MACULAR SECTOR THICKNESS IN OPEN ANGLE GLAUCOMA

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Keywords: *macular sectors, thickness, glaucoma, OCT*

Abstract: *Objective: To evaluate the macular thickness by sectors in primary open angle glaucoma, using Time Domain optical coherence tomography (TD-OCT). Method: A total of 275 eyes from 138 patients were enrolled. The study was conducted from March 2010 to December 2012. The eyes were divided into: the group of normal eyes which comprised 72 eyes (GN), one group of glaucoma suspects and eyes with preperimetric open angle glaucoma (GSPP), which comprised 78 eyes and another group of patients with perimetric open angle glaucoma, comprising 125 eyes. For all the macular sectors, the measurement of macular thickness was done by using optical coherence tomography, and the correlation with glaucoma was calculated by using the mean defect (MD), measured by computerized perimetry. All the patients gave their consent, in accordance with the Helsinki Declaration. The results of the study have shown that the most affected macular sector in primary open angle glaucoma is the inferior one. This study concluded that the macular thickness decreases in glaucoma, and the most significant decrease occurs in the inferior sector. Macular thickness in the central area remained within normal values in glaucoma.*

Cuvinte cheie: *sectoare maculare, grosime, glaucom, OCT*

Rezumat: *Obiectiv: Evaluarea grosimii sectoarelor maculare în glaucomul primitiv cu unghi deschis, utilizând tomografia în coerenţă optică (OCT) time domain (TD). Metodă: Au fost examinaţi 275 de ochi, la 138 de pacienţi. Studiul s-a desfăşurat în perioada martie 2010 – decembrie 2012. Ochii au fost împărţiţi în: grupul de control care a cuprins 72 de ochi normali (GN), grupul ochilor suspecţi de glaucom şi glaucom preperimetric (GSPP) care a cuprins 78 de ochi, iar grupul ochilor cu glaucom perimetric (GP) a cuprins 125 de ochi. Pentru toate sectoarele maculare s-a efectuat măsurarea grosimii prin tomografie în coerenţă optică şi s-a stabilit corelaţia cu glaucomul funcţie de defectul mediu (MD) măsurat prin perimetrie computerizată. Toţi pacienţii şi-au dat acordul în conformitate cu Declaraţia de la Helsinki. Rezultatele studiului au arătat că sectorul macular cel mai afectat în glaucomul primitiv cu unghi deschis este cel inferior. Concluziile studiului sunt că grosimea maculei scade în glaucom şi scăderea cea mai importantă este la nivelul sectorului inferior. Grosimea în zona macular centrală rămâne în limite normale în glaucom.*

INTRODUCTION

Open-angle glaucoma is a chronic, progressive optic neuropathy characterized by morphological changes at the optic nerve head and retinal fibre layer in the absence of other ocular disease or congenital anomalies. Progressive retinal ganglion cells death and visual field loss are associated with these changes.(1) Glaucoma is an acquired disease and the high intraocular pressure might be the determining factor of the cellular events that trigger apoptosis of the ganglion cells.(2) In the retina, there is one row of the ganglion cells but in the macula there are up to 10 rows of ganglion cells with the largest concentration in the parafoveal region.(3) The ganglion cells together with the nerve fibre layer represent approximately 30-45% of the macular thickness.(4) Visual field modifications in glaucoma appear when more than 50% of ganglion cells have already been lost.(5) The fovea, central region of the macula, is characterized by a high cone density and lack of ganglion cells.(3) The concept of using macular thickness for glaucoma diagnosis was used for the first time in 1996 (6) and numerous studies have reported that the macular changes can precede the development of visual field loss in glaucoma. The macular thickness can be measured using OCT

OCT is a non-contact, non invasive imaging method, based on the principle of low-coherence interferometry that uses near-infrared light to scan the retina and optic disc and has become an important component of the retina and optic nerve examination. OCT performs high-resolution, cross-sectional images, which allow in vivo measurements of the macula, RNFL and the head of the optic nerve.(7)

PURPOSE

The purpose of the study is to evaluate the macular thickness by sectors in primary open angle glaucoma, using Time Domain optical coherence tomography (TD-OCT).

METHODS

Study group selection

The lots comprised patients between 40 and 78 years old, irrespective of gender. Patients with visual acuity under 20/40 with best correction were excluded, as well as patients with refraction errors: hypermetropia with over +3 spherical

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diopters, myopia with over -5 spherical diopters, astigmatism with over 2 cylindrical diopters, patients with affections that might affect the macula or the optic nerve, such as: diabetic retinopathy, macular degeneration, vascular occlusions, neuropathies. Patients who had undergone eye surgery – except for those with pseudofac implants with visual acuity within the set limits – and patients who had undergone chronical corticoid treatment, ocular or general, were also excluded.

