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Automated Static Perimetry: The Influence of Myopic Anisometropia on Evaluation of Visual Field

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A B S T R A C T

The aim of study was to establish which level of myopic refractive error influences visual field defects in automated static perimetry, if these defects are typical, and if optimal correction normalized the visual field. The study included 100 patients (200 eyes) divided into three groups according to the severity of the myopic refractive error: group A (till –3.25 Dsph), group B (–3.50 Dsph to –5.25 Dsph) and group C (–5.50 Dsph to –8.00 Dsph). The control group included 20 emmetropes (40 eyes). This study confirms that optimal corrected and uncorrected myopia up to –3.25 Dsph does not produce quantitative visual field defects, when tested by static automated perimetry. Even in optimally corrected myopics, with myopia higher than –5.50 Dsph, visual field defects on gray scale can be found. Defects are in the intermediary zone with more prominent defects in the upper quadrants. Visual field indices (MD, MS, LV, RF) were completely normalized.

Key words: *myopia, anisometropia, automated static perimetry, visual field, visual field indices*

Introduction

It is estimated that 1.6 billion people worldwide have myopia, a refractive error, and this number is expected to increase to approximately 2.5 billion by the year 2020[1]. High myopia, occurring in 1–2% of the general population, is the fourth most frequent cause of blindness[2]. Myopia has reached epidemic proportions in Japan, Hong Kong, Taiwan and Singapore[3].

The epidemiological data from studies like Barbados Family Study and Blue mountains Study have showed that myopics have statistical significant higher probability for glaucomatousus impairment of the optical nerve compared to hyperopics[4,5]. On the other hand, Quigley and colleagues didn't find clear connection between myopic ametropia and glaucomatousus changes of the visual field in the prospective study of 647 patients with ocular hypertension[6]. It still remain unclear whether the impairments of visual field in the myopic glaucomatousus patients are caused by myopia itself or those changes represent natural course of the glaucoma. The automated perimetry visual filed analysis is also very important in diagnostics of the prechiasmatical lesions[7], lesions of the optical nerve in the hiasma area[8], tractus[9] or brain sphere[10].

The Chorean authors[11] analyzed automated perimetry visual field changes after mydriasis and induced myopia in the group of emmetropic persons. They found decrease of retinal sensitivity in the area of central 30 degrees of visual fields, in both groups. Goldstick and Weinrab came out to the same conclusion analyzing the influence of induced myopia in the emmetropic persons in G1 program (Octopus)[12]. Aung and al.[13] were testing the influence of automated static perimetry visual changes depending on the correction way (contact lenses or eye glasses). They concluded that retinal sensitivity was decreased in the patients with moderate or high myopia, no matter of way of correction. Those findings are in correlation with data from other studies such as Rudnick and Edgar[14], who confirmed that retinal sensitivity is decreasing according to the myopia grade and with increase of axial length of the eye.

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Many authors confirmed that correction of refraction can influence on the result of perimetric testing. The aim of this study was to establish which level of myopic refractive error influences visual field defects in automated static perimetry, if these defects are typical, and if optimal correction normalizes the visual field.

Materials and Methods

The study included 100 patients (200 eyes) who were divided into three groups according to the severity of myopic refractive error: 34 patients in group A (till –3.25 Dsph), 36 patients in group B (from –3.50 Dsph to –5.25 Dsph) and 30 patients in group C (from –5.50 Dsph to –8.00 Dsph). The control group included 20 emmetropes (40 eyes). The inclusion criteria were visual acuity 6/6 or better with or without correction and completely normal eye exam, with no changes on the anterior neither posterior segment of the eyes. The PNO excavation was also within normal limits (c/d ratio till 0.2). The mean age of the participants was 32 years with a range from 18 to 40 years. The median age of 20 participants in control group was 32.5 (SD=4.39); range 23–40. There was no statistical difference according to age and gender in any of the groups. Automated static perimetry was performed with an Octopus 101 G2 program analysis, normal strategy and a standard size 3 stimulus. All the patients (group A, B, C) were tested with and without optimal visual correction. The control groups were tested without correction and by placing a prelens of specific dioptry (+2.00 Dsph, +3.50 Dsph, +5.00 Dsph, +8.00 Dsph). We determined the quantitative and qualitative values. Quantitative values that we followed were: mean sensitivity, mean defect, loss variance and reliability factor. We compared all quantitative parameters and changes on the gray scale between each of the groups and within the each group itself, with and without correction. The study complied with the Declaration of Helsinki. All subjects received oral and written information concerning the study before giving written informed consent.

