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Binocular Correction in Patients with Central Retinal Impairment

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Abstract

Background: Many of visual functions are usually impaired by serious retinal diseases. With different speed of progression, the point of sharpest vision is being damaged and visual acuity as well as contrast sensitivity and fixation stability declines. Instead of the damaged fovea the new preferred retinal points are arising and taking over its function as the referential position for the whole motoric system. The development of such new points of fixation can evoke condition which is similar to fixation disparity. Of course, binocular vision (e. g. binocular summation of visual acuity) is markedly deteriorated too, together with the diminished central fusion due to inequality of the both, differently affected retinal pictures. It's obvious that former binocular vision disturbances (e.g. latent strabismus) could now become decompensated. The purpose of this study is to evaluate the efficiency of the binocular prismatic correction in patients with central retinal impairment that allows the restoration of the best possible correspondence of the preserved retinal areas.

Methods: Two groups of volunteer participants were established. There were 17 patients with central retinal impairment in the group A and 17 people with healthy eyes in the second control group (Group A) in about the same age. The visual acuity and monocular and binocular vision at a far and near distance was examined and the best correction determined. Two pairs of spectacle correction were completed, one pair (glasses for far and glasses for near vision) with full sphero-cylindrical correction and full prism correction and the other pair only with full sphero-cylindrical correction without prisms. The participants tested each pair for 1 month and the binocular visual acuity and summation were evaluated and subjective notions were noted.

Results: The outcomes were evaluated both within each group and between the groups. It was found out that the improvement of binocular visual acuity (compared to the monocular of the better eye) was approximately the same in both groups when using the prismatic correction. On the other hand, participants with central retinal impairment achieved markedly lower amount of binocular summation of the visual acuity while wearing the non-prismatic spectacle correction. Vice versa, participants with healthy eyes reached higher levels of binocular summation with the non-prismatic correction than with prismatic glasses and higher than the group of patients with macular diseases. We found similar trends after evaluation of subjective notions to the worn glasses of participants in both groups.

Conclusion: The results of our study predicate that the non-prismatic correction is less effective than the prismatic binocular correction in patients with central retinal impairment considering the visual acuity gain. Nevertheless, it should not be considered as a rule. Instead of global management of the eyesight correction of patients with macular diseases with either prismatic or non-prismatic glasses, the approach should be individualized. Unambiguously, it would be a mistake to reject the possibility to assess the correction binocularly and apply it particularly in patients with central retinal impairment.

Keywords

Binocular vision, Binocular summation, Binocular refraction, Macular diseases, Prismatic correction, Visual acuity

Introduction

Nowadays, the macular diseases are representing more and more often serious involvement of eyesight, particularly because of growing incidence of the age-related macular degeneration (AMD). Another important subgroup of central vision deteriorations are the maculopathies linked to the general diseases (diabetic retinopathy, hypertensive retinopathy). It's obvious that these degenerative, dystrophic and other impairments of central vision will become an appreciable economic and social problem in the near future because of the patients' limitations in the major society and the restricted and expansive possibilities of their treatment. The determination of the way of the most effective improvement of the remaining visual functions should be one of the main therapeutical goals.

The different speed of retinal impairment progression and visual acuity deterioration in the both eyes is a characteristic sign of the most of macular diseases. Typically, not only the visual acuity, [1] but also contrast sensitivity is being affected. Its deterioration is usually related to aging too, but in case of macular impairment the contrast sensitivity is being reduced at all spatial frequencies and primarily aggravates the ability to discern low and medium contrast stimuli [2]. Hence, usage of the low-contrast optotypes can better express the extension of visual handicap and improve the early diagnostics of macular diseases [3]. Further, instability of fixation also influences the quality of vision significantly. The damaged foveola (that means the original) is unable to provide appropriate visual output for efficient motoric control of the eyes. Its sequelae will manifest not only at monocular, but, of course, also at binocular viewing conditions [4]. A new referential point (so called *preferred retinal locus,* PRL) arises on margin of the central scotoma of the affected eye as a compensation process [2] and performs the function of the referential point of the visual motoric system [4]. The quality of fixation depends (i.a.) on eccentricity of the PRL. That means the larger the central scotoma and the distance of the PRL from original foveola is, the poorer functions the PRL provides because of lower physiological visual acuity levels of the out-foveolar retinal areas [5]. It also means unambiguously that the fixation stability of the more affected ("worse") eye will be worse than fixation stability of the less affected ("better") eye. Another complication arises, when (rarely) more than 1 PRL develop

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in one eye and when (usually) PRLs on retinas of the both eyes don't correspond to each other [4]. We could describe this situation as some special form of retinal disparity. If the viewing conditions switch from monocular to binocular, also the change of just used PRL (more often in the "worse" eye) is possible which means that different PRLs can be used on one retina in monocular and binocular vision [4].

Commonly, binocular vision provides better visual performance (visual acuity and contrast sensitivity) than monocular vision. This phenomenon is called *binocular summation* and is defined as difference between binocular visual performance (e.g. visual acuity) and monocular visual performance of the "better" eye [2] Because of unequal impairment of the "better" and the "worse" eye, the retinal images don't correspond each other (different shape, structure, illumination, size etc.) and withheld enough fusion stimuli to induce sufficient fusion effort [6]. This can be the reason, why binocular summation turns to binocular inhibition (superior monocular visual performance of the "better" eye in comparison to binocular vision) more often in subjects with central retinal impairment than in healthy population. Binocular inhibition is more frequently related to contrast sensitivity (almost 50% of all cases AMD) than to visual acuity [1].

Changes of sensory retinal correspondence (induced by e.g. epiretinal membrane development), accompanied by metamorphopsia, can evoke diplopia due to disruption between impaired bifoveal and intact peripheral fusion. There is no given general approach or treatment to this phenomenon, called "dragged fovea syndrome" [7]. There are mentioned occlusions and monovision correction to avoid diplopia or (occasionally) application of prismatic correction to achieve the bifoveal fusion [7].

It's obvious that all mentioned conditions could negatively influence binocular visual performance and deteriorate it below the monocular values of the "better" eye. Further, weakened fusion ability could contribute to decompensation of latent strabismus, occasionally slipping to manifest deviation with all of its consequences. The aim of our study is to describe the potential of the application of binocular prismatic correction to achieve the most exact correspondence of functional retinal areas. There are evaluated results of binocular visual acuity and its summation as well as subjective responses of participants. It should be mentioned that there are some studies that refer to using of glasses with prismatic correction to improve the low vision rehabilitation [8]. Mostly, the authors suppose that prismatic correction deflects the picture of the fixed object out of the central scotoma and PRL [8]. But there is no evidence, how do they explain the "passivity" of the eyes, e.g. the necessary absence of refixation movements that will follow after deviation of the fixation object from the foveola or PRL. This is not the aim of our study. Contrariwise, prismatic correction that was used in our research, should contribute to achievement of the best possible retinal correspondence, regardless of which part of the retinal picture will project at the scotoma areas.

Methods

Our study was designed as prospective, single blinded two sample trial with placebo masking and cross-over design.

Participants

Two groups were created, each about 17 volunteers. There were 9 women and 8 men with central retinal impairment between the ages 20 and 88 years (mean age 66 years, SD 16.29) in the group A. Entry conditions of this group were as follows:

- Unambiguously determined diagnosis of macular pathology with any kind of origin (degenerative/dystrophic/traumatogenic…).
- Developed binocular vision before the pathology outset.
- Visual acuity at a distance (in case of need with the latest correction) of the "worse" eye at least 0.3 (6/20), except of subjects with lower visual acuity, who were able to undergo the examination of binocular vision (see below).
- Ability to undergo subjective binocular examination (meaningful communication and cooperation).
- Relative stability of visual functions during the research duration.
- There were following macular pathologies represented (in some cases cumulated): AMD (6 cases), Juvenile Best disease (1 case), central serous retinopathy (1 case), central areolar choroidal dystrophy (1 case), retinal vein occlusion (2 cases), hypertensive retinopathy (2 cases), diabetic retinopathy (1 case), adult vitelliform macular dystrophy (1 case), retinitis pigmentosa (1 case), senile macular hole (1 case), traumatogenic retinal ablation (1 case) and chronic panuveitis (1 case). There was cystoid macular edema present in 6 cases.

