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Optical devices in highly myopic eyes with low vision: A prospective study

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Abstract

Aims. To compare, in relation to the cause of visual impairment, the possibility of rehabilitation, the corrective systems already in use and the finally prescribed optical devices in highly myopic patients with low vision. Some considerations about the rehabilitation of these subjects, especially in relation to their different pathologies, have also been made.

Materials and Methods. 25 highly myopic subjects were enrolled. We evaluated both visual acuity and retinal sensitivity by Scanning Laser Ophthalmoscope (SLO) microperimetry.

Results. 20 patients (80%) were rehabilitated by means of monocular optical devices while five patients (20%) were rehabilitated binocularly. We found a good correlation between visual acuity and retinal sensitivity only when the macular pathology did not induce large areas of chorioretinal atrophy that cause lack of stabilization of the preferential retinal locus. In fact, the best results in reading and performing daily visual tasks were obtained by maximizing the residual vision in patients with retinal sensitivity greater than 10 dB. A well circumscribed area of absolute scotoma with a defined new retinal fixation locus could be considered as a positive predictive factor for the final rehabilitation process.

Discussion. A more careful evaluation of visual acuity, retinal sensitivity and preferential fixation locus is necessary in order to prescribe the best optical devices to patients with low vision, thus reducing the impact of the disability on their daily life. ***Clin Ter 2012; 163(3):e115-120***

Key words: *low vision, microperimetry, myopia, optical device, retina, Scanning Laser Ophthalmoscope (SLO)*

Introduction

High myopia represents one of the most important causes of low vision in the young population of developed countries and the seventh cause of visual impairment for adult subjects. Among patients aged 30-60 years, only diabetic retinopathy ranks higher (1-6). Low vision is directly induced by both haemodynamic and anatomical changes related to the excessive axial length of the eye (2). Indeed, several different factors may concur to cause low vision in highly myopic eyes: choroidal neovascularization, macular atrophy, lacquer cracks, macular hole, retinal detachment, glaucoma, macular retinoschisis, complications due to cataract extraction and, most recently, complications due to refractive surgery (2, 7, 8). The high incidence of retinal pathologies or complications associated with high myopia, inducing a total or partial vision loss, are the main causes that account for the great number of highly myopic patients with low vision. These subjects have difficulty accomplishing visual tasks, but can enhance their ability by using compensatory strategies, optical devices and by modifying the environment (9).

Materials and Methods

We selected 25 patients (8 males and 17 females, mean age 66.75 years) with high myopia ranging from -15 to -25 diopters (mean value -18.00 D), presenting a visual acuity less than 0.3 binocularly. We selected patients for both monolateral and bilateral rehabilitation. The study was approved by the Institutional Ethics Committee and after its full explanation, all patients had to sign a written informed consent to be enrolled in the study. We excluded patients whose visual loss was caused by glaucoma (even if associated with high myopia), due to the specific involvement of the optic disc that requires a different approach in the rehabilitation process.

All patients were subjected to a full eye examination, completed by retinography. Functional tests were performed, measuring visual acuity by means of Snellen charts tested at three meters and near low vision by means of standard Jaeger eye chart. Reading capacity was evaluated by measuring reading speed, defined as good (>80 words/min), slow (40-80 words/min) and poor (<40 words/min). We subjected all patients to Scanning Laser Ophthalmoscope (SLO) microperimetry (Rodenstock®, Düsseldorf, Germany), in order to test the retinal macular sensitivity, to detect the possible presence of a relative or absolute scotoma and the exact location of a new preferential retinal locus. We

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followed all patients over a mean period of eight months, with a total amount of six sessions of examination for each one. The clinical evaluation of low vision consisted of the following steps:

– clinical evaluation and case history: review of functional visual assessment, previous lenses and/or optical devices already used by the patient; ophthalmic health evaluation; far and near visual acuity measurements; objective refraction; SLO microperimetry; retinography;
– evaluation of the best devices for far, intermediate and near vision;
– instructions and trial: instructions for using the recommended devices; indoor and outdoor clinical evaluation in order to assess the need of additional UV-absorption lenses;
– follow-up examinations: to review the efficacy of the prescribed optical devices and the recommendations for accessory or non-optical devices.

We divided the whole sample into two groups according to the possibility of performing a monocular or binocular rehabilitation for near vision.

Table 1. Causes of disability and mean visual acuity (VA) in the enrolled highly myopic subjects. The eyes with the greatest visual loss (VA less than 0.2) have been reported only.