Statistical analysis

The distributions of collected variables were presented with descriptive statistical methods. Normality of distributions was tested by Kolmogorov Smirnov test. One way ANOVA or Kruskal-Wallis tests with the post-hoc tests were used to test the significance of difference between groups. The χ^2 test was used to test the difference in qualitative variables between groups. To test the differences between corrected and non-corrected variables in same groups of examinees the Wilcoxon's test was applied.

Results

The median age of 100 patients was 32 years (SD= 5.50); range 18–40. There was no statistical difference between age and seks among the groups.

Distribution of MD values is statistical difference between three groups of corrected myopic (Kruskal-Wallis H (2, N=199)=16.99; (p<0.001). According to post-hoc test in group C we registered significant higher values than in group A (p<0.001) and B (p<0.034). There was no statistical difference in MD values between group A i B (p=0.247) (Table 1, Figure 1).

Distribution of MS values is statistical difference between three groups of corrected myopic (Kruskal-Wallis H (2, N=199) = 22.94; p<0.001. According to post-hoc test in group C we registered significant decreased values than in group A (p<0.001) and B (p=0.025). There was no statistical difference in MS values between group A and B (p=0.057) (Table 1, Figure 2).

Distribution of LV values is statistical difference between three groups of corrected myopic (Kruskal-Wallis H (2, N=199) = 10.23; p=0.0060. According to post-hoc test in group C we registered significant higher values than in group A (p=0.013) and B (p=0.016).

There was no statistical difference in LV values between group A and B (p=1.000) (Table 1, Figure 3).

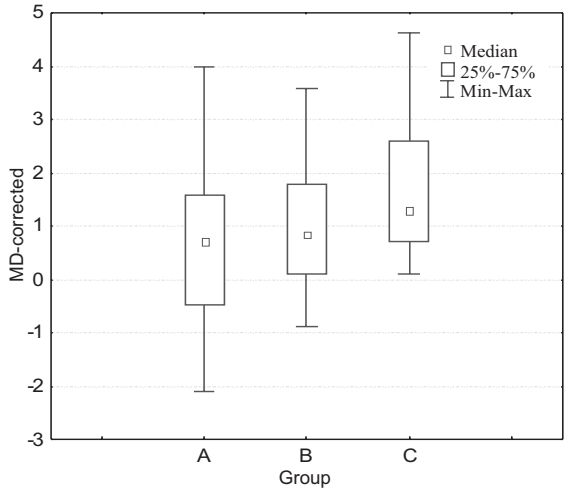

Fig. 1. MD – corrected in three groups.

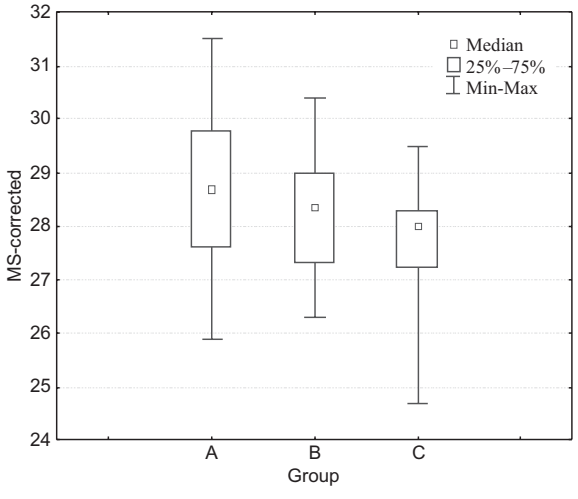

Fig. 2. MS – corrected in three groups.

TABLE 1.

