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Research Article

The Role of Evaluation of Macular Pigment Optical Density in Diagnosing and Monitoring of Eye Diseases

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Received: July 23, 2018; **Published:** October 29, 2018

Abstract

Purpose: To evaluate changes and their statistical significance of macular pigment optical density (MPD) in patients with different ophthalmic pathology.

Methods: 240 patients (454 eyes) were involved in the investigation. No one used additional supplementation during 6 months before. Groups of patients: 1st - 60 patients (105 eyes) average age 61.8 ± 10.1 with dry form of age related macular degeneration (AMD) (AREDS I-II), emmetrops; 2nd - 32 patients (64 eyes), average age 43.8 ± 11.5 with high myopia (HM) and refraction -7.6 ± 2.3 D and axial length 26.4 ± 1.3 mm, good macula and BCVA from 20/25 or higher; 3rd - 29 patients (53 emmetropic eyes), age 62.8 ± 10.3 with primary open angle glaucoma (POAG) in different stages; 4th - 35 patients (68 eyes) in average age 51.3 ± 15.8 with different refraction and peripheral rhegmatogenous retinal degeneration (PRD); 5th - 30 patients (57 eyes), age 56.2 ± 17.4 with POAG and HM with refraction -7.4 ± 2.0 D and axial length 26.3 ± 1.8 mm. Controls - 54 healthy persons (107 eyes) with age 54.6 ± 13.4. MPD was measured by heterochromatic flicker photometry.

Results: MPD in groups were: 1st group - 0.28 ± 0.14, 2nd group - 0.32 ± 0.17, 3rd group - 0.26 ± 0.15 ($p < 0.05$), 4th group - 0.27 ± 0.14, 5th group - 0.26 ± 0.12 ($p < 0.05$), in controls - 0.31 ± 0.2. There were no strong Spearman correlation found for MPD with any analyzed parameters.

Conclusion: It was found that MPD is reduced in patients with POAG, as well as in the combination of POAG and HM. Further research is needed to identify MPD as an additional diagnostic factor of POAG or to justify the inclusion of macular pigments in the quality of neurotrophic therapy for patients with this disease. The absence of reduction in the MPD in patients with retinal peripheral dystrophy, HM and dry AMD degeneration indicate the absence of significant effects of macular carotenoids on these diseases.

Keywords: *Macular Pigment Optical Density; Heterochromatic Flicker Photometry*

Abbreviations

AL: Axial Length; AMD: Age Related Macular Degeneration; BCVA: Best Corrected Visual Acuity; HM: High Myopia; MPD: Macular Pigment Optical Density; POAG: Primary Open Angle Glaucoma; PRD: Peripheral Retinal Degeneration

Introduction

Macular pigments, like lutein and zeaxanthin, are localized in the outer plexiform layer and in Henle layer of the retina. They play an important role in retina protection against oxidative stress and filtering the short wavelength in the eye as well [1]. Because of their localization, macular pigment optical density (MPD) can represent the information about the outer retina health. Also, MPD can be used as a possible diagnostic tool for detecting and monitoring of different posterior eye diseases, not only retinal ones [2-4].

Results of MPD measurement in young-to-old age groups and in ophthalmic diseases are different. Some investigations showed decrease of MPD with increasing age [5,6], some of them demonstrated absence of correlation between age and MPD [7]. What is more, some researches established the decreasing of MPD in Age related macular degeneration (AMD) [8] or Primary open angle glaucoma (POAG) [9,10]. But the comparison of current research results is very complicated because of the great variability of MPD levels in different healthy ethnicity - from 0.22 to 0.56 [8].

MPD levels in Russian population are investigated insufficiently. That is why MPD measurement is believed to be an interesting, new and relevant research.

Purpose of the Study

To evaluate changes and their statistical significance of MPD in patients with different ophthalmic pathology.

Materials and Methods

240 patients (454 eyes) were involved in the investigation. No one patient took any additional supplementation with lutein or zeaxanthin during 6 months before the investigation. There were five groups of patients and one control group (Table 1).

