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

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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 the 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).

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

Table 1: Characteristics of the study groups.

The purpose of the study was to investigate the changes and their statistical significance of MPD in patients with different ophthalmic pathology.

Results

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

MPD measurement results are demonstrated in the table 2.

<table>
<thead>
<tr>
<th>Group</th>
<th>Glaucoma stage</th>
<th>Macular pigment optical density</th>
<th>Statistical significance (Mann-Whitney U test) for the average result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry AMD</td>
<td></td>
<td>0.28 ± 0.14</td>
<td>0.209</td>
</tr>
<tr>
<td>HM</td>
<td></td>
<td>0.32 ± 0.17</td>
<td>0.107</td>
</tr>
<tr>
<td>POAG</td>
<td>I</td>
<td>0.26 ± 0.15</td>
<td>0.26 ± 0.15</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>0.27 ± 0.09</td>
<td></td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>0.24 ± 0.17</td>
<td></td>
</tr>
<tr>
<td>PRD</td>
<td></td>
<td>0.27 ± 0.14</td>
<td></td>
</tr>
<tr>
<td>POAG + HM</td>
<td>I</td>
<td>0.26 ± 0.12</td>
<td>0.24 ± 0.1</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>0.28 ± 0.12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>0.26 ± 0.11</td>
<td></td>
</tr>
<tr>
<td>Controls</td>
<td></td>
<td>0.31 ± 0.2</td>
<td></td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Coefficient of Spearman rank correlation MPD, (r_s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>-0.114 *</td>
</tr>
<tr>
<td>BCVA</td>
<td>0.060</td>
</tr>
<tr>
<td>AL</td>
<td>-0.062</td>
</tr>
<tr>
<td>Stage of glaucoma</td>
<td>-0.170</td>
</tr>
</tbody>
</table>

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.

**Bibliography**


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