In the group B, there were 7 women and 10 men without any ocular pathology (except of incipient cataracts) between the ages 57 and 86 years (mean age 66.9 years, SD 7.73). Entry conditions of this group were as follows:

- Age 55 years and older. It was expected an elderly population in the group A because of age-related retinal changes and thus the age of participants in the control group (B) was regulated.
- Presence of binocular vision its anomaly (latent or manifest strabismus).
- No retinal or other eyesight or neurological pathology. Incipient cataract was tolerated.

It was expected that no one of the volunteers was an eye care specialist or optician. All participants were familiarized with research process and signed an informed consent according to the principles of the Declaration of Helsinki.

Equipment

All measurements took place in an optometry workplace, which met all compulsory requirements. Visual acuity was verified using ETDRS letter optotype charts at a 4 m distance (Good-Lite Company, Elgin, USA), which were available in 4 levels of Weber's contrast (standard, 50%, 25% and 10%). Visual acuity testing at these 4 contrast levels should better imitate visual conditions in real life. Visual acuity was recorded as a number of correctly recognized symbols using the ETDRS protocol. Subjective monocular as well as binocular refraction examination was performed on LCD optotype Multivisus with positive A-V (45°/135°) polarisation at a 4.5 m distance (bon Optic Vertriebsgesellschaft, Lübeck, Germany). The 0.5 m difference between optotypes distances was neglected. There were used a common trial lens case with an extended prism glasses set and a trial frame with horizontal as well as vertical adjustable centration for both eyepieces separately. Visual acuity at a near distance (35 cm) in terms of minimum legibile was checked using a reading chart with decimal grading from 0.1 to 1.0. Binocular refraction at a near distance was examined using Optoprox device (Essilor, Cedex, France) with negative A-V (45°/135°) polarisation. There were available simple heterophoria and stereoscopic tests with central fusion stimulus.

Examination

All subjects underwent a complex entry optometric examination to confirm their capability to participate on the study. Its main parts were personal and familiar anamnesis, complete subjective monocular refraction, binocular refraction examination according to MKH methodics (Mess- und Korrektionsmethodik nach Haase; measure and correction methodics according to Haase) as defined by IVBS (Internationale Vereinigung für binokulares Sehen; International Association for Binocular Vision) [9], determination of addition for near vision, examination and correction of binocular vision for a near distance (aligning prism), near point of convergence assessment and eye motility check. The visual acuity for far as well as for near vision

was checked after the examination of refraction with full monocular correction in both eyes separately and binocular with full prismatic correction and without prismatic correction. Binocular summation (BS) of visual acuity (VA) was computed according to equation (1).

$$BS = BVA - MVA_{BE} \quad ..(1)$$

Calculation of binocular summation of visual acuity, where BS = binocular summation of visual acuity, BVA = binocular visual acuity and MVA_{BE} = monocular visual acuity of the "better" eye.

The participants should try out the both versions of binocular corrections for far and near vision for a while (approximately 5 minutes). Upon this experience the subjects had to assess, which kind of correction (prismatic or non-prismatic) they prefer in categories "stability of vision and easiness of orientation in the space" (STABILITY), "visual acuity" (VA) and "visual comfort" (COMFORT). The rating possibilities were "better with prismatic correction", "better with non-prismatic correction" and "without difference".

Two pairs of spectacles were prepared for each participant. One pair (glasses for far vision and glasses for near vision) included the full prismatic binocular correction, the other pair was made without prismatic correction. One of the spectacle pairs was given to the participant and his task was to wear these glasses the most as possible. The check-up date was set about 30 days later. The monocular as well as binocular visual acuity was evaluated and participants had to rate the worn correction (separately for far and near vision) in the next 5 categories: "subjectively perceived visual acuity" (VA), "visual comfort" (COMFORT), "length and difficulty of the habituation" (HABITUATION), "stability of vision and easiness of orientation in the space" (STABILITY) and "overall perception of the correction/spectacles" (OVERALL). The rating grades were set from 1 (the worst) to 5 (the best). After then, the lenses were changed (prismatic instead of non-prismatic and vice versa) into the same frames and the second check-up date was set about 30 days later. The participants didn't ever known, which type of correction (prismatic or non-prismatic) they were already wearing. The second check-up was identical to the first one, but finally the participants had to assess, which of these spectacle corrections were subjectively better (for distance and for near vision separately). Upon the twice 30-day using experience the subjects had to assess again, which type of correction (prismatic or non-prismatic) they prefer in categories "stability of vision and easiness of orientation in the space" (STABILITY), "visual acuity" (VA) and "visual comfort" (COMFORT). The rating possibilities were again "better with prismatic correction", "better with non-prismatic correction" and "without difference". The largest motivation to unbiased judgement was given by opportunity to keep the glasses for far and near vision which were assessed as the best (this decision was registered and between the groups statistically evaluated too).

Statistical evaluation

Outputs were evaluated by both, paired and unpaired tests. We analysed the efficiency of the prismatic/non-prismatic correction in each group (in each subject; paired) as well as between the groups

Table 1: Binocular visual acuity (BVA) and binocular summation (BS) of BVA in the group A (patients with central retinal impairment) with prismatic and non-prismatic correction after the entry examination and after 30-day trial wearing. The bold marked pairs (prism vs. non-prism) vary at statistically significant level $p < 0.05$ (column „Wilcoxon test results). Number behind BVA and BS signs the Weber's contrast level; „total" = sum of ETDRS letters, correctly read at all contrast levels.

Group A. binocular visual acuity (BVA) and summation (BS)							
After examination	Mean values | Standard deviations						Wilcoxon test results (p)
At a distance (number of ETDRS letters)	Prism		Non-prism		Difference		
BVA (full contrast)	80.588	12.679	79.412	11.336	1.176	3.695	0.167
BVA (50% contrast)	77.706	12.348	77.412	12.947	0.294	1.929	0.529
BVA (25% contrast)	**73.941**	**13.836**	**71.294**	**14.451**	**2.647**	**4.315**	**0.032**
BVA (10% contrast)	**60.824**	**15.163**	**59.059**	**15.762**	**1.765**	**2.969**	**0.023**
BVA (sum of all contrast levels)	**293.059**	**52.996**	**287.176**	**52.551**	**5.882**	**7.817**	**0.006**
BS (full contrast)	0.529	2.875	-0.647	4.212	1.176	3.695	0.167
BS (50% contrast)	0.941	3.191	0.647	3.161	0.294	1.929	0.529
BS (25% contrast)	**1.412**	**3.374**	**-1.235**	**5.847**	**2.647**	**4.315**	**0.032**
BS (10% contrast)	**3.353**	**3.823**	**1.588**	**3.447**	**1.765**	**2.969**	**0.023**
BS (sum of all contrast levels)	**6.235**	**8.166**	**0.353**	**13.048**	**5.882**	**7.817**	**0.006**
At near distances (decimal)							
BVA	**0.871**	**0.229**	**0.821**	**0.237**	**0.050**	**0.269**	**0.012**
BS	**0.032**	**0.058**	**-0.027**	**0.059**	**0.059**	**0.081**	**0.012**
After 30-day trial wearing	Mean values | Standard deviations						Wilcoxon test results (p)
At a distance (number of ETDRS letters)	Prism		Non-prism		Difference		
BVA (full contrast)	80.647	11.816	79.353	12.257	1.294	3.312	0.132
BVA (50% contrast)	77.529	12.625	77.059	13.021	0.471	4.732	0.950
BVA (25% contrast)	72.941	12.765	71.471	13.125	1.471	3.955	0.088
BVA (10% contrast)	56.882	15.341	57.118	15.194	-0.235	6.006	0.938
BVA (sum of all contrast levels)	288.000	51.116	285.000	52.709	3.000	13.143	0.332
BS (full contrast)	1.000	2.806	0.000	3.041	1.000	4.213	0.320
BS (50% contrast)	0.882	4.729	-0.647	4.795	1.529	5.680	0.414
BS (25% contrast)	1.529	3.955	-0.529	4.361	2.059	4.867	0.093
BS (10% contrast)	1.765	8.318	0.529	4.033	1.235	6.969	0.421
BS (sum of all contrast levels)	5.176	16.576	-0.647	13.852	5.824	14.943	0.326
At near distances (decimal)							
BVA	0.858	0.245	0.818	0.261	0.040	0.075	0.076
BS	**0.048**	**0.085**	**-0.003**	**0.066**	**0.051**	**0.074**	**0.028**