FREQUENCY DISTRIBUTIONS OF CORRECTED MYOPIC AND CORRECTED VARIABLES THAT DESCRIBES VISUAL FIELD

Group			Dioptry (corrected)	MS-corrected	MD-corrected	LV-corrected	RF-corrected
A	N	Valid	67	67	67	67	67
		Missing	0	0	0	0	0
	$\overline{X}$		–1.8881	28.788	0.573	3.899	3.372
	Median		–2.0000	28.700	0.700	3.200	0.000
	Mode		–2.0000	29.800	0.800	2.300	0.000
	Std. Deviation		0.79687	1.4102	1.3531	3.2132	5.2532
	Range		2.50	5.6	6.1	20.3	14.5
	Minimum		–3.00	25.9	–2.1	1.0	0.0
	Maximum		–0.50	31.5	4.0	21.3	14.5
	Percentiles	25	–2.5000	27.600	–0.500	2.300	0.000
		50	–2.0000	28.700	0.700	3.200	0.000
		75	–1.2500	29.800	1.600	4.000	9.100
B	N	Valid	74	74	74	74	74
		Missing	0	0	0	0	0
	$\overline{X}$		–4.2872	28.266	0.997	3.826	2.011
	Median		–4.2500	28.350	0.850	2.700	0.000
	Mode		–4.0000	27.300	–0.1(a)	2.4(a)	0.000
	Std. Deviation		0.51797	.9659	1.0609	2.7830	4.3223
	Range		1.75	4.1	4.5	16.9	14.0
	Minimum		–5.25	26.3	–0.9	1.1	0.0
	Maximum		–3.50	30.4	3.6	18.0	14.0
	Percentiles	25	–4.7500	27.300	0.075	2.400	0.000
		50	– 4.2500	28.350	0.850	2.700	0.000
		75	–3.9375	29.000	1.800	4.325	0.000
C	N	Valid	58	58	58	58	58
		Missing	0	0	0	0	0
	$\overline{X}$		–6.5086	27.678	1.557	4.253	3.764
	Median		–6.2500	28.000	1.300	4.500	0.000
	Mode		–6.0000	28.200	0.700	4.600	0.000
	Std. Deviation		0.76515	1.0403	1.0800	1.6753	5.2315
	Range		2.50	4.8	4.5	6.9	14.0
	Minimum		–8.00	24.7	0.1	1.4	0.0
	Maximum		–5.50	29.5	4.6	8.3	14.0
	Percentiles	25	–7.0625	27.150	0.700	2.875	0.000
		50	–6.2500	28.000	1.300	4.500	0.000
		75	–6.0000	28.300	2.600	5.200	8.575

MS – mean sensitivity, MD – mean defect, LV – loss variance, RF – reliability factor

There was no statistical difference in RF value between three groups of corrected myopic (Kruskal-Wallis test: H (2, N=199) = 10.23; p=0.0060 (Table 1).

Distribution of MD values is statistical difference between three groups of uncorrected myopic (Kruskal-Wallis test: H (2 N=199)=145.20; p<0.001. According to post-hoc test in group A registered the lowest values (p<0.001), in group C the highest MD values (p<0.001). There was statistical difference between group A and B (p<0.001) (Table 2, Figure 4).

Distribution of MS values is statistical difference between three groups of uncorrected myopic (Kruskal-Wallis test: H (2, N=199) = 144.74; p=0.001. According to post-hoc test in group A registered the highest (p<

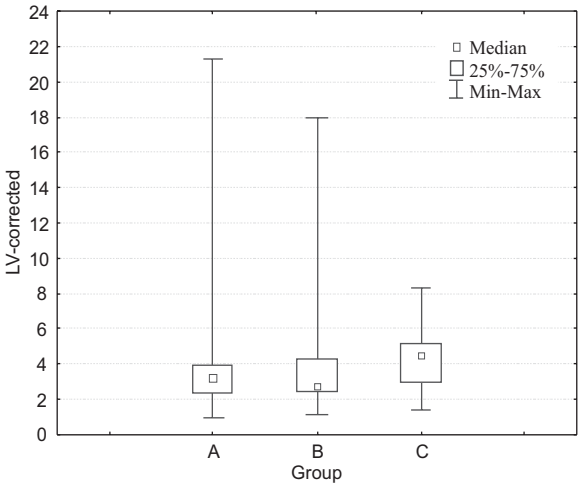

Fig. 3. LV – corrected in three groups.