Causes of disability	Patients	Eyes
Choroidal neovascularization monolateral: 9 patients bilateral: 2 patients subjected to PDT: 11 eyes untreated: 2 eyes mean VA: 0.12	11 (44%)	13
Macular atrophy monolateral: 6 patients bilateral: 1 patient mean VA: 0.14	7 (28%)	8
Retinal detachment monolateral: 2 patients bilateral: 1 patient mean VA: 0.15	3 (12%)	4
Retinal detachment with macular hole (monolateral) mean VA: 0.06	3 (12%)	3
Full thickness macular hole (monolateral) mean VA: 0.10	1 (4%)	1

Results

The main causes of disability as well as the clinical features of the enrolled eyes have been presented in the Tables 1 and 2.

In our study, there was a good correlation between visual acuity and retinal sensitivity tested by SLO microperimetry only when the macular pathology was not able to induce large areas of chorioretinal atrophy that cause lack of stabilization of the new preferential locus. The best retinal sensitivity and the best reading performance, in terms of ability to read the smallest printed letter at the highest speed of reading, were found in patients subjected to photodynamic therapy (PDT) for choroidal neovascularization (Fig. 1), while the worst results were found in patients with large areas of chorioretinal atrophy and severe macular dystrophy (Fig. 2), presenting a deep and homogeneous reduction of retinal sensitivity. In the first cases, the preferential retinal locus maintained a central location. On the contrary, we found that

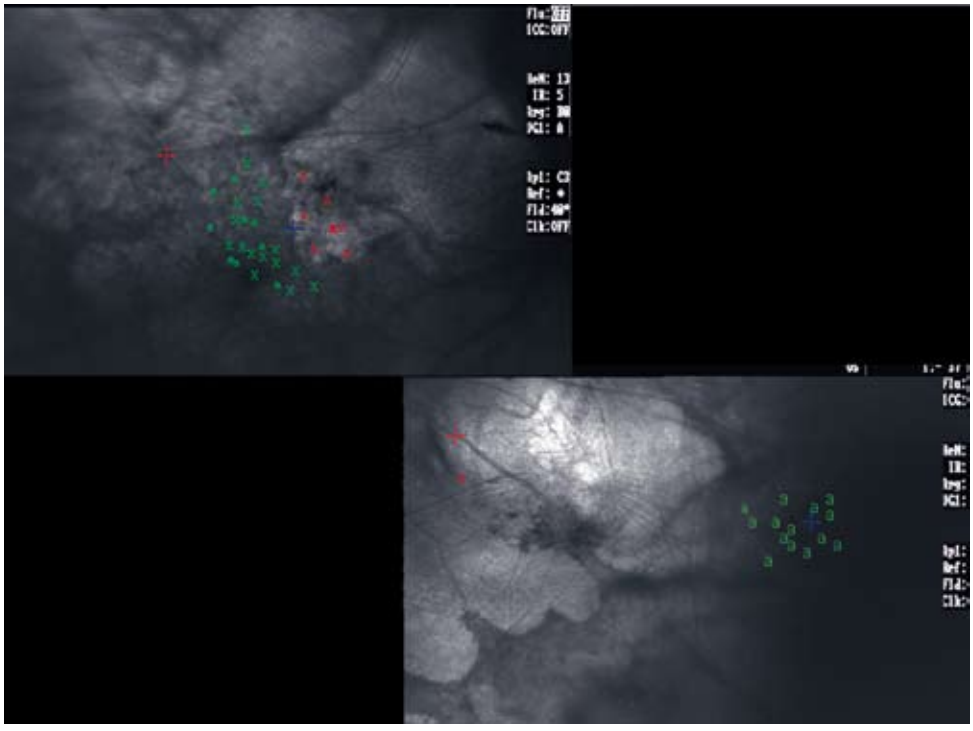

Fig. 1. SLO microperimetry of a patient in which the right eye presented a good retinal sensitivity (choroidal neovascularization treated by photodynamic therapy) and the left eye an absolute scotoma due to a naturally evolved choroidal neovascularization.