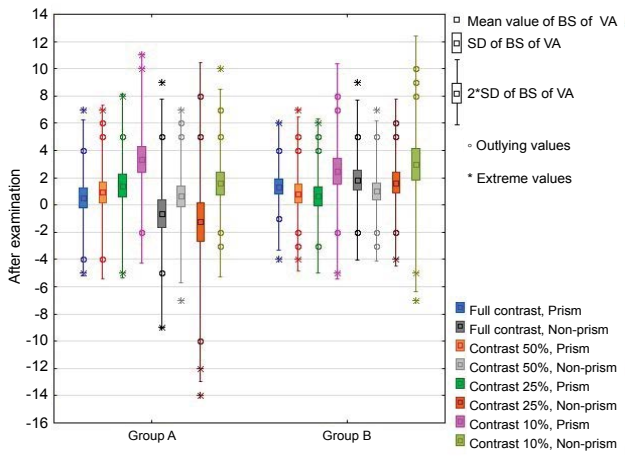

Figure 1: BS of visual acuity (VA) at far after examination of refraction. Values in number of ETDRS letters. Mean, outlying and extreme values and standard deviations (SD) are marked.

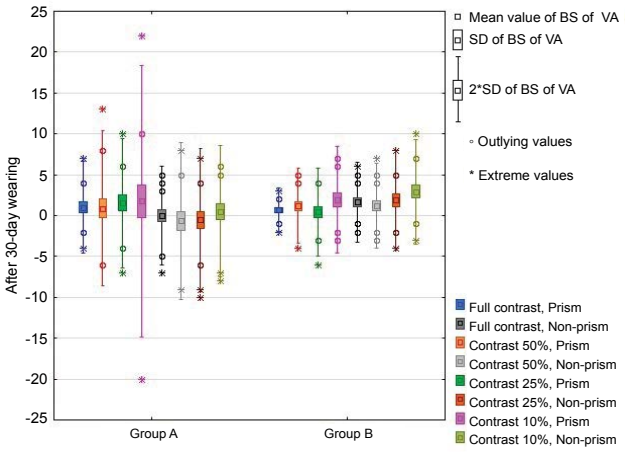

Figure 2: BS of visual acuity (VA) at far after 30-day trial wearing. Values in number of ETDRS letters. Mean, outlying and extreme values and standard deviations (SD) are marked.

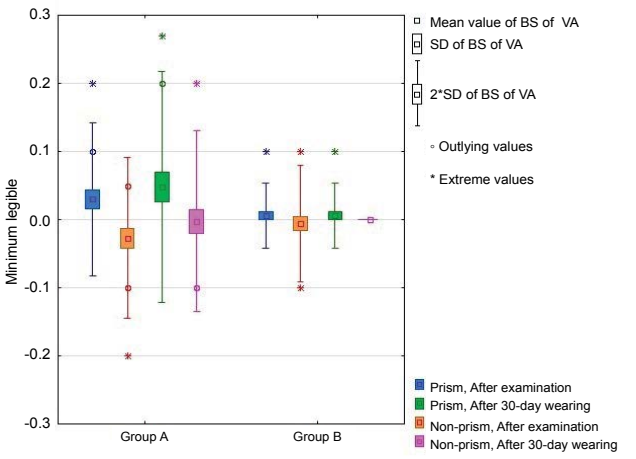

Figure 3: BS of VA at near distances. Values in a decimal scale. Mean, outlying and extreme values and standard deviations (SD) are marked.

(between "healthy" and "affected" subjects; unpaired). Because of the abnormal distribution of input data (checked by Shapiro-Wilk's test), the nonparametric analyses were performed (Wilcoxon's paired test, Mann-Whitney's U test (unpaired) and Spearman's correlations). We used the Statistica 12 software (StatSoft, Inc., Tulsa, USA) and all tests were set at critical value of confidence interval 0.05.

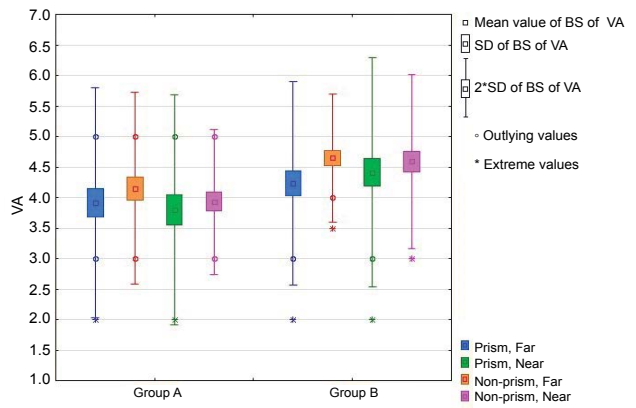

Figure 4: Subjective rating of both types of binocular correction in category "visual acuity" (VA). Mean, outlying and extreme values and standard deviations (SD) are marked.

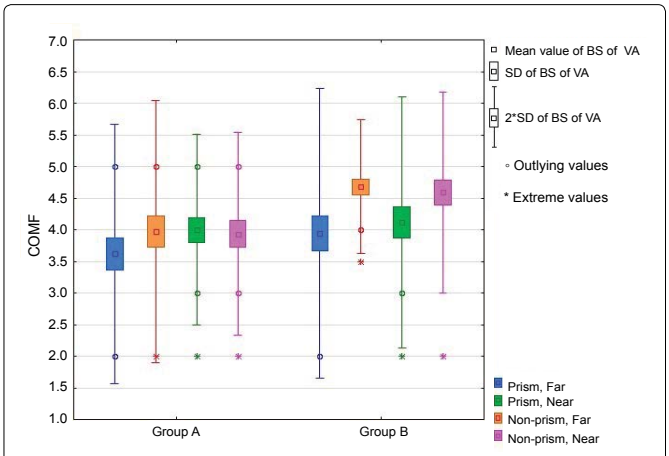

Figure 5: Subjective rating of both types of binocular correction in category "comfort" (COMF). Mean, outlying and extreme values and standard deviations (SD) are marked.

Results

Patients with central retinal impairment (Group A)

Mean values of binocular visual acuity (BVA) and binocular summation (BS) of BVA at a distance as well as for near vision with both types of correction (prism/non-prism) after the refraction examination and after 30-day trial wearing are shown in table 1. Graphics summary is present in figure 1, figure 2 (far) and figure 3 (near). Weber's contrast reduction of optotype letters to 10% led to decline of the visual acuity about 25% binocularly).

The average rating of prismatic correction counts 3.78 points (of max. 5) for vision at a distance and 4.04 points for the near vision. The average values of non-prismatic correction rating were 4.02 for the distance as well as for the near vision. The data in all categories are shown in table 2 and figure 4, figure 5, figure 6, figure 7 and figure 8. Subjective preferences of both versions of binocular correction are shown in table 3. The participants with central retinal impairment preferred the prismatic correction in about 24% cases for the vision at a distance and in 60% for the near vision.