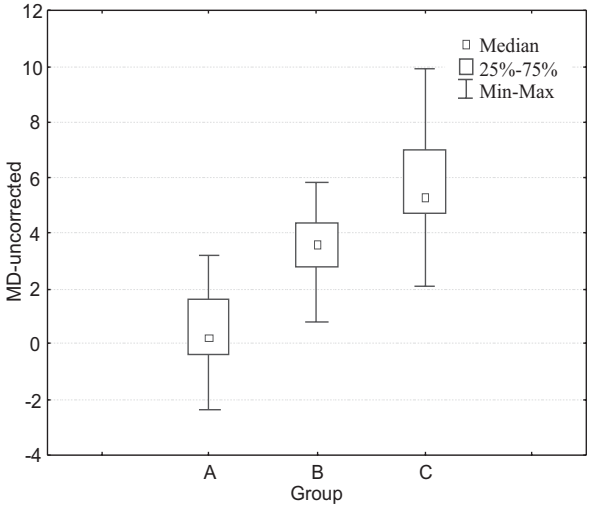

Fig. 4. MD – uncorrected in three groups.

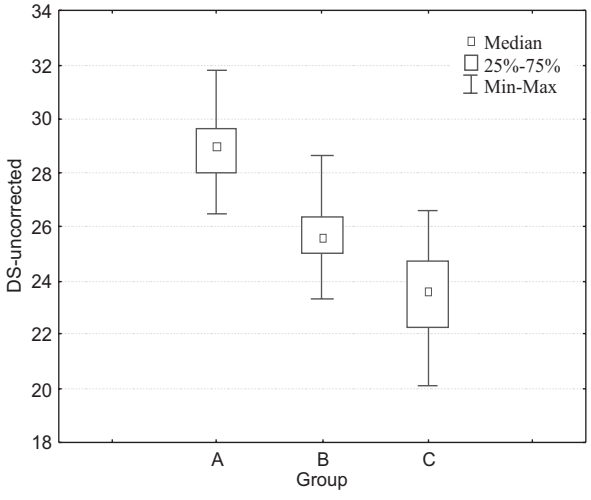

Fig. 5. MS– uncorrected in three groups.

0.001), in group C the lowest (p<0.001) MS values. There was statistical difference between group A and B (p< 0.001) (Table 2, Figure 5).

Distribution of LV values is statistical difference between three groups of uncorrected myopic (Kruskal-Wallis test: H (2, N=199)=73.20; p<0.001. According to post-hoc test in group A registered the lowest LV values (p<0.001), in group C the highest LV values (p<0.001). There was statistic difference between group A and B (p<0.001) (Table 2, Figure 6).

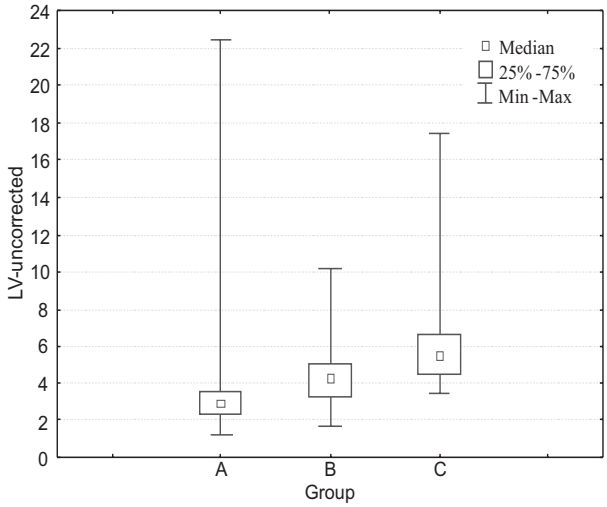

Fig. 6. LV–uncorrected in three groups.