Sign	AMD	HM	POAG		PRD	POAG + HM		Controls
Number of patients (eyes)	60 (105)	32 (64)	29 (53)		35 (68)	30 (57)		54 (107)
Number of male/female	17/43	5/27	14/15		15/20	12/18		20/34
Glaucoma stage, number of eyes			I	18		I	25	
			II	17		II	22	
			III	18		III	10	
Mean age, years old	61.8 ± 10.1	43.8 ± 11.5	62.8 ± 10.3		51.3 ± 15.8	56.2 ± 17.4		54.6 ± 13.4
Mean axial length, mm	23.4 ± 1.2	26.4 ± 1.3	23.7 ± 0.6		24.8 ± 3.9	26.3 ± 1.8		23.3 ± 0.6

Table 1: *Characteristics of the study groups.*

The first group consisted of 60 patients (105) eyes with average age 61.8 ± 10.1 years old with dry form of AMD (I and II AREDS [11] - with pigment changes in the macula area and small or middle hard drusen), almost emmetropic and without any other severe ophthalmic pathology. BCVA was 0.88 ± 0.18.

The second group consisted of 32 patients (64 eyes) with average age 43.8 ± 11.5 years old with high axial myopia (HM) and average objective refraction -7.6 ± 2.3 D and axial eye length (AL) 26.4 ± 1.3 mm, without any visible ophthalmoscopy changes in the macular and best corrected visual acuity (BCVA) from 20/25 or higher, with BCVA 0.90 ± 0.16.

The third group consisted of 29 patients (53 emmetropic eyes) with average age 62.8 ± 10.3 years old with POAG in different stages from early to advanced (from I to III). BCVA was 0.71 ± 0.28. Glaucoma was staged mostly on the basis of visual fields defects [12,13].

The forth group consisted of 35 patients (68 eyes) with average age 51.3 ± 15.8 years old with different types of refraction but having rhegmatogenous peripheral retinal degeneration (PRD) like snail track degeneration or lattice degeneration, or tears etc. BCVA in this group was 0.95 ± 0.08.

The fifth group was composed of 30 patients (57 eyes) with average age 56.2 ± 17.4 years old with POAG in different stages from early to advanced (from I to III) and with HM with average objective refraction -7.4 ± 2.0 D and AL 26.3 ± 1.8 mm, and BCVA 0.72 ± 0.22.

Control group consisted of 54 healthy persons (107 eyes) in average age 54.6 ± 13.4 years old without any eye pathology and mostly emmetrops with BCVA 0.99 ± 0.03.

All patients went through the standard ophthalmological examination for setting the diagnosis. The examination included autorefractometry, visual acuity measurement, pneumotonometry, gonioscopy, static automated perimetry, AL measurement, biomicroscopy of the anterior segment of the eye, indirect ophthalmoscopy with the slit lamp and 60D lens. Also macular pigment optical density was measured with the heterochromatic flicker photometry and by using the densitometer Mpod MPS 1000 (Tinsley Precision Instruments) once. This current device demonstrated good results repeatability [14].

Statistical data processing was performed using STATISTICA 7.0. Descriptive statistics of quantitative traits represented by a mean and standard deviation (M ± SD). Hypothesis testing was performed using the nonparametric method of calculating the level of statistical significance for 2 unrelated samples - Mann-Whitney U test (comparison with the control). The critical level of statistical significance was considered p = 0.05. Also the correlation analysis was conducted by calculating of rank correlation Spearman coefficient (r_s).

Results

For more clarity, all measurement results are presented in tables.

MPD measurement results are demonstrated in the table 2.

Group	Glaucoma stage	Macular pigment optical density		Statistical significance (Mann-Whitney U test) for the average result
Dry AMD		0.28 ± 0.14		0.209
HM		0.32 ± 0.17		0.107
POAG	I	0.26 ± 0.15	0.26 ± 0.15	0.003
	II		0.27 ± 0.09	
	III		0.24 ± 0.17	
PRD		0.27 ± 0.14		0.156
POAG + HM	I	0.26 ± 0.12	0.24 ± 0.1	0.047
	II		0.28 ± 0.12	
	III		0.26 ± 0.11	
Controls		0.31 ± 0.2		

Table 2: *Macular pigment optical density of the study groups.*

Correlation analysis for MPD by calculated coefficient of Spearman rank correlation is showed in the table 3.