Participants without central retinal impairment (Group B)

The mean values of BVA and BS of BVA are shown in table 4. The participants in group B assessed the prismatic correction at a distance on average by 4.06 points and at nearby 4.32. The rating of non-prismatic correction was on average 4.55 points at a distance and 4.61 at near. The ratings in all categories are shown in table 5 and figure 4, figure 5, figure 6, figure 7 and figure 8. Table 3 shows the subjective preferences of the both correction types in the group B.

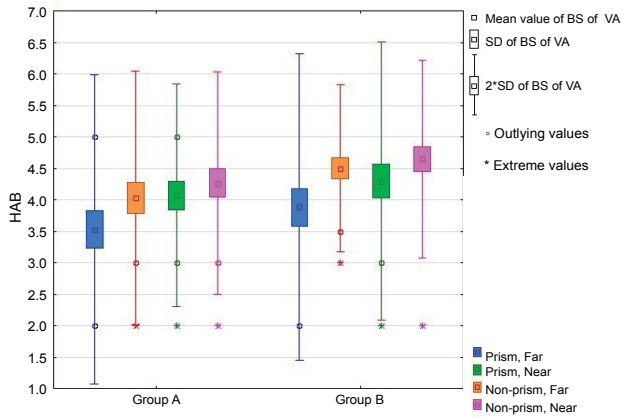

Figure 6: Subjective rating of both types of binocular correction in category "habituation" (HAB). Mean, outlying and extreme values and standard deviations (SD) are marked.

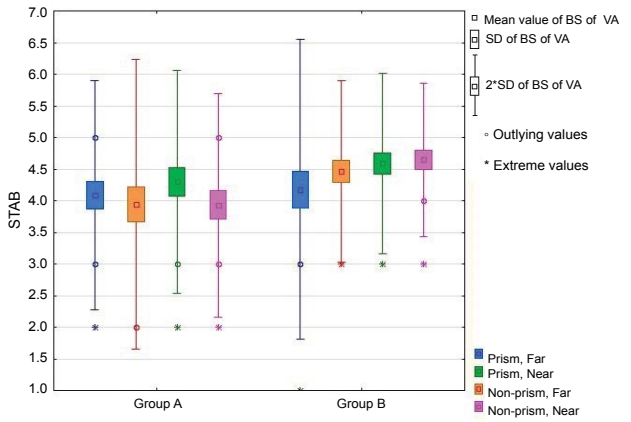

Figure 7: Subjective rating of both types of binocular correction in category "stability" (STAB). Mean, outlying and extreme values and standard deviations (SD) are marked.

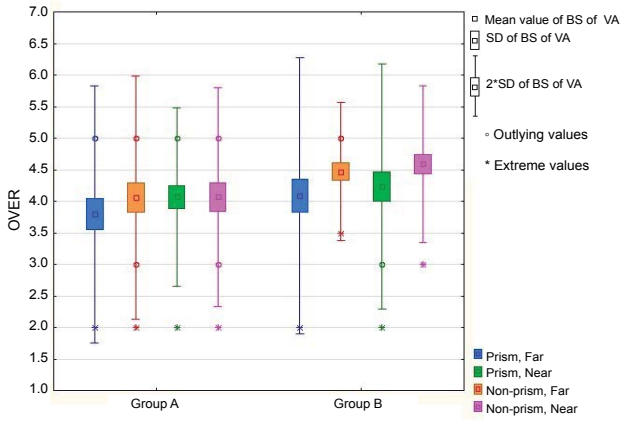

Figure 8: Subjective rating of both types of binocular correction in category "overall" (OVER). Mean, outlying and extreme values and standard deviations (SD) are marked.

Prismatic correction efficiency within each group

We have analysed the values of binocular visual acuity and binocular summation of visual acuity to revise the contribution of prismatic correction in the group A as well as in the group B. Non-parametric Wilcoxon's tests proved statistically significant difference between the binocular visual acuity (BVA) and summation (BS) with and without prismatic correction at a distance, when the contrast levels were lower; 25% ($p = 0.0323$) and 10% ($p = 0.029$) and for the total number of correctly read ETDRS letters ($p = 0.0059$) in the group A after the entry examination of refraction (Table 1). Better results were reached with the prismatic correction. On the other hand, there were no significant differences in BVA and BS after 30-day of trial wearing of both correction types (each for 1 month) in the group A (Table 1). In case of the near vision, the binocular summation of minimum legibile was statistically significantly better while using the prismatic correction after the refraction examination ($p = 0.0117$) as well as after 30 days of trial wearing ($p = 0.0277$) (Table 1). Statistically significant better results of BVA and BS at a distance at lower contrast level (25 %) with non-prismatic correction after examination were found in the group B, $p = 0.0330$ (Table 4). Further, we found statistically significant difference ($p = 0.0409$) between binocular summation of visual acuity at a distance with prismatic and non-prismatic correction after 30-day of trial wearing in the group B (Table 1). Surprisingly, there was no difference between binocular value of minimum legibile and its summation with both types of correction in the group B after refraction examination as well as at the following check-ups (Table 4).

Further, we evaluated, if there was a statistically significant difference in subjective rating between prismatic and non-prismatic correction in the group A as well as in the group B. Differences in the group A for the far as well as for the near vision were insignificant (Table 2). On the other hand, participants with "healthy" eyes (group B) subjectively rated the prismatic correction at a distance more negatively than the non-prismatic one in the category "COMFORT" ($p = 0.0208$) (Table 5).

Lastly, we compared the subjective preferences of both types of binocular correction at the beginning (after entry examination) and at the end (at 2nd check-up) of the study. It's obvious that they've changed during the participation in particular in group A. In table 3 we can see that immediately after the examination of refraction the prismatic correction was preferred most frequently, but after 30-day of trial wearing of both types of correction the preferences became almost opposite. The confidence interval reached the values $p = 0.0117$ in category "STABILITY" and $p = 0.0178$ in category "COMFORT" at a distance and 0.0179 in category "STABILITY" and $p = 0.0499$ in category "COMFORT" at near. This tendency can be observed in the group B too, but less expressive (only in the category "STABILITY" the p - value achieved the significant level $p = 0.0423$).

Comparison of Prismatic Correction Efficiency between Patients with Central Retinal Impairment and Participants with Healthy Eyes

One of the main goals of this study was to describe differences in effect of binocular prismatic correction between subjects with macular pathology and healthy ones. The comparison was made with the help of values of BS of VA at all contrast levels at a distance and binocular summation of VA (minimum legibile) at near distances. Mean values and results of the Mann-Whitney U test are shown in table 6 (prismatic) and table 7 (non-prismatic correction). BS of VA with prismatic correction is very similar in both groups at a distance after the examination as well as after 30-day wearing. Slightly better results were achieved with prismatic correction at near distances in the group A than in the group B (statistically significant after examination ($p = 0.036$), but no more after 30-day trial wearing). When we compare the efficiency of non-prismatic correction in both groups, the amount of BS of VA is appreciable lower in patients with central retinal impairment than in the control group B, but with statistical significance only at a distance after examination in full-contrast conditions ($p = 0.045$, table 6).

$$\Delta BS = BS_{PRISM} - BS_{NON-PRISM} \quad ..(2)$$

Calculation of the difference between BS of VA with prismatic and non-prismatic correction, where ΔBS = difference of binocular summations, BS_{PRISM} = binocular summation of visual acuity with prismatic correction, $BS_{NON-PRISM}$ = binocular summation of visual acuity without prismatic correction.

Further, according to equation (2), we checked the differences

Table 2: Subjective rating of prismatic and non-prismatic correction in the group A (patients with central retinal impairment). 1 = the worst. 5 = the best. The bold marked pairs (prism vs. non-prism) vary at statistically significant level p < 0.05 (column, Wilcoxon test results).