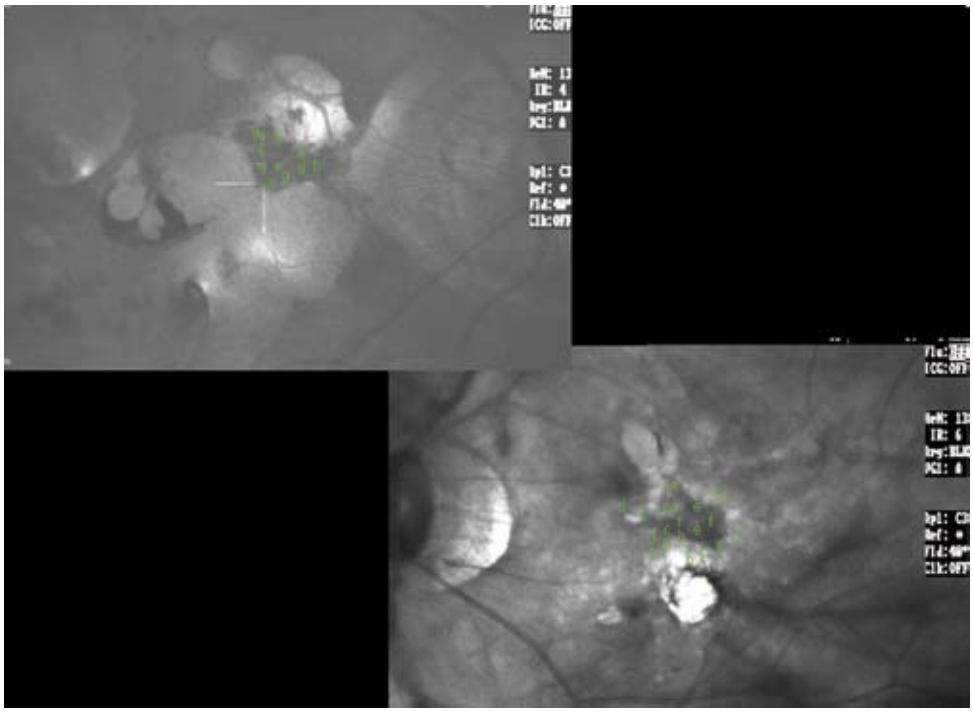

Fig. 2. SLO microperimetry of a patient affected in both eyes by severe myopic macular dystrophy with central relative scotoma.

Table 2.

Ocular features	Eyes
Phakic	20 (40%)
Pseudophakic (IOL in posterior chamber)	18 (36%)
Aphakic	10 (20%)
Radial keratotomy	2 (4%)

in the presence of an absolute scotoma involving the whole macular area, the new preferential locus usually moved to the area characterized by the highest retinal sensitivity, and not necessarily to a superior-temporal area in the right eye and to a superior-nasal area in the left eye, thus differing from what has been previously suggested by other Authors (10-13). However, in these studies observation was limited to selected diseases of the eye, in particular full-thickness macular hole and age-related macular disease, which are essentially different from high myopia.

The type of rehabilitation has been summarized in the Table 3: 20 patients (80%) were rehabilitated with monocular optical devices, such as aplanatic or hypercorrective spherical systems, while five patients (20%) were rehabilitated binocularly, with hypercorrective spherical and/or prismatic systems.

At baseline, between the 20 monocular patients, five (25%) of them - affected by retinal detachment (one patient), retinal detachment with macular hole (one patient), and macular atrophy (three patients) - referred inability to read during the previous 12 months with any kind of optical device or standard glasses. Four patients (20%) - affected by macular atrophy (two patients), retinal detachment with

Table 3.

Type of rehabilitation	Causes of disability / visual loss	Patients
Monocular optical devices (20 patiens: 80%; 20 treated eyes)	Retinal detachment	2 (10%)
	Retinal detachment wit macular hole	3 (15%)
	Macular atrophy	6 (30%)
	Choroidal neovascularization	7 (35%)
	Full-thickness Macular hole	1 (5%)
	Choroidal neovascularization + macular hole in the fellow eye	1 (5%)
Binocular optical devices (5 patiens: 20%; 10 treated eyes)	Bilateral retinal detachment	1 (20%)
	Bilateral choroidal neovascularization	2 (40%)
	Bilateral macular atrophy	1 (20%)
	Choroidal neovascularization + macular dystrophy in the fellow eye	1 (20%)

macular hole (one patient) and choroidal neovascularization (one patient) - had tried to read, but slowly and with poor results, without lenses and bringing the paper nearer. Eight patients (40%) - with retinal detachment (one patient), retinal detachment with macular hole (one patient), macular atrophy (one patient), macular hole (one patient), and choroidal neovascularization (four patients) - had used binocular glasses with a lower correction than for far vision. One patient (5%) with choroidal neovascularization had also used glasses with a lower correction than for far vision, but occluding the worst eye. Two patients (10%), the first one with choroidal neovascularization and the other one with choroidal neovascularization associated with macular hole in the fellow eye, came to our observation referring the use of a Video Display Generator (VDG) Magnifier, even if our final clinical evaluation highlighted that the best reading results were obtained by using a simple aplanatic monocular system.