There was statistical difference in RF value between three groups of uncorrected myopic (Kruskal-Wallis test: H (2, N=199) = 73.20; p<0.001. There was ststistical difference between group A and group B (p<0.007) and C (p<0.040). There was no statistic difference between group B and C (p=1.000) (Table 2).

Analysis of the variables of the visual field in the conrol group

The mean age of 20 patients was 32.5 (SD=4.39); range 23–40.

Mean value of MD without a correction in the control group was –0.04 dB; range from –2.90 to 1.60 dB. dB. Mean value of MD with +2.00 dsph; +3.50 dsph; +5.00 dsph; +8.00 dsph prelens was 0.55 dB (range from –1.40 to 2.20 dB); 4.33 dB (range from 2.70to 7.20 dB); 5.53 dB (range from 4.00 to 7.10 dB); 7.29 dB (range from 3.60 to 10.80 dB).

Mean value of MS without a correction in the control group was 29.32 dB; range from 27.50 to 32.30 dB. Mean value of MS with +2.00 dsph; +3.50 dsph; +5.00 dsph; +8.00 dsph prelens was 28.82 dB (range from 27.10 to 30.70 dB); 24.96 dB (range from 22.30 to 26.80 dB); 23.77 dB (range from 22.10 to 25.30 dB); 21.78 dB (range from 17.90 to 25.40 dB).

TABLE 2.

FREQUENCY DISTRIBUTIONS OF NON CORRECTED MYOPIC AND NON CORRECTED VARIABLES THAT DESCRIBES VISUAL FIELD

Group			Dioptry-non corrected)	MS-non corrected	MD-non corrected	LV-non corrected	RF-non corrected
A	N	Valid	67	67	67	67	67
		Missing	0	0	0	0	0
	Mean		0	28.882	0.466	3.454	4.53
	Median		0	29.000	0.200	3.000	0.00
	Mode		0	29.000	0.200	3.500	0.00
	Std. Deviation		0	1.2359	1.1381	2.6832	5.360
	Range		0	5.3	5.6	21.3	14
	Minimum		0	26.5	–2.4	1.2	0
	Maximum		0	31.8	3.2	22.5	14
	Percentiles	25	0	28.000	–0.400	2.300	0.00
		50	0	29.000	0.200	3.000	0.00
		75	0	29.700	1.600	3.600	10.00
B	N	Valid	74	74	74	74	74
		Missing	0	0	0	0	0
	Mean		0	25.753	3.514	4.335	1.53
	Median		0	25.600	3.600	4.300	0.00
	Mode		0	26.0	2.8	5.0	0
	Std. Deviation		0	1.1845	1.1879	1.6071	3.494
	Range		0	5.3	5.0	8.5	13
	Minimum		0	23.3	0.8	1.7	0
	Maximum		0	28.6	5.8	10.2	13
	Percentiles	25	0	24.975	2.800	3.175	0.00
		50	0	25.600	3.600	4.300	0.00
		75	0	26.425	4.400	5.100	0.00
C	N	Valid	58	58	58	58	58
		Missing	0	0	0	0	0
	Mean		0	23.533	5.719	6.105	1.98
	Median		0	23.600	5.300	5.550	0.00
	Mode		0	23.5(a)	4.7(a)	5.2	0
	Std. Deviation		0	1.7396	1.7680	2.4279	3.774
	Range		0	6.5	7.8	14.0	13
	Minimum		0	20.1	2.1	3.5	0
	Maximum		0	26.6	9.9	17.5	13
	Percentiles	25	0	22.150	4.675	4.500	0.00
		50	0	23.600	5.300	5.550	0.00
		75	0	24.725	7.000	6.750	0.00

MS – mean sensitivity, MD – mean defect, LV – loss variance, RF – reliability factor

Mean value of LV without a correction in the control group was 3.40 dB^2; range from 0.60 to 8.20 dB^2. Mean value of LV with +2.00 dsph; +3.50 dsph; +5.00 dsph; +8.00 dsph prelens was 3.00 dB^2 (range from 1.70 to 6.30 dB^2); 9.31 dB^2 (range from 1.30 to 40.5 dB^2); 5.58 dB^2 (range from 2.50 to 13.30 dB^2); 9.02 dB^2 (range from 2.90 to 26.10 dB^2).