Group A	Mean values | Standard deviations						Wilcoxon test results (p)
Category:	Prism		Non-prism		Difference		
VA (far)	3.912	0.939	4.147	0.786	-0.235	1.059	0.398
COMFORT (far)	3.618	1.024	3.971	1.038	-0.353	1.412	0.311
HABITUATION (far)	3.529	1.231	4.029	1.007	-0.500	1.414	0.184
STABILITY (far)	4.088	0.905	3.941	1.144	0.147	1.643	0.845
OVERALL (far)	3.794	1.016	4.059	0.966	-0.265	1.373	0.410
VISUS (near)	3.800	0.941	3.933	0.594	-0.133	1.147	0.767
COMFORT (near)	4.000	0.756	3.933	0.799	0.067	1.062	0.889
HABITUATION (near)	4.067	0.884	4.267	0.884	-0.200	1.046	0.594
STABILITY (near)	4.300	0.882	3.933	0.884	0.367	1.271	0.295
OVERALL (near)	4.067	0.704	4.067	0.863	0.000	1.140	0.933

Table 3: Subjective preferences of the prismatic and the non-prismatic correction in both groups. The bold marked preferences vary (between examination and 2nd check-up) at statistically significant level p < 0.05 (column „Wilcoxon test results). *There were 2 volunteers unable to participate on trial wearing of prismatic spectacles for near vision in the main group and one of them wasn't able to undergo the binocular refraction examination at near at all.

Subjective preferences of correction type (number of subjects)*											
Categories / Groups & Preferences			STABILITY			VA			COMFORT		
			After exam.	After 2nd check-up	Wilcoxon test results (p)	After exam.	After 2nd check-up	Wilcoxon test results (p)	After exam.	After 2nd check-up	Wilcoxon test results (p)
Group A	Far	Non-prism	**1**	**7**		2	9		**4**	**10**	
		Any difference	**6**	**5**	**0.0117**	9	4	0.0843	**3**	**3**	**0.0178**
		Prism	**10**	**5**		6	4		**10**	**4**	
	Near	Non-prism	**0**	**3**		1	5		**1**	**4**	
		Any difference	**7**	**9**	**0.0180**	7	5	0.1235	**6**	**7**	**0.0500**
		Prism	**9**	**3**		8	5		**9**	**4**	
Group B	Far	Non-prism	**3**	**8**		6	8		8	12	
		Any difference	**10**	**8**	**0.0423**	5	6	0.3078	6	4	0.2213
		Prism	**4**	**1**		6	3		3	1	
	Near	Non-prism	1	4		1	7		1	7	
		Any difference	12	10	0.3452	9	6	0.0995	9	6	0.1579
		Prism	4	3		7	4		7	4	

between mean values of BS with prismatic and non-prismatic correction in each group to single out, in which group will be the possible positive effect on BS better either with prismatic or with non-prismatic correction type. Positive difference of binocular summations (ΔBS) means that BS of VA is on average better with the prismatic correction, negative ΔBS value signifies better binocular summation of visual acuity with the non-prismatic correction. Values of differences of binocular summation of visual acuity in both groups are presented in table 8. Statistically significant results were gained at lower contrast levels, 25% (p = 0.0005) and 10% (p = 0.0446) and after the entry examination of refraction at a distance (p = 0.0022). At the check-ups, we can see similar results with p - values 0.0147 for contrast 25% and 0.0437 for the sum of all recognized letters. In both cases, after the entry examination of refraction (p = 0.0176) and at the check-ups (p = 0.0401), there were statistically significant differences of summation of minimum legibile at near distances. It's obvious that patients with central retinal impairment reached on average better results of binocular summation with prismatic correction (positive ΔBS) in contrast with higher binocular summation with the non-prismatic correction (negative ΔBS) in the group B.

Another way to compare the correction efficiency in the both groups directly is by help of the subjective rating. Again, we've observed the height of rating score of each correction type, filled out at check-ups (Table 9 and Figure 4, Figure 5, Figure 6, Figure 7 and Figure 8), and the subjective preferences of correction type at the beginning and at the end of participation on the study (Table 10). Some significant differences in subjective rating of the non-prismatic correction were found between the both groups (Table 9). The non-prismatic correction was better rated in category "COMFORT" at a distance (p = 0.0457) and in categories "VISUS" (p = 0.0114), "COMFORT" (p = 0.0149) and "STABILITY" (p = 0.0223) at near distances by participants without central retinal impairment. The subjective preferences of prismatic or non-prismatic correction differ significantly between the both groups after the entry examination in categories "STABILITY" (p = 0.0388) and "COMFORT" (p = 0.0305) at a distance and in category "STABILITY" (p = 0.0480) at near distances. The preferences at the end of participation on the study are much more similar in the both groups and without statistically significant difference (Table 9).

Conclusion

Analysis of the mentioned results provides many interesting and somewhat unexpected, but logical outputs. The prismatic correction in patients with central retinal impairment produces better results of binocular visual acuity and summation in comparison to the non-prismatic correction only immediately after the examination of refraction. This difference was more pronounced at lower contrast levels. We didn't find significant differences in visual performance in these subjects after longer period of using both types of correction for distant vision. On the other hand, binocular summation of visual acuity at near distances (minimum legibile) was on the average better in the group A with prismatic correction, regardless of section of the study, when the performance was examined. In the group B, the using of prismatic correction didn't bring better results of binocular visual acuity and summation in comparison to the non-prismatic type, even contrariwise and with similar outcomes after the entry examination

Table 4: Binocular visual acuity (BVA) and binocular summation (BS) of BVA in the group B with prismatic and non-prismatic correction after the entry examination and after 30-day trial wearing. The bold marked pairs (prism vs. non-prism) vary at statistically significant level p < 0.05 (column „Wilcoxon test results). Number behind BVA and BS signs the Weber's contrast level; total = sum of ETDRS letters, correctly read at all contrast levels.

Group B. binocular visual acuity (BVA) and summation (BS)							
After examination	Mean values | Standard deviations						Wilcoxon test results (p)
At a distance (number of ETDRS letters)	Prism		Non-prism		Difference		
BVA (full contrast)	87.765	5.007	88.235	5.032	-0.471	2.154	0.551
BVA (50% contrast)	85.471	5.467	85.647	5.279	-0.176	2.215	0.975
BVA (25% contrast)	**81.118**	**6.781**	**82.118**	**6.698**	**-1.000**	**1.871**	**0.033**
BVA (10% contrast)	70.941	9.236	71.471	9.008	-0.529	2.503	0.594
BVA (sum of all contrast levels)	325.294	25.201	327.471	24.925	-2.176	5.318	0.124
BS (full contrast)	1.353	2.317	1.824	2.921	-0.471	2.154	0.551
BS (50% contrast)	0.824	2.834	1.000	2.574	-0.176	2.215	0.975
BS (25% contrast)	**0.647**	**2.827**	**1.647**	**3.061**	**-1.000**	**1.871**	**0.033**
BS (10% contrast)	2.471	3.939	3.000	4.690	-0.529	2.503	0.594
BS (sum of all contrast levels)	5.294	8.651	7.471	10.180	-2.176	5.318	0.124
At near distances (decimal)							
BVA	0.994	0.024	0.982	0.039	0.012	0.033	0.180
BS	0.006	0.025	-0.006	0.043	0.012	0.034	0.180
After 30-day trial wearing	Mean values | Standard deviations						Wilcoxon test results (p)
At a distance (number of ETDRS letters)	Prism		Non-prism		Difference		
BVA (full contrast)	88.588	4.273	89.000	5.050	-0.412	3.312	0.496
BVA (50% contrast)	86.941	5.761	87.059	5.651	-0.118	4.732	0.724
BVA (25% contrast)	82.647	6.294	83.412	5.280	-0.765	3.955	0.433
BVA (10% contrast)	72.235	8.066	72.647	8.208	-0.412	6.006	0.660
BVA (sum of all contrast levels)	330.412	23.262	332.118	23.358	-1.706	13.143	0.670
BS (full contrast)	0.706	1.312	1.647	2.422	-0.941	2.703	0.187
BS (50% contrast)	1.176	2.298	1.235	2.611	-0.059	3.363	0.969
BS (25% contrast)	0.471	2.695	1.882	3.039	-1.412	3.743	0.060
BS (10% contrast)	1.941	3.288	2.941	3.211	-1.000	3.279	0.196
BS (sum of all contrast levels)	**4.294**	**5.497**	**7.824**	**6.849**	**-3.529**	**6.539**	**0.041**
At near distances (decimal)							
BVA	0.994	0.024	0.988	0.049	0.006	0.072	0.655
BS	0.006	0.024	0.000	0.000	0.006	0.024	-

