Coll. Antropol. **37** (2013) Suppl. 1: 153–156
Professional paper

Binocular Refraction in Patients with Age-Related Macular Degeneration

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A B S T R A C T

We've been finding possible association of central vision damage with binocular vision disorders in our clients suffering from age-related macular degeneration (ARMD), but whose visual acuity still allowed us to examine their binocular vision. Our findings show that there is a significant number of patients with heterophoria in horizontal, as well as vertical direction. The clients rate the vision with prismatic correction as more comfortable, clearer and long-term tolerable. Getting used to prismatic correction was spontaneous and non-problematic. Based on these results we expect to find possibly the most effective rehabilitation of vision in patients suffering from ARMD.

***Key words**: binocular vision, macular degeneration, vision disparity, visual acuity*

Introduction

Age-related macular degeneration (ARMD) is a serious degenerative retinal disease that represents one of the most common causes of blindness in developed countries. Its incidence is connected to the increasing lifespan in western population. With different speed of progression, the points of sharpest vision (the fovea as well as the macula) are being damaged and the visual acuity declines. The process of this loss could be unequal in the two eyes. Provided that there was a similar visual performance in both eyes before the onset of ARMD, both the sudden drop in visual acuity and the difference in the quality of perception between the eyes can cause various difficulties in binocular vision.

The impact on binocular vision in patients with ARMD unfolds at several levels. Many authors (for example Quillen[1]) notice that binocular vision of ARMD patients often provides worse visual performance than monocular perception of the less impaired eye separately. The cause of this is often identified as the »binocular inhibition«, meaning the negative outcome of »binocular summation«. Generally, it is caused by a large dissimilarity of the visual perception quality of each, differently affected, eye[2]. The progressive loss of the fovea function as the referential position for the whole motoric system, leads to the development of substitutional, eccentrically located »pseudofovea«, so called »preferred retinal locus (PRL)«[3]. It was established that the instability of eye fixation rises proportionally to the eccentricity of the »preferred retinal locus« location[4]. Further, it was confirmed that in conditions of binocular vision the control of fixation is assumed by »PRL« of the less impaired eye, usually located identically for mono- and binocular viewing conditions; whereas in the case of a monocular vision by the more impaired eye, its »PRL« seems to have a different location for mono- and binocular vision conditions[3]. The authors believe that the main outcome is the significant reduction in the binocular contrast sensitivity and visual acuity that shifts the binocular summation into binocular inhibition[2].

The referenced authors however don't note, how (or even if) the subjects' vision was corrected during the examination. Due to a possible rise of a central scotoma on the place of former fovea (even with a different progression in the left and right eye), it can be expected that the fusion could be significantly impaired. We have determined that about 70% of our clients suffer some form of latent strabismus*, compensated by motoric or sensorial fusion. Is it possible that the binocular inhibition of visual acuity and contrast sensitivity is caused, among other things, by the decompensation of latent strabis-

Received for publication June 25, 2012

* In this paper we don't differentiate between »heterophoria« and »associated phoria« and instead use a common term »latent strabismus«.

mus? We wanted to research this relationship further, as the similarity of some cases seemed to be too obvious to be coincidental.

Materials and Methods

The standard optometric examination** of our clients includes objective and subjective measurement of the eye refraction, binocular examination for distance and near vision (after assessment of the addition for near vision), using the »Mess- und Korrektionsmethodik nach Haase« (MKH) methodics with positive (distance vision) polarisation and negative polarisation tests for near vision. Based on anamnesis and medical certificates, we selected a group of ARMD patients, which we further subdivided between those individuals that could and could not be examined binocularly. The collected data sets were analyzed and compared with each other.

Results

The basic group included 12 subjects with different stages of ARMD. Usually it was possible to distinguish the more and less affected eye (in the following Tables 1, 2 and 3 we use the terms »worse« and »better«). The condition of 5 of the subjects allowed binocular examination. In the rest of the subjects from the ARMD group, the damage of the »worse« eye was too extensive to perform a binocular examination, or the binocular vision was never developed (amblyopia, alternating vision, etc.). The characteristics of the described complete group sample are shown in the following tables (Tables 1–3).

This comparison shows that while the age range is quite similar, the values of visual acuity are different. Compared to the whole group average, they are significantly higher (especially in the »worse« eye) in cases where binocular examination was possible. Further, we don't see appreciable difference between the visual acuity of the right and left eye, which is one of the main prerequisites for implementation of binocular eye examination. A noticeable drop in binocular visual acuity (binocular inhibition) without prismatic correction is significant in 2 of 3 subjects with latent strabismus, whereas with appropriate prismatic correction we were able to reach a 7% gain in binocular visual acuity (binocular summation). However, due to the low sample size of subjects with ARMD, whose condition allowed the examination of binocular vision functions, it is impossible to apply more advanced statistical research methods and this remains one of our future goals. From the initial supposition it appears however, that the prismatic correction in ARMD patients could play an important role more frequently than in the case of »healthy« individuals. For example, in our practice, about 14% of clients with any form of latent strabismus are treated with a prismatic correction (this is 8% of all examined people, including orthophoric, those without binocular vision and uncooperative individuals), whereas in patients with ARMD the prismatic correction is applied in 2/3^{rds} of cases with latent strabismus. This is about 17% of all clients with confirmed ARMD, apart from the fact that in ¾ of subjects the binocular refraction examination cannot be carried out any more.