Inclusion in the control group was done if the intraocular pressure was under 21 mmHg, camerular open angle for gonioscopy, corneal thickness over 500 microns, normal visual field upon examination with the perimeter Octopus 1-2-3, TOP strategy, considering the normal parameters Mean Defect (MD) and Loss Variance(LV) with values considered normal for 95% of the population, that is, with MD between -2 and + 2 decibels, LV under 6 decibels, and the Barbie Curve with normal aspect for 95% of the normal population. Upon ophthalmoscopic examination with a biomicroscope with aspheric lens of +78D, it was observed that the papilla and nerve fibre layer had a normal aspect.

The group of glaucoma suspects and patients with preperimetric glaucoma included eyes without visual field modifications, with one or several risk factors or clinical aspects of the optic nerve observed in glaucoma: ocular hypertension - PIO over 24 mmHg, congener eye with perimetric glaucoma, modifications of the papilla or defects of the nerve fibre layer falling within the clinical appearance of glaucoma.

The group of eyes with perimetric glaucoma was comprised of eyes with visual field outside normal parameters, meaning diffuse or localized visual field losses, with MD greater than +/- 2 decibels and LV greater than 6 decibels, depressed Barbie curve, modifications of the aspect of the optic papilla: thinning of the neuroretinian ring (diffuse or localized), optic disc hemorrages, cup/disc ratio > (C/D) vertical 0.7, asymmetry greater than 0,2 in the C/D ratio between congener eyes, localized or diffuse defects in the nerve fibre layer.

Measurements of the macular thickness

Measurements were done with the ocular tomograph STRATUS OCT, software version 5.0.1, scan type “Fast Macular Thickness Map”. The macular area is subdivided into three circles of 1, 3 and 6mm diameter, into: the central area, the internal ring and external ring. The macular sectors are central, superior, inferior, nasal and temporal. The macular area is thus divided into 9 different scanning areas: the central area, the internal ring divided into 4 sectors, and the external ring also divided into 4 sectors. The scan is performed on six radial lines which intersect at the fovea, and each scan line is comprised of 128 individual scans. By protocol analysis, macular thickness is measured in microns for each of the 9 areas.(7) Thickness of the central area is provided automatically in the scan results and the macular sectors’ thickness was measured using statistical programs.

Statistical methods

The statistical analysis was done with the statistic programs R, version 2.15.3, and Statistica, versions 10 and 12. To determine whether the macular thickness differs among normal patients, glaucoma suspects and patients with glaucomatous eyes, statistical tests Chi-square, P and the Pearson correlation were used. Dispersion graphs were also used in the data analysis.

RESULTS

For the central area, measurements showed similar values for all three groups. Macular thickness values were between 173 – 228 microns in group GN, 179 – 225 microns in group GSPP and 175 - 223 microns in group GP.

For the inferior sector, the average macular thickness was 247,32 microns in the control group, 231,95 microns in the GSPP group, and 214,56 microns in the GP group.

For the superior sector, the average thickness had values of 251,6 micros in the GN group, 242, 95 microns in the GSPP group and 231,46 microns in the GP group.

The measurements results for the minimum, maximum and average thickness in the inferior and superior sectors in the three groups are centralized in table no. 1 below.

Table no. 1. Minimum, maximum and average values for inferior and superior macular sectors, in microns, for the three groups: GN, GSPP, GP

Macular sector	Inferior Sector Minimum	Inferior Sector Average	Inferior Sector Maximum	Superior Sector Minimum	Superior Sector Average	Superior Sector Maximum
GN thickness in µm	235	247,32	261,5	230,5	251,6	271,5
GSPP thickness in µm	217	231,95	250	224	242,95	262
GP thickness in µm	186,6	214,56	239	185	231,46	264,5

For the nasal sector, average macular thickness was 260,41 microns in group GN, 250 microns in group GSPP and 238,04 microns in group GP.

For the temporal sector, values for the average thickness were 240,78 microns in the GN group, 231,6 microns in the GSPP group and 214,88 microns in the GP group.

Minimum, average and maximum values for macular thickness in the nasal and temporal sectors are illustrated in table no. 2 below.

Table no. 2. Minimum, average and maximum values for the nasal and temporal macular sectors, in microns, for the three groups: GN, GSPP and GP

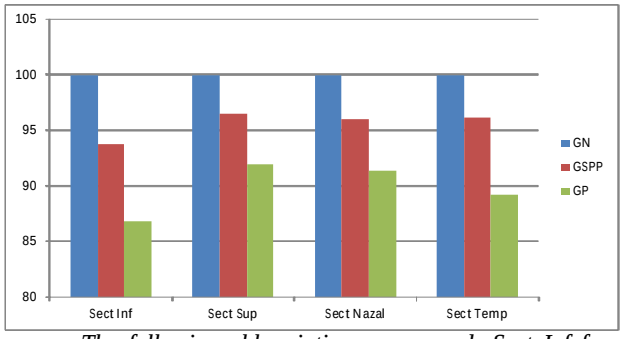
Macular sector	Nasal Sector Minimum	Nasal Sector Average	Nasal Sector Maximum	Temporal Sector Minimum	Temporal Sector Average	Temporal Sector Maximum
GN thickness in µm	239,5	260,41	277,5	223	240,78	274
GSPP thickness in µm	235	250	267	212,5	231,6	243
GP thickness in µm	195,5	238,04	273	181,5	214,88	257

The decrease in macular thickness was calculated in percentages for each sector and study group, the results are shown in figure no. 1.