Table 5: Subjective rating of prismatic and non-prismatic correction in the group B (patients without central retinal impairment). 1 = the worst. 5 = the best. The bold marked pairs (prism vs. non-prism) vary at statistically significant level p < 0.05 (column „Wilcoxon test results).

Group B	Mean values | Standard deviations						Wilcoxon test results (p)
Category:	Prism		Non-prism		Difference		
VA (far)	4.235	0.807	4.647	0.508	-0.412	0.862	0.066
COMFORT (far)	**3.941**	**1.110**	**4.676**	**0.513**	**-0.735**	**1.086**	**0.021**
HABITUATION (far)	3.882	1.182	4.500	0.642	-0.618	1.301	0.086
STABILITY (far)	4.176	1.150	4.471	0.696	-0.294	1.273	0.407
OVERALL (far)	4.088	1.060	4.471	0.528	-0.382	1.008	0.183
VISUS (near)	4.412	0.911	4.588	0.691	-0.176	1.150	0.600
COMFORT (near)	4.118	0.963	4.588	0.771	-0.471	0.977	0.086
HABITUATION (near)	4.294	1.072	4.647	0.762	-0.353	1.281	0.294
STABILITY (near)	4.588	0.691	4.647	0.588	-0.059	0.802	0.686
OVERALL (near)	4.235	0.941	4.588	0.600	-0.353	1.026	0.214

and during check-ups. How do we explain that the patients with retinal diseases achieve better visual performance at a distance with prismatic correction immediately after the examination, but they do not so after a longer period of wearing prismatic glasses? The explanation consists probably in the prolonged time of separation of monocular visual inputs during the monocular and in particular binocular MKH examination of refraction. In this procedure the vision is separated by help of non-transparent cover during the monocular refraction and further immediately (without the possibility to see binocularly after termination of monocular refraction) through the positive-polarization separators during the binocular part of examination. The prismatic lenses are added gradually until the best possible correspondence (and isovalence, if possible) is achieved. After the termination of MKH binocular refraction examination and removing of separators the binocular vision is adapted at full prismatic values without need of any compensatory fusion. Because of inequality of retinal images in patients with defect of central vision, it is expectable that they can't restore the fusion after removal of prismatic trial lenses

Table 6: Binocular summation of visual acuity (BS) with prismatic correction in both groups immediately after the entry examination and after 30-day trial wearing. Values at a distance represents count of recognized ETDRS letters, values at near distances (BS near) are recorded in decimal scale. The bold marked pairs vary at statistically significant level $p < 0.05$.

Binocular summation (BS) of BVA with prismatic correction						
After examination	Mean values | Standard deviations				Difference	Mann-Whitney U Test results (p)
At a distance (number of ETDRS letters)	Group A		Group B			
BS (full contrast)	0.529	2.875	1.353	2.317	-0.824	0.328
BS (50% contrast)	0.941	3.191	0.824	2.834	0.118	0.986
BS (25% contrast)	1.412	3.374	0.647	2.827	0.765	0.473
BS (10% contrast)	3.353	3.823	2.471	3.939	0.882	0.958
BS (sum of all contrast levels)	6.235	8.166	5.294	8.651	0.941	0.782
At near distances (decimal) BS (minimum legible)	**0.032**	**0.058**	**0.006**	**0.025**	**0.026**	**0.036**
After 30-day trial wearing	Mean values | Standard deviations				Difference	Mann-Whitney U Test results (p)
At a distance (number of ETDRS letters)	Group A		Group B			
BS (full contrast)	1.000	2.806	0.706	1.312	0.294	0.538
BS (50% contrast)	0.882	4.729	1.176	2.298	-0.294	0.332
BS (25% contrast)	1.529	3.955	0.471	2.695	1.059	0.405
BS (10% contrast)	1.765	8.318	1.941	3.288	-0.176	0.756
BS (sum of all contrast levels)	5.176	16.576	4.294	5.497	0.882	0.849
At near distances (decimal) BS (minimum legible)	0.048	0.085	0.006	0.024	0.042	0.052

Table 7: Binocular summation of visual acuity (BS) with non-prismatic correction in both groups immediately after the entry examination and after 30-day trial wearing. Values at a distance represents the count of recognized ETDRS letters, values at near distances (BS near) are recorded in decimal scale. The bold marked pairs vary at statistically significant level $p < 0.05$.

Binocular summation (BS) of BVA with non-prismatic correction						
After examination	Mean values | Standard deviations				Difference	Mann-Whitney U Test results (p)
At a distance (number of ETDRS letters)	Group A		Group B			
BS (full contrast)	**-0.647**	**4.212**	**1.824**	**2.921**	**-2.471**	**0.045**
BS (50% contrast)	0.647	3.161	1.000	2.574	-0.353	0.481
BS (25% contrast)	-1.235	5.847	1.647	3.061	-2.882	0.170
BS (10% contrast)	1.588	3.447	3.000	4.690	-1.412	0.210
BS (sum of all contrast levels)	0.353	13.048	7.471	10.180	-7.118	0.088
At near distances (decimal) BS (minimum legible)	-0.027	0.059	-0.006	0.043	-0.021	0.307
After 30-day trial wearing	Mean values | Standard deviations				Difference	Mann-Whitney U Test results (p)
At a distance (number of ETDRS letters)	Group A		Group B			
BS (full contrast)	0.000	3.041	1.647	2.422	-1.647	0.126
BS (50% contrast)	-0.647	4.795	1.235	2.611	-1.882	0.275
BS (25% contrast)	-0.529	4.361	1.882	3.039	-2.412	0.111
BS (10% contrast)	0.529	4.033	2.941	3.211	-2.412	0.100
BS (sum of all contrast levels)	-0.647	13.852	7.824	6.849	-8.471	0.088
At near distances (decimal) BS (minimum legible)	-0.003	0.066	0.000	0.000	-0.003	0.278

as quickly and easily as individuals with healthy eyes. Logically, the binocular vision results (visual acuity and binocular summation) without full prismatic correction are after that measurably worse. Using of test glasses during 1 month wasn't accompanied by previous separation, so that the participants put on their test glasses with full prismatic correction in condition of active compensatory fusion, which had to be released and which was capable to provide sufficient (asymptomatic) vision in many cases. This is the reason, why the binocular visual acuity was after the entry examination superior with prismatic correction, but approximately equal with both corrections after the 30 day period of trial wearing. We didn't register this phenomenon in the group B, because (except of subjects with decompensated heterophoria or other binocular vision anomalies) the restoration of compensatory fusion seems to be much easier when both retinal images are intact and similar to each other. The limitation of fusion ability in patients with central retinal impairment could be the reason, why the prismatic correction at near distances enables statistically significant better results of binocular summation of visual acuity (Table 1). In our sample, there were 62% of all deviations exo (pure exophoria or combined with vertical deviation) in the group A at near distance and 64 % in the group B. Near exophoria about 6 pD is considered to be common, or even physiological in the elderly population [7]. Usually, it doesn't evoke any problems and it's fully compensated by fusion convergence, but we can

Table 8: Differences between binocular summation of visual acuity with prismatic and non-prismatic correction (ΔBS) in both groups. Values at a distance represents count of recognized ETDRS letters, values at near distances (ΔBS near) are recorded in decimal notation. The bold marked pairs vary at statistically significant level $p < 0.05$.