TABLE 1
SUMMARY OF THE SELECTED MONITORED DATA IN THE GROUP OF 12 SUBJECTS WITH ARMD

	Average	Minimum	Maximum	Standard deviation
Age (years)	73.67	61.00	85.00	8.51
Prism – distance R (pD)	4.39	3.30	5.23	0.99
Prism – near R (pD)	3.59	2.24	5.23	1.52
Prism – distance L (pD)	4.39	3.30	5.23	0.99
Prism – near L (pD)	3.59	2.24	5.23	1.52
V. n. better eye	0.57	0.10	1.50	0.44
V. c. c. better eye	0.88	0.40	1.50	0.35
Diff v. c. c. & v. n. better eye	0.32	0.00	0.90	0.34
V. n. worse eye	0.25	0.00	1.00	0.29
V. c. c. worse eye	0.45	0.00	1.20	0.41
Diff v. c. c. & v. n. worse eye	0.20	0.00	0.80	0.25
Better / worse eye v. n. diff	0.32	-0.06	0.70	0.26
Better / worse eye v. c. c. diff	0.43	0.20	0.89	0.22
V. n. bino	0.58	0.10	1.50	0.42
V. c. c. bino	0.89	0.40	1.50	0.34
V. c. c. bino with prism	1.10	0.80	1.50	0.36
Diff v. c. c. & v. n. bino	0.31	0.00	0.90	0.33
Diff bino vis.acuity with & without prism	0.07	0.00	0.10	0.06

R – right eye, L – left eye, pD – prismatic diopter (cm/m), distance – values for distance vision, near – values for near vision, bino – binocular(ly), prism – prismatic correction value, diff – difference between, v. n. – visual acuity without any correction, v. c. c. – visual acuity with correction, vis. – visual, better eye – less impaired eye, worse eye – more impaired eye

The similarity of amplitude of latent strabismus in the ARMD cases is also remarkable (standard deviation only 0.99 pD). In prismatic corrected clients we found eso-deviations (8.5 pD and 8.0 pD temporal) combined

** Does not include all measurments taken during the examinations (for example pupillar distance, height of the centration).

TABLE 2
SUMMARY OF THE SELECTED MONITORED DATA IN THE GROUP OF 5 SUBJECTS, WHOSE CONDITION ALLOWED THE EXAMINATION OF BINOCULAR VISION

	Average	Minimum	Maximum	Standard deviation
Age (years)	70.00	61.00	85.00	10.17
Prism – distance R (pD)	4.39	3.30	5.23	0.99
Prism – near R (pD)	3.59	2.24	5.23	1.52
Prism – distance L (pD)	4.39	3.30	5.23	0.99
Prism – near L (pD)	3.59	2.24	5.23	1.52
V. n. better eye	0.74	0.10	1.50	0.59
V. c. c. better eye	1.16	0.70	1.50	0.36
Diff v. c. c. & v. n. better eye	0.42	0.00	0.90	0.43
V. n. worse eye	0.44	0.16	1.00	0.34
V. c. c. worse eye	0.84	0.50	1.20	0.27
Diff v. c. c. & v. n. worse eye	0.40	0.00	0.80	0.30
Better / worse eye v. n. diff	0.30	-0.06	0.70	0.30
Better / worse eye v. c. c. diff	0.32	0.20	0.50	0.13
V. n. bino	0.75	0.16	1.50	0.58
V. c. c. bino	1.16	0.70	1.50	0.36
V. c. c. bino with prism	1.10	0.80	1.50	0.36
Diff v. c. c. & v. n. bino	0.41	0.00	0.90	0.41
Diff bino vis.acuity with & without prism	0.07	0.00	0.10	0.06

R – right eye, L – left eye, pD – prismatic diopter (cm/m), distance – values for distance vision, near – values for near vision, bino – binocular(ly), prism – prismatic correction value, diff – difference between, v. n. – visual acuity without any correction, v. c. c. – visual acuity with correction, vis. – visual, better eye – less impaired eye, worse eye – more impaired eye

TABLE 3
SUMMARY OF THE SELECTED MONITORED DATA IN A GROUP OF 3 SUBJECTS, WHOSE EXAMINATION DETECTED SOME FORM OF RECTIFIABLE LATENT STRABISMUS