Five (20%) of the 25 selected patients were subjected to binocular rehabilitation. At baseline, two of them, the first one with bilateral retinal detachment and the other one with bilateral choroidal neovascularization, referred inability to read since more than 12 months. For the other three patients, the causes of visual loss were bilateral macular atrophy, bilateral choroidal neovascularization and choroidal neovascularization associated with macular dystrophy in the fellow eye. At baseline, these three patients referred the ability to read without any correction by bringing the text nearer to the eye.

Between the 20 patients (20 eyes) rehabilitated as monocular, seven of them (35%) had previously used a monocular corrective reading system, while 13 of them (65%) had used a binocular reading system. On the contrary, all five patients (10 eyes) rehabilitated as binocular had also previously used a binocular, although different, corrective system for near vision. In these subjects, the residual binocular visual acuity allowed the use of binocular frontal lenses or contact lenses for far tasks. The intermediate and near distance activities, for example manual jobs, were simply aided by the use of glasses with a positive hypercorrective spherical addition. Although a Galileian system (2x) with a positive spherical addition for a focal distance of 25 cm could be considered a good rehabilitation option, it was refused by all patients.

Finally, it was possible to enhance the visual performance by adding a selective filter to the system in use to reduce dazzling and to maximize contrast. We used a 511 nm and 527 nm filter for indoor and outdoor tasks respectively.

Discussion

The main goal of rehabilitation is learning how to use at best the residual visual function in order to reduce the impact of the disease on the patient's quality of life. The multiple strategies for rehabilitation should be personalized for each subject and many factors may influence the final choice. These factors include individual features, preferences, needs, and other circumstances.

Patients with low vision have many options to maximize their vision. The modification of the environment is often the first choice and includes changes regarding lighting, contrast, distance and size.

The use of optical devices is another different approach. Optical devices are very well integrated into the patient's life if portable, adequate, and usable for many tasks in many settings throughout the day. By evaluating the best optical device for near, intermediate and far vision, it is always necessary to make some psychological considerations. In fact, people affected by low vision may experience their visual impairment in a different way. Each patient has an individual medical and personal history that may influence his perception of low vision such as differences in the onset of the disease, in the temporal evolution of a central scotoma, and, consequently, in the possible development of adaptive mechanisms. Moreover, the personal cultural and socio-economic background of each patient might also be taken into account since it may influence the patient's approach to the rehabilitation process.

In all enrolled patients we found a deep reduction of retinal sensitivity (tested by SLO microperimetry) associated with an absolute scotoma, when chorioretinal atrophy or a full-thickness macular hole were present. Low retinal sensitivity is already documented in highly myopic eyes with chorioretinal dystrophy, as they have a thin retina with a thin choroid and sclera (14). Day vision is impaired in high spatial frequency, whereas night vision with or without central glare is impaired in all frequencies. Electroretinographic (ERG) recordings show a significant decrease in amplitude and prolonged latency in highly myopic eyes compared to controls. However, ERG is reported to be normal in simple myopia with mild fundus changes whereas b-wave amplitude is decreased in degenerative myopia only. No correlation was found between the b-wave amplitude and the degree of myopia (15).

Patients with high myopia are affected by diffuse chorioretinal atrophy and decreased thickness of the ganglion cell layer. These anatomical changes may explain the enhancement of visual activity by adding non optical systems to the prescribed corrective lenses. Filter lenses from yellow to red (511, 522 and 550 nm) cut the dangerous blue radiations of the spectrum, thus reducing light diffusion in the eye, improving contrast and offering a UV-A protection against oxidative photo-stress. In this paper, we used 511 nm and 527 nm filters for indoor and outdoor tasks respectively.

It is interesting to highlight that in our study the worst visual acuity and retinal sensitivity were present in patients with untreated choroidal neovascularization whereas patients with choroidal neovascularization subjected to PDT had a relatively good visual acuity. These data confirm the key role played by PDT in changing the natural history of choroidal neovascularization, in terms of visual acuity and retinal sensitivity, thus reducing the number of totally blind patients and increasing the number of patients affected by low vision who might start a rehabilitation process (16, 17).