Differences of BS of VA with prismatic and non-prismatic correction					
After examination	Mean values | Standard deviations				Mann-Whitney U Test results (p)
At a distance (number of ETDRS letters)	Differences in Group A		Differences in Group B		
BS (full contrast)	1.176	3.695	-0.471	2.154	0.118
BS (50% contrast)	0.294	1.929	-0.176	2.215	0.697
BS (25% contrast)	**2.647**	**4.315**	**-1.000**	**1.871**	**0.000**
BS (10% contrast)	**1.765**	**2.969**	**-0.529**	**2.503**	**0.045**
BS (sum of all contrast levels)	**5.882**	**7.817**	**-2.176**	**5.318**	**0.002**
At near distances (decimal) BS (minimum legible)	**0.059**	**0.081**	**0.012**	**0.034**	**0.018**
After 30-day trial wearing	Mean values | Standard deviations				Mann-Whitney U Test results (p)
At a distance (number of ETDRS letters)	Differences in Group A		Differences in Group B		
BS (full contrast)	1.000	4.213	-0.941	2.703	0.107
BS (50% contrast)	1.529	5.680	-0.059	3.363	0.554
BS (25% contrast)	**2.059**	**4.867**	**-1.412**	**3.743**	**0.015**
BS (10% contrast)	1.235	6.969	-1.000	3.279	0.189
BS (sum of all contrast levels)	**5.824**	**14.943**	**-3.529**	**6.539**	**0.044**
At near distances (decimal) BS (minimum legible)	**0.051**	**0.074**	**0.006**	**0.024**	**0.040**

Table 9: Subjective rating of prismatic and non-prismatic correction at a distance in both groups. 1 = the worst, 5 = the best.

Groups & Rating / Category:		Mean values | Standard deviations				Difference	Mann-Whitney U Test results (p)
		Group A		Group B			
Prism	VA (far)	3.9118	0.9393	4.2353	0.8065	-0.3235	0.2987
	COMFORT (far)	3.6176	1.0236	3.9412	1.1099	-0.3235	0.2849
	HABITUATION (far)	3.5294	1.2307	3.8824	1.1823	-0.3529	0.4084
	STABILITY (far)	4.0882	0.9055	4.1765	1.1497	-0.0882	0.4841
	OVERALL (far)	3.7941	1.0164	4.0882	1.0605	-0.2941	0.2505
	VA (near)	**3.8000**	**0.9411**	**4.4118**	**0.9113**	**-0.6118**	**0.0375**
	COMFORT (near)	4.0000	0.7559	4.1176	0.9630	-0.1176	0.5577
	HABITUATION (near)	4.0667	0.8837	4.2941	1.0718	-0.2275	0.2602
	STABILITY (near)	4.3000	0.8824	4.5882	0.6910	-0.2882	0.2556
	OVERALL (near)	4.0667	0.7037	4.2353	0.9412	-0.1686	0.3445
Non-prism	VA (far)	4.1471	0.7859	4.6471	0.5077	-0.5000	0.0541
	COMFORT (far)	**3.9706**	**1.0379**	**4.6765**	**0.5128**	**-0.7059**	**0.0286**
	HABITUATION (far)	4.0294	1.0073	4.5000	0.6417	-0.4706	0.1698
	STABILITY (far)	3.9412	1.1440	4.4706	0.6960	-0.5294	0.1842
	OVERALL (far)	4.0588	0.9663	4.4706	0.5278	-0.4118	0.2598
	VA (near)	**3.9333**	**0.5936**	**4.5882**	**0.6910**	**-0.6549**	**0.0060**
	COMFORT (near)	**3.9333**	**0.7988**	**4.5882**	**0.7715**	**-0.6549**	**0.0075**
	HABITUATION (near)	4.2667	0.8837	4.6471	0.7624	-0.3804	0.1029
	STABILITY (near)	**3.9333**	**0.8837**	**4.6471**	**0.5882**	**-0.7137**	**0.0123**
	OVERALL (near)	4.0667	0.8633	4.5882	0.5999	-0.5216	0.0551

expect some difficulties in patients with central retinal impairment. These are presumably linked with aggravated fusion conditions (unequal distortions of images, central scotomas, etc.), which lead in decompensation of this near exophoria. This could be the reason, why the binocular summation of visual acuity at near distances (in term of minimum legibile) stays better with prismatic correction both at the entry examination and at the check-up, and why the values of binocular summation with non-prismatic correction at near sink into binocular inhibition (< 0) in this group. In opposite, values of binocular summation in participants with "healthy" eyes didn't ever drop under zero to binocular inhibition neither with prismatic, nor with non-prismatic correction.

Subjective rating of both types of correction didn't show any statistically significant differences in the group A. Indeed, the participants with central retinal impairment rated slightly better the non-prismatic correction for vision at a distance and prismatic correction at near, but the differences were really inappreciable. In the group B, volunteers with "healthy" eyes rated markedly better the non-prismatic correction for both, distant and near vision. The statistical significance even reached the value $p < 0.05$ in the category "COMFORT" for vision at a distance.

In the group A, significant differences in subjective preferences of both correction types at the beginning and at the end of the study were found. There was a considerable drop of preferences of prismatic

Table 10: Subjective preferences of correction type in both groups. Bold marked pairs vary at statistically significant level $p < 0.05$.

Preferred correction type / Categories			Group A (count of preferences)			Group B (count of preferences)			Mann-Whitney U Test results (p)
			Prism	Any difference	Non-prism	Prism	Any difference	Non-prism	
Preferences after examination	Far	STABILITY	**10**	**6**	**1**	**4**	**10**	**3**	**0.0388**
		VA	6	9	2	6	5	6	0.3204
		COMFORT	**10**	**3**	**4**	**3**	**6**	**8**	**0.0305**
	Near	STABILITY	**9**	**7**	**0**	**4**	**12**	**1**	**0.0480**
		VA	8	7	1	7	9	1	0.4650
		COMFORT	9	6	1	7	9	1	0.2928
Preferences after 2nd check-up	Far	VA	4	4	9	3	6	8	0.9401
		COMFORT	4	3	10	1	4	12	0.3498
		HABITUATION	10	5	2	2	8	7	0.3775
		STABILITY	5	5	7	1	8	8	0.3417
		OVERALL	4	2	11	3	1	13	0.7720
	Near	VA	5	5	5	4	6	7	0.5606
		COMFORT	4	7	4	4	6	7	0.6709
		HABITUATION	2	8	5	2	8	7	0.6922
		STABILITY	3	9	3	3	10	4	0.8134
		OVERALL	7	2	6	4	3	10	0.2141
Preferred type (far)			4	X	13	4	X	13	0.9813
Preferred type (near)			9	X	6	6	X	11	0.1758

correction at the end of the study in comparison to preferences after the entry examination in categories "STABILITY" and "COMFORT" for both, vision at a distance and near vision. This corresponds to our experience with changes of binocular summation of visual acuity with prismatic correction, mentioned above. Probably, the inability to fully re-establish the fusion without prismatic binocular correction after its long-term disruption during the examination lead to better subjective "feeling", when the prismatic correction was put on. Surprisingly, subjective preferences in category "VISUS", which describes the (dis) satisfaction with visual acuity the best, didn't differ as much at the beginning and at the end of the study in the group A. We can suppose that at the end of the wearing of test glasses (at least) patients with central retinal impairment did conform their subjective correction preference according to sensational impression more than to the visual performance (visual acuity, amount of binocular summation, etc.). An important difference between the both groups is that subjects with "healthy" eyes were, in comparison to participants with central retinal impairment, more capable to determine immediately after the entry examination such type of correction (prismatic/non-prismatic) that will be preferred at the final check-up too. Only in the category "STABILITY" for vision at a distance the participants preferred the prismatic correction markedly more often after the entry examination than at the end of the study in this group (B).