	Average	Minimum	Maximum	Standard deviation
Age (years)	75.00	64.00	85.00	10.54
Prism – distance R (pD)	4.39	3.30	5.23	0.99
Prism – near R (pD)	3.59	2.24	5.23	1.52
Prism – distance L (pD)	4.39	3.30	5.23	0.99
Prism – near L (pD)	3.59	2.24	5.23	1.52
V. n. better eye	0.33	0.10	0.60	0.25
V. c. c. better eye	1.03	0.70	1.50	0.42
Diff v. c. c. & v. n. better eye	0.70	0.40	0.90	0.26
V. n. worse eye	0.24	0.16	0.40	0.14
V. c. c. worse eye	0.80	0.50	1.20	0.36
Diff v. c. c. & v. n. worse eye	0.56	0.34	0.80	0.23
Better / worse eye v. n. diff	0.09	-0.06	0.20	0.14
Better / worse eye v. c. c. diff	0.23	0.20	0.30	0.06
V. n. bino	0.35	0.16	0.60	0.22
V. c. c. bino	1.03	0.70	1.50	0.42
V. c. c. bino with prism	1.10	0.80	1.50	0.36
Diff v. c. c. & v. n. bino	0.68	0.40	0.90	0.26
Diff bino vis.acuity with & without prism	0.07	0.00	0.10	0.06

R – right eye, L – left eye, pD – prismatic diopter (cm/m), distance – values for distance vision, near – values for near vision, bino – binocular(ly), prism – prismatic correction value, diff – difference between, v. n. – visual acuity without any correction, v. c. c. – visual acuity with correction, vis. – visual, better eye – less impaired eye, worse eye – more impaired eye

with vertical deviations (right hyper-deviation 3.75 pD and 5.0 pD). Only one case of latent strabismus stayed uncorrected – an exo-deviation combined with vertical deviation, but its absolute values (6.0 pD nasal and 2.75 pD right hyper-deviation) were quite similar to the previous ones. Due to the limited equipment and possibilities of our facility, as well as limited period of no more than 4 years for the monitoring of the mentioned subjects, it is not possible to determine with certainty whether the findings relate to latent strabismus already existing before the onset of ARMD, or if the discovered deviation was a result of the devastation of the fovea and the beginning of the eccentrically located »PRL« fixation centres. If these »PRLs« would develop and become the new referential spot for fixation and fusion, but at the same time if the other (mainly peripheral located retinal areas) wouldn't directionally re-orient to the newly leading referential spots (PRLs)[5], couldn't we observe a similar phenomenon as for example an uncorrected fixation disparity? Could the newly disparate location of the original perifoveal and perimacular areas of both eyes in the relationship to the new »PRLs« be the reason for the decrease in binocular perception, in other words binocular inhibition? Could the prismatic correction in patients with ARMD adjust this disruption to the point where the vision would become subjectively more comfortable? Or is the contribution of prismatic correction in subjects with ARMD attributed to the fusion weakening due to fovea devastation and the resulting decompensation of latent strabismus?

For one female subject we have 6 repeated measurements within the last 4 years. The first 3 were results of binocular tests based on negative polarisation. Esophoria was found in approximately one third and right hyperforia in one half of the values, compared to the last 3 results from tests based on positive polarisation. The majority (5/6) of esophoria was found in the positive polarisation tests without central fusion stimulus, compared to only 1/2 in the vertical direction. The rest was discovered in tests with central fusion stimulus. We can say that the deviation rate (of measurements undertaken on the same devices) got higher only between the first and the second examination in the negative polarised tests (before the application of prismatic correction). The results of the next repeated examinations stayed more or less constant (didn't rise any more).

Interesting is also that clients with ARMD adapt to prismatic correction significantly easier, faster and more trouble free than those with unimpaired central vision. Thanks to the necessity of addition and the same values of latent strabismus for distance and near vision, the use of prismatic bifocals proved to be useful.

Conclusion

The prismatic correction in our clients with ARMD turned out as very convenient. It is subjectively well tolerated and in these cases there is no observed decrease in the binocular visual perception (binocular inhibition) compared to the vision in the »better« eye. On the contrary, the binocular visual acuity appears to be slightly improved. Our clients rate their vision as clearer, brighter and sharper. There is also a positive finding in that the more affected eye can be more effectively integrated into the binocular vision following proper binocular correction. With some exaggeration, we could say that the »worse« eye changes in some cases from an »perpetrator« back to a »helper« in the vision performance. In addition, the possibility of enhancement in visual performance creates a psychological benefit for the patients with ARMD, despite the negative final prognosis. It is necessary to add that the possibility of the binocular correction examination and application depends on the actual stage of the condition and it applies more in the beginning stages, ie the phases of dry form without progressive decline of visual acuity.

At this time, we are not able to determine with certainty, if the disparate projection corrected by prismatic correction, is caused by latent strabismus present before the onset of ARMD and symptomatically manifesting itself because of the alteration of fusion abilities of the visual apparatus, or, if it is a result of fovea destruction as the referential spot for fixation and fusion and the resulting development of PRL (pseudofovea) without directional reorientation of the other, unaffected retinal areas. This could be explored during the next phase of our research, especially focussing on monitoring of the binocular refraction of people before and at the beginning of the ARMD.

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BINOKULARNA REFRAKCIJA U BOLESNIKA SA MAKULARNOM DEGENERACIJOM-AMD

SAŽETAK

U ovoj studiji opisuje se tretman binokularne preskripcije naočala u bolesnika sa AMD.Ispitivanja pokazuju da je u bolesnika sa AMD često prisutna horizontalna heteroforija,vertikalnim usmjerenjem. Korekcija sa prizmama daje dobre rezultate u rehabilitaciji i komfora vida.