The most important goal of rehabilitation is to allow a sufficient reading ability. Our approach to rehabilitation was essentially based on two different kinds of magnification. The first one is very simple and obtained by nearing the object to the eye, through the use of frontal glasses or contact lenses in highly myopic eyes. The second type of approach is an angular magnification obtained by several optical devices which make an object appear closer to the eye, thus spreading its image over a larger portion of the

retina and producing the magnification effect. Focal distance may be a key factor in the success of these devices. In fact, it is a common experience for highly myopic patients to bring papers nearer to the eyes for reading. The nearer is the device to the eye, the larger is the field of view and the smaller is the distortion of the read letters.

Among the available optical devices, we did some experience with microscopes that may be used both monocularly and binocularly. Should a high power be required or convergence and binocular focus not be achieved, we usually prescribed optical devices for a monocular use, aplanatic or hypercorrective spherical, selecting the dominant eye or the eye with the better visual acuity. Particularly, if a patient is aphakic the use of an aplanatic optical device is preferred to a hypercorrective spherical system, but for social activities the best choice would rather be the use of contact lenses with a spherical addition.

For far distance, we should distinguish between two different tasks: mobility and watching without movement. If the visual acuity is higher than 0.1, a binocular vision could still be possible whereas for visual acuity lower than 0.1 we are forced to choose one eye only for using the optical device. This choice is made on several basis: the evaluation of visual acuity, the presence of a relative or an absolute scotoma and the stability of a new preferential retinal locus. For example, we observed that a small absolute scotoma is easier to rehabilitate than a relative but extensive scotoma. Thus, at the end of the rehabilitation process, patients with macular atrophy obtained a better speed of reading compared to patients with diffuse macular dystrophy who had a homogeneous reduction of retinal sensitivity as evaluated by SLO microperimetry.

For social activities and everyday life, the best quality of vision is reached by using contact lenses, which provide both best resolution and minimal aberration in highly myopic eyes, thus offering a good visual field perception.

For different tasks, such as watching television, it is absolutely necessary to take into account the residual visual acuity. Theoretically, if the visual acuity ranges from 0.01 to 0.05, the best choice would be the use of a 7x20 Keplerian telescopic system. 4x12 or 6x18 spot telescopic systems are also available but their use would be restricted to momentary activities, such as looking at a number plate. Practically, all patients prefer to use frontal correction with glasses or, when possible, contact lenses.

As previously reported, the best results in reading and performing daily visual tasks were obtained by maximizing the residual vision in patients with retinal sensitivity higher than 10 dB, whose rehabilitated eye was affected by choroidal neovascularization subjected to PDT, chorioretinal atrophy (if sufficient to stabilize a new retinal locus) and myopic macular dystrophy. We believe that the presence of a well circumscribed area of absolute scotoma with a defined new retinal locus should be considered as a positive predictive factor for the final success of rehabilitation. In fact, it is possible in these cases to prescribe the correct optical system, combining eccentric viewing with the use of magnification devices. These techniques spread the visual image over a larger area of the retina, thereby allowing the patient to reduce his/her visual impairment by using a healthy part of the retina localized around the scotomatous area. Even though peripheral vision does not allow the best image resolution, it may be good enough to improve the patient's visual outcome.

On the contrary, we found that a significant reduction of retinal sensitivity involving the whole macular region does not allow the stabilization of a new preferential retinal locus. In these patients, the anatomic fovea, although characterized by a very low retinal sensitivity, is still in use, thus making the rehabilitation process more difficult and less effective in terms of visual performance, speed of reading and reading comprehension. This condition is typically observed in some retinal diseases, such as, in order of frequency, highly myopic macular dystrophy, extensive retinal detachment and vitreoretinal schisis of the posterior pole. In our patients, we observed the first two pathologies as main causes of permanent low vision.

Finally, some considerations, with important social and economic outcomes, must be made. Remembering that the main goal of rehabilitation, established together with our patients during the first examination, was to reach good abilities in reading, we observed a significant lack of correspondence between the corrections for near distance used by patients at baseline and the final prescribed optical devices. Indeed, the corrective system for near vision previously used by patients was generally never confirmed by us. Among the group of 20 patients rehabilitated as monocular, only 35% had used a monocular system, although ineffective, while 65% came to our observation with a binocular spherical correction, which caused confusion and did not succeed in allowing a good reading performance. Two patients, one with choroidal neovascularization alone and the other one with choroidal neovascularization associated with macular hole in the same eye, came to our observation at baseline with a VDG Magnifier, even if the clinical evaluation revealed that the best reading results were obtained by using a simple binocular hypercorrective system. The analysis of devices previously dispensed for far vision gave less important results: the use of glasses or contact lenses was confirmed or only slightly modified. This observation highlights the need for a greater attention in evaluating visual acuity and the possible corrective devices for patients with low vision. It is also important to consider economic factors, especially the possibility to obtain the best visual performance with the cheapest solution. For example, a VDG Magnifier is almost four times more expensive than a hypercorrective or aplanatic system, which represent, when applicable, more practical and cheaper choices for social activities.