In the GSPP group, the largest decrease is in the inferior sector (6,22%), followed by the nasal sector (4%), temporal sector (3,83%) and the superior sector (3,44%).

In the GP group, the largest decrease is also observed in the inferior sector (13,25%), followed by the temporal sector (10,76%), nasal sector (8,59%) and the superior sector(8,01%).

Figure no. 1. The percent decrease of the macular thickness by sectors in the study groups



The following abbreviations were used: Sect Inf for the inferior sector, Sect Sup for the superior sector, Sect Naz for the nasal sector and Sect Temp for the temporal sector.

Statistical analysis

Comparative analysis of the study groups (GSPP and GP) and the control group shows a statistically significant decrease in mean macular thickness ($p< 0,05$) in glaucomatous eyes compared to normal eyes, in all stages of glaucoma evolution.

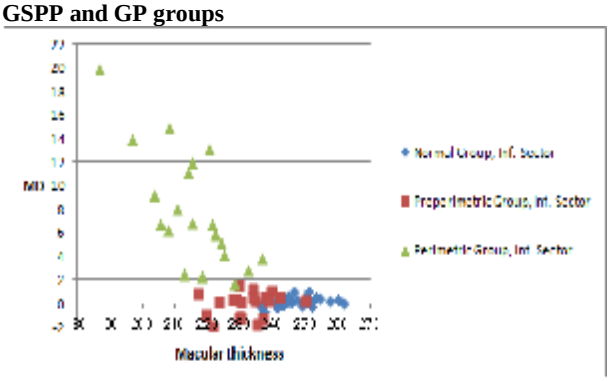
Statistical analysis by sectors

Statistical analysis shows that the decrease in macular thickness in GP group is statistically significant compared to the GSPP group, for all four sectors ($p<0.05$). The correlation between glaucoma and the macular thickness in glaucomatous eyes, measured with the Pearson correlation coefficient, is also high for the four sectors. The inferior sector is the most correlated with glaucoma, with a correlation of -0.78, followed by the temporal sector with a correlation of -0.74, the nasal sector with -0.72 and the superior sector with -0.66.

In the GSPP group, the only sector showing a correlation larger than 0.2 is the inferior sector with 0.26. The other three sectors in the GSPP group are not correlated with glaucoma (the correlation values are lower than 0.2).

The correlation for the inferior sector in the three groups is shown in the dispersion graph below.

Figure no. 2. Correlation between glaucoma and the macular thickness in the inferior macular sector in GN, GSPP and GP groups



The analysis shows that the decrease in macular thickness in the inferior sector is statistically significant, and highly correlated with the evolution stage of glaucoma.

DISCUSSIONS

From the OCT measurements, it was observed that the patients with glaucoma had lower macular thickness indices compared to the normal patients. The macular thickness is significantly lower in glaucoma in both study groups and several similar studies consider the macular thickness modifications may be a surrogate indicator for retinal ganglion cell loss which is characteristic to this affection.(8) Studies show that the decrease in macular thickness is significantly correlated with glaucoma.(5,8-12) The present study shows that there is a decrease in macular thickness in all sectors for both study groups and the decrease is larger in advanced glaucoma stages, for all sectors. For the GSPP group, the biggest decrease was in the inferior sector, followed by the nasal, temporal (the nasal and temporal sectors show similar decrease percentages) and superior sector. For the GP group, the largest decrease was in the inferior sector, followed by the temporal, nasal and superior sectors. In the GP group all sectors are correlated with glaucoma, while in the GSPP group only the inferior sector shows a low correlation. The other GSPP sectors are not correlated with glaucoma. The correlation is low in the GSPP group as MD values in this group are within normal values, similar to the values in the GN group.

The inferior sector is the most affected in all stages of the disease, and the results are similar to other studies.(9,12)

The measurements of the present study and the statistical analysis did not show a decrease in thickness for the central area; the results are similar to several studies (13,14), while others show that the macular thickness in the central area is decreased in glaucoma.(5,10) The results of this study are in line with anatomical data that shows the central area lacks ganglion cells.

Other studies done with the Spectral Domain OCT, a more advanced technology, also show that the macular parameters for thickness are affected in glaucoma.(15,16)

CONCLUSIONS

Based on the OCT measurements, the results of this study show that the macular sector most affected in glaucoma is the inferior one, with a significant decrease in macular thickness in more advanced stages of the disease. The decrease in macular thickness precedes modifications of the visual field in glaucoma.

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