Mean value of RF without correction in the control group was 3.75%; range from 0.0 to 14.30%. Mean value of RF with +2.00 dsph; +3.50 dsph; +5.00 dsph; +8.00 dsph prelens was 4.61% (range from 0.0 to 12.50%); 1.11% (range from 0.0 to 11.10%); 2.25% (range from 0.0 to 12.50%); 1.11% (range from 0.0 do 11.10%).

Discussion and Conclusion

The researches up to date have not systematically followed changes in visual fields in certain stages of myopia with and without correction, nor have they systematically investigated effect of inductive myopia by emmetropic, related to changes in visual fields. Aung et al.[13] have investigated the effects of changes in visual field by applying automatic static perimetry depending on types of correction (contact lenses or glasses).

They concluded that the sensitivity of retina is decreased with medium and high level of myopia regardless of methods of applied correction. This conclusion is in correlation with other authors such as Rudnick and Edgar who confirmed that the sensitivity of retina decreases with degree of myopia and increase in axial length of the eye. Koller et al.[15] recommended use of contact lenses when testing visual field between 30–50 degrees in the case of high myopias.

A number of Korean authors[11] have analyzed the changes in visual field by automatic perimetry after dilatation of pupil and induced myopia in emmetropic patients.

They concluded that in both cases there had been a reduction in sensitivity of retina within 30 degrees of vision. Glodstick and Weinreb arrived to the same conclusion analyzing effects of induced myopia on emmetropic patients in G-1 programme[12]. During the analysis the following characteristics were investigated: MD (middle defect), MS (middle sensitivity), LV, RF (reliability factor). Many research papers imply that with repetitive automatic visual field the best approach is to analyze MD and LV variables[11–14]. In our research the registered differences in MD distributions with corrections within three investigated myopic group of eyes are statistically significant. In group C, a significantly higher values are registered than in group A ($p<0.001$) and group B ($p=0.034$), while the difference between group A and B is not statistically significant. ($p=0.247$) (Table 2). All three groups have the values within the normal range. The registered differences in MS distributions with correction in three group of myopic eyes are statistically significant. In group C, a significantly lower values were registered than in group A ($p<0.001$) and group B ($p=0.025$), while the difference between group A and B is not statistically significant ($p=0.057$). The registered differences in LV distributions in three group of myopic eyes is statistically significant. In group C, a significantly higher values are registered than in group A ($p=0.013$) and B (0.016), while the difference between groups A and B is not statistically significant ($p=1$). LV value was slightly increased only in group C of uncorrected myopic patients, while in all other groups the values were within normal limits. The RF values were in all groups below 15%, which is considered acceptable for relevance of the results, obtained by testing of the visual field. MD, MS and LV values are largely in correlation with most of the well known studies that researched effects of myopic amethropy on the values of the automated visual field. The registered differences in MD distributions without correction in three group of myopic eyes were statistically significant. All the groups are statistically significantly different. The lowest MD values are recorded in group A ($p<0.001$) and the highest in group C ($p<0.001$). The recorded differences in MS distributions without correction between three groups are significant. All the groups are statistically significantly different. In group A, the highest values are recorded ($p<0.001$) and in group C the lowest MS values are recorded ($p<0.001$). The recorded differences in LV distributions without correction between three group of myopic eyes are significant. All the groups are statistically significantly different. In group A, the lowest values are recorded ($p<0.001$), and in group C the highest LV values are recorded ($p<0.001$). The groups A and B are statistically significantly different ($p<0.001$). The values RF in all groups were below 15%, which is considered acceptable for relevance of the results, obtained by testing of the vision.