Parameter	Coefficient of Spearman rank correlation MPD, (r_s)
Age	-0,114 *
BCVA	0,060
AL	-0,062
Stage of glaucoma	-0,170

Table 3: *Correlation analysis for MPD.*

*Note: *p < 0,05.*

Discussion

The results of this study indicate that the decrease of MPD in the group with dry form of AMD, PRD, POAG and POAG with a combination and HM. However, a statistically significant decline in MPD was observed only in the group with glaucoma and the combination of glaucoma and HM. This reduction of MPD in patients with glaucoma was described in Igras E., *et al.* [9], where authors demonstrated a statistically significant lowering in average values of this parameter (MPD was 0.23) in patients with POAG compared with a control group of healthy individuals (MPD was 0.36). Despite the fact that glaucoma is considered to be a disease involving the internal retinal regions, these results with the described changes in MPD in other authors in primary open-angle glaucoma suppose partial involvement of the external retina in glaucoma. It is known that oxidative stress plays a special role in the development of glaucomatous process [15]. And the components of macular pigment have powerful antioxidant function [1]. Therefore, persons with lower values of MPD have a weaker antioxidant protection against glaucomatous process and are more prone to the development of glaucoma. In addition, the loss of a layer of nerve fibers and apoptosis of retinal ganglion cells in glaucoma leads to a loss of localization for macular pigments [4]. This may explain the decrease the MPD in patients with glaucoma.

MPD did not reduce in the group with HM. In the present study the correlations (r_s = -0.062) between MPD and AL also was not found. In the work of Czepita M., *et al.* polish authors also demonstrated the lack of significant correlation between MPD and AL [16]. Thus, MPD results, presented by the authors for the Polish patients, were higher than founded by Russian researchers (MPD was 0.50 ± 0.21 for people with HM and 0.49 ± 0.21 in the control group, using heterochromatic flicker-photometry). Also, when referring to the Chinese study, authors Tong N., *et al*. revealed a statistically significant weak inverse correlation (-0.253) between MPD and AL for cases with AL more than 26.0 mm, and the lack of correlation (0.104) of MPD and AL for eyes with AL less than 26.0 mm [17]. The differences between MPD levels in patients from different countries goes to the problem of analysis of MPD within the same ethnic group [8,18].

Statistically not significant decreasing of MPD was detected in the group with dry form of AMD. MPD measurement in AMD has always had great importance and has been studied for several years. It was shown that MPD often reduced in AMD cases (MPD was 0.35 ± 0.12 in AMD group compared to 0.39 ± 0.12 in the control group) [19] and in addition, it is believed to be a risk factor for developing the disease AMD [20,21]. However, more recent studies demonstrate the lack of correlation between the presence of AMD and the decrease in the level of MPD [22,23]. In the research work of Chinese authors Ren X., *et al*. MPD in the group of patients with the dry form of AMD (0.52 ± 0.19) was higher than in the control group (0.47 ± 0.17) [22]. In the study of Spanish authors Puell M., *et al.* the difference MPD values between the group with AMD (0.27 ± 0.15) and control (0.30 ± 0.24) were inaccurate, which is consistent with the results of the present study.

Similar recurring results of the assessment of MPD in the dry form of AMD, confirmed in our study, let us reconsider the position about the key role of macular pigment in the development of this disease.

In the present study the MPD level was not significantly correlated neither with age, nor with BCVA, nor with AL, nor with the staging of the glaucoma for POAG groups. While MPD - anatomically independent parameter. However, our results may indicate the possibility of MPD measurement in the assessment of outer retinal layers in patients with degenerative diseases of the posterior eye segment.

Conclusion

In this study, it was found that the optical density of macular pigment is significantly reduced in patients with primary open-angle glaucoma, as well as in the combination of glaucoma and axial myopia. Further research is needed to identify this parameter as an additional diagnostic factor in the differential diagnosis of glaucoma or to justify the inclusion of macular pigments in the quality of neurotrophic therapy for patients with this disease. The absence of reduction in the MPD in patients with retinal peripheral dystrophy, axial myopia and dry form of AMD indicates the absence of significant effects of macular carotenoids on these diseases.

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Volume 9 Issue 11 November 2018