
11. SOMMER A, MILLER NR, POLLAK I, *et al.* Nerve fiber layer in the diagnosis of glaucoma. Arch Ophthalmol 1977;95:2149-56.

Sažetak

GLAUKOMSKI PARAMETRI U ZDRAVIM OČIMA, OČIMA S OČNOM HIPERTENZIJOM I GLAUKOMSKIM OČIMA MJERENI OPTIČKOM KOHERENTNOM TOMOGRAFIJOM

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Cilj ove studije bio je procijeniti izgled glave vidnoga živca i debljinu retinalnog nervnog sloja (RNFL) u zdravim očima, očima s očnom hipertenzijom i glaukotskim očima pomoću optičke koherentne tomografije (OCT). U ovoj usporedbenoj analizi bila su uključena 62 oka i to 24 zdrava oka, 16 očiju s očnom hipertenzijom i 22 glaukotska oka. Topografski parametri OCT kao promjer ekskavacije, područje ekskavacije, područje ruba i omjer promjera ekskavacije u odnosu na promjer papile bili su značajno veći u očima s očnom hipertenzijom u odnosu na zdrave oči. Parametri su također bili značajno veći u glaukotskim očima u odnosu na zdrave oči i one s očnom hipertenzijom. Retinalni nervni sloj je bio značajno tanji u donjem kvadrantu u očima s očnom hipertenzijom u odnosu na zdrave oči, te značajno tanji u glaukotskim očima u odnosu na zdrave oči i one s očnom hipertenzijom u prosjeku i u sva četiri kvadranta. Optička koherentna tomografija je osjetljiva metoda za otkrivanje ranih organskih oštećenja u glaukomu, dok su parametri glave vidnoga živca i debljina retinalnog nervnog sloja dobiveni tom metodom isto tako korisni u kliničkoj procjeni glaukoma.

Ključne riječi: *Parametri glave vidnoga živca; Debljina retinalnog nervnog sloja; Optička koherentna tomografija*