In the controlled group of patients without correction (emmetropic eyes), the group with prelens +2.00 Dsph had normal MD values. The middle value of MD in the group of emmetropic without correction is –0.04, and in the group with prelens of +2.00 Dpt the value is 0.55 dB. Group of patients with prelenses +3.50 Dsph, +5.00 Dsph and +8.00 Dsph had MD values above the normal thresholds. The middle value of MD in the group with prelens with +3.50 Dpsh is 4.33 dB; in the group with prelens of +5.00 Dsph the value is 5.53 dB; in the group with prelens of +8.00 Dsph the value is 7.29 dB. MS values in the controlled group of patients with prelenses +3.50 Dsph, +5.00 Dsph, +8.00 Dsph are statistically significantly lower than the values in the controlled emmetropic group without correction and in the group with prelens of +2.00 Dsph. LV values were above the normal values in the control group of patients with +3.50 Dsph and +8.00 Dsph. RF factor was below 15% in all the groups. The final results for the controlled group are consistent with prior results that investigated effects of induced myopia on the values of automated visual field.[11,12] It is obvious, from the results, that all the measured values (MD, MS and LV) are completely normalized with optimum visual correction. There are many reports that are using visual field indices (MD, MS, LV, RF) for research of visual field loss in myopic eyes. However, that numeric values may not capture information on the pattern and location of visual field loss that may be more helpful in differential diagnosis of visual field changes. Even in optimally corrected myopics, with myopia higher than –5.50 Dsph, visual field defects on the gray scale can be found. Defect is in the intermediary zone with more prominent defects in the upper quadrants. Numerical values of visual field indices were completely normalized. A particular benefits from the results is in understanding whether certain changes are linked to glaucoma or are result of myopic ametropy. Several authors investigated changes of the visual field in myopic eyes as a potential contributor in establishing diagnosis for glaucoma in myopic eyes. Epidemiological studies, such as

Barbados Family study and Blue Mountain study, have shown that myopia, in comparison to hypermetropia, has statistically significantly higher probability for glaucomic damage of the nerve[4,5]. In contrast to this epidemiological study, Quigley and co-authors did not find clear link between myopia and glaucoma changes of the visual field in their prospective study of 647 patients with ocular hypertension. They concluded that the risk factors such as myopia and positive family anamnesis more complex than previously thought. A group of German authors[26] concluded, as well, that myopia (up to –8.00 Dsph) do not represent a significant risk for development of glaucoma. The results obtained from this research indicate a particular importance of optimum visual correction before visual field testing with the aim of avoiding errors in interpreting certain variables found in the research of visual field. This research make one step further to understanding visual field changes and avoiding mistakes in interpretation. We established that myopia up to –5.50 Dsph , even optimally corrected, can have a deficit on the gray scale in intermediary zone, especially in the upper quadrant. Numeric values of visual field indices were completely normalized.

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UTJECAJ MIOPSKE AMETROPIJE NA ISTRAŽIVANJE VIDNOG POLJA AUTOMATSKOM PERIMETRIJOM

SAŽETAK

Cilj istraživanja bio je utvrditi koja veličina miopske greške uzrokuje ispade u vidnom polju koje je testirano automatskom statičkom perimetrijom. Jesu li pretpostavljeni ispadi tipični, te da li optimalna korekcija vida u potpunosti normalizira vidno polje. Istraživanje je provedeno na skupini od 100 bolesnika (200 očiju) podijeljenih u tri skupine prema veličini miopske greške: skupina A (do –3,25 Dsph), skupina B (–3,50 Dsph za – 5,25 Dsph) i skupina C (–5,50 Dsph da –8,00 Dsph). Kontrolnu skupinu činila je grupa od 20 emetropa (40 očiju). Provedenim istraživanjem jasno je utvrđeno da kod optimalno korigirane i kod nekorigirane miopije do –3,25 Dsph nije bilo značajnog smanjenja mrežničke osjetljivosti, testirane automatskom statičkom perimetrijom. Kod optimalno korigirane miopije veće od –5,50 Dsph mogu se naći ispadi vidnog polja na sivoj skali. Ispadi vidnog polja su u intermedijarnoj zoni sa značajniim ispadom u gornjim kvadrantima. Numeričke vrijednosti vidnog polja (MD, MS, LV, RF) su se u potpunosti normalizirale.