The comparison of BS of VA with prismatic correction between the groups didn't show any significant differences for vision at a distance neither after the entry examination, nor at the final check-up. It's obvious that patients with central retinal impairment reached slightly better results with prismatic correction, firstly at lower contrast levels, but this amount doesn't achieve the statistical significance. The binocular summation of visual acuity with prismatic correction at near distances was markedly higher in the group A after the entry examination. More pronounced outcomes were obtained when the non-prismatic correction was used - patients with central retinal impairment reached much poorer results (especially for vision at a distance) of binocular summation of visual acuity than participants without retinal pathology. This trend was even more obvious when the values of differences of binocular summations (Equation (2)) were confronted. It enables to sort out, if the subjects achieve about the same amount of summation with both types of correction (the difference is near to zero), or if they profit only from one type of correction markedly (positive values predicate better results with prismatic correction, negative with non-prismatic correction). In the table 8 we can clearly see that on the average the values at a distance in the "main" group stay above zero, but in the "control" group without exception below zero. Statistical significance $p < 0.05$ was reached for vision at a distance on lower contrast levels (25% and 10%) and for the sum of all recognized ETDRS letters and for minimum legibile at near distances after the entry examination of refraction and for vision at a distance on 25% contrast level and for the sum of all recognized ETDRS letters and for minimum legibile at near distances at the check-ups.

Patients with central retinal impairment rated the both types of correction with lower score than participants with "healthy" eyes. This could be attributed to the overall dissatisfaction of subjects with macular pathology with their quality of vision. Thus, the key evaluating criterion is the size of difference, how much more dissatisfied the volunteers in the group A were in comparison to the participants with "healthy" eyes. There wasn't found any significant difference in rating of prismatic correction for far vision by subjects in both groups, but the non-prismatic correction was better classified on points by participants with "healthy" eyes (statistically significant in category "COMFORT" for vision at a distance and in categories "VISUS", "COMFORT" and "STABILITY" for near vision). Hence, the conclusion of intergroup comparison could be that the correction, which provides different visual performance and is perceived unlikely by the participants, is not the prismatic but rather the non-prismatic one, which enables better results in the group B and slightly worse in the group A.

Lastly, we investigated and compared subjective preferences of correction type in both groups to each other. After the entry examination of refraction, the preferences varied quite markedly. Patients with central retinal impairment more often preferred the prismatic correction at this moment in comparison to the participants with "healthy" eyes (statistically significant in categories "STABILITY" and "COMFORT" for vision at a distance and in category "STABILITY" for near vision). It's essential that this difference doesn't appear after the two periods of 30 day wearing of trial glasses neither for vision at a distance, nor at near vision. Again, we can observe greater deflection from prismatic correction in the "main" group during the research than in the "control" group. This is probably related to the above mentioned troublesome restoration of binocular vision after long-term separation during the binocular refraction examination.

At the end of our study, participants were asked to choose the version of glasses for vision at a distance and near vision, which they

considered as the best. This selection was identical in both groups for vision at a distance, 4:13 in favour of non-prismatic correction (Table 10). Participants with central retinal impairment preferred more often the prismatic correction for near vision (9:6) than volunteers in the "control" group (6:11), but the difference between both groups didn't reach statistical significance. We can consider these conclusions as surprising. It was expected that the prismatic correction at least for vision at a distance will be more profitable in patients with central retinal impairment than in 24%. On the other hand, the number of preferred prismatic corrections in the "normal" population for vision at a distance, also 24%, seems to be higher, than presumed, and it's surely higher than overall percentage of worn prismatic glasses in the general public. From this point of view, we shouldn't overestimate the importance of prismatic correction in patients with macular diseases, but we can't leave it out, because approximately ¼ of subjects preferred it in comparison to "standard" non-prismatic correction. The majority of chosen prismatic corrections (60%) for near vision in the "main" group should be a sufficient reason, why to examine subjective binocular refraction not only at far, but in every patient even at near distances too. We suppose that the efficiency of prismatic correction for near vision consist in the combination of in elderly common exophoria at near and poor fusion ability of patients with central retinal impairment. This could be probably similar in other causes of deteriorated central vision, e. g. late cataract, corneal diseases etc.

The most important findings of this study can be interpreted as follows. Some of patients with central retinal impairment can achieve better binocular visual performance when using of binocular prismatic correction, which can improve the fusion ability, prevent diplopia and restore stereopsis etc. However, there are some reasons that appear to be limiting of its universal usage. Firstly, it seems to be essentials for the majority of participants in our study to feel comfortable with the correction prior to reach the best possible visual acuity and binocular summation. Mostly, the subjective reason, why to prefer the non-prismatic correction, wasn't visual acuity, but easier habituation without accompanying adverse effects (distortion and other optical aberrations, changes of space perception etc.). Further, the apparent benefit of the binocular prismatic correction that the practitioner can suppose on the basis of examination outcomes and examinants' notices, may not correspond to expectation in everyday use. In other words, the fact that the correction enables better visual performance and comfort during the examination in the optometry workplace doesn't necessarily mean that it will be more useful in real life. This probably hangs together with aggravated fusion ability after long-term disruption of binocular vision during the examination (discussed above) that could produce false conclusion about necessity of prismatic correction. In fact, the fusion ability in normal conditions could be sufficient to provide comfortable vision. This phenomenon wasn't observed in such an extent in participants without macular diseases, so that it should be considered as one of critical moments especially in examination of binocular refraction in patients with central retinal impairment.

The higher efficiency of prismatic correction in participants with macular diseases for near vision probably comes from two sources. Firstly, as mentioned, the common near exophoria in elderly people and aggravated fusion ability because of inequality of retinal images could create conditions, whereat the prismatic correction contribution is irrefutable. Secondly, the visual tasks at near distances (reading, writing etc.) are usually done in static position and motionless and thus are not as much susceptible to be affected by undesirable side effects of full prismatic correction. The habituation to prismatic correction for near vision is expected to be easier than at far thanks to this.

Of course, some limitations of our study have to be mentioned. The sample of participants wasn't large and it's a question, if higher number of volunteers in both groups would lead into another results. Further, our purpose was to achieve the best possible retinal correspondence by help of prismatic correction and because of this reason only full prismatic correction according to MKH examination procedure for vision at a distance was used in this study. No other modifications of prismatic correction were allowed, although they could seem to be advantageous in healthy population. Naturally, the application of the full prismatic correction connotes incidence of considerable adaptation difficulties, especially in elderly people like in our study. Further, the full prismatic correction was applied in this study in all participants regardless of presence of any symptoms due to aggravated binocular functions. In practice it would be useless to prescribe such corrections to asymptomatic subjects, who are usually well corrected with ordinary glasses. If the participating criteria were set differently (e.g. only subjects with asthenopia, diplopia, higher or incomitant heterophoria etc.), the percentage successfulness of prismatic correction would be probably higher.

In our study, the effectivity of both correction types was evaluated on the part of both, practitioner (assess binocular visual acuity and binocular summation) and glasses wearer (reports subjective experience) and the final choice was relinquish to the participants themselves. In a standard practice, except of this study, practitioners have to make the decision, what kind of correction will be used, and they have to take into account both factors - the improvement of visual performance and the visual comfort. The disclosure of relations between those 2 different factors, described in our study, should help to make the final decision about the binocular correction in patients with central retinal impairment easier.

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