In conclusion, it is possible to aid patients affected by low vision much more than might appear at a glance. A more careful evaluation of visual acuity, retinal sensitivity and preferential fixation locus on the macular area is necessary in order to prescribe the best optical devices to patients with low vision, thus reducing the impact of the disability on their daily life, with evident social and economical benefits (18-21).

References

1. Fledelius HC. Myopia and significant visual impairment; Global aspects. In: LL-K Lin, YF Shih, PT Hung (Eds). Myopia Updates II, Hong Kong: Springer 2000; 31-7

2. Shih YF, Ho TC, Hsiao CK, et al. Visual outcomes for high myopic patients with or without myopic maculopathy: a 10 year follow up study. Br J Ophthalmol 2006; 90:546-50
3. Curtin BJ. The myopias. Basic science and clinical management. In Curtin BJ (ed). The myopias. New York: HarperCollins 1985; 247-69
4. Tokoro T. Atlas of posterior fundus changes in pathologic myopia. Tokio: Springer 1998; 23-63
5. Fledelius HC. Refraction and eye size in the elderly. A review based on literature, including own results. Acta Ophthalmol 1988; 66:241-8
6. Giusti C. Novel diagnostic and therapeutic approaches to the diabetic retinopathy. Eur Rev Med Pharmacol Sci 2001; 5:155-66
7. Albert DM, Jakobiec FA. Principles and practice of ophthalmology: clinical practice. Philadelphia: Saunders 1994; 2:1036
8. Thylefors B, Negrel AD, Pararajasegaram R, et al. Global data on blindness. Bull World Health Organ 1995; 73(1)2:115-21
9. Corn AL, Koenig AJ. Foundations of low vision: clinical and fuctional perspectives. New York, AFB Press 2000; 3:43-52
10. Guez JE. Is there a systematic location for the pseudofovea in patients with central scotoma? Vision Res 1993; 33(9):1371-9
11. Timberlake GT, Mainster MA, Peli E, et al. Reading with a macular scotoma. Retinal location of scotoma and fixation area. Invest Ophthalmol Vis Sci 1986; 27(7):1137-47
12. Timberlake GT, Peli E, Essock EA, et al. Reading with a macular scotoma. Retinal locus for scanning text. Invest Ophthalmol Vis Sci 1987; 28(8):1268-74
13. Acosta F, Lashkari K, Reynaud X, et al. Characterization of functional changes in macular holes and cysts. Ophthalmology 1991; 98(12):1820-3
14. Nagaoka N. In: Tokoro T, (Ed.), Myopia Updates: Proceedings of the 6th International Conference on Myopia Tokyo: Springer 1998; 394-8
15. Chen PC, Woung LC, Yang CF, et al. Changes in the modulation and critical flicker frequency in high myopia patients. Myopia Updates II, Tokyo: Springer 2000; 81-2
16. Tholen AM, Bernasconi PP, Fierz AB, et al. Reading ability after photodynamic therapy (PDT) for age-related macular degeneration (AMD) and for high myopia. Ophthalmol 2003; 100(1):28-32
17. Montero JA, Ruiz-Moreno JM. Verteporfin photodynamic therapy in highly myopic subfoveal choroidal neovascularization. Br J Ophthalmol 2003; 87(2):173-6
18. Rohrschneider K, Kiel R, Pavlovska V, et al Satisfaction with low vision aids. Klin Monatsbl Augenheilkd 2002; 219(7):507-11
19. Rinnert T, Lindner H, Behrens-Baumann W. At home utilization of low-vision aids by the visually impaired. Klin Monatsbl Augenheilkd 1999; 215(5):305-10
20. Rohrschneider K, Bruder I, Blankenagel A. Ophthalmological rehabilitation - experience at the University Eye Hospital Heidelberg. Ophthalmol 1999; 96(9):611-6
21. Scott IU, Smiddy WE, Schiffman J, et al. Quality of life of low-vision patients and the impact of low-vision services. Am J Ophthalmol 1999; 128(1):54-62