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Contact lens field examiner

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Low vision aids have not been successfully prescribed for many patients with peripheral visual field loss. In this experiment, visual field and visual acuity measurements for eighteen subjects with artificially restricted fields were made with and without two contact lens field expanders. The calculated visual efficiency was significantly improved with these devices which led the experimenters to believe that the potential of this device is very good for being a useful low vision aid.

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CONTACT LENS FIELD EXPANDER

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John Krebsbach, O.D.

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Contact Lens Field Expander

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Low vision aids have not been successfully prescribed for many patients with peripheral visual field loss. In this experiment, visual field and visual acuity measurements for eighteen subjects with artificially restricted fields were made with and without two contact lens field expanders. The calculated visual efficiency was significantly improved with these devices which led the experimenters to believe that the potential of this device is very good for being a useful low vision aid.

Key Words: Reversed telescope, visual field expander, visual efficiency, constricted fields, low vision, contact lens field expander.

CONTENTS

INTRODUCTION AND LITERATURE REVIEW

Traditionally, most optical low vision aids have been magnifiers which are useful to patients with decreased visual acuity. For patients with peripheral field loss, such as those afflicted with retinitis pigmentosa, image magnifiers are of little value and, in fact, are a detriment since they further decrease the size of the patient's field of view.

The loss of peripheral vision is a severe handicap even when good central visual acuity remains intact. For example, the normal observer with a 150 degree field can see 36% of his surroundings per fixation, whereas a patient with a 20 degree field sees only .75% of his surroundings per fixation.[2] Patients have problems recognizing others,[1] moving about without collisions,[1,2,3,4,5] eating because they can't see the whole plate at once,[1] and even reading because they can't see whole words in one fixation;[3] the list goes on. This handicap has been recognized in legal definitions of blindness as well as by Spaeth[6] who developed a system to estimate the loss of visual efficiency. In this system, best corrected visual acuity, visual fields, ocular motility and binocular vision are all factors in determining visual efficiency.

In the past 15 years many attempts have been made to reduce the handicap which peripheral field constrictions impose on patients with retinitis pigmentosa. One of the most promising concepts is that of using a Galilean telescope in reverse, which is called a field expander. This optical system forms a minified image and has an increased field of view relative to looking through an aperture of equal size with magnification equal to or greater than one. Theoretically, the effect of this system on a patient with contracted peripheral fields should be to increase the field of view by a factor equal to the reciprocal of its magnification.[2] However, the visual acuity through such a device should be decreased by a factor equal to its magnification. The systems effect on accomodative demand and depth of focus should allow objects to be viewed at very short distances utilizing relative distance magnification in certain situations.[2] Some investigators have found that the overall effect of such a system on visual efficiency is negligible[7] while others feel it should improve.[5] Clinical trials with these field expanders seem to contradict one another as to the optimum magnification.[1,2,3,4] However, much of the discrepancy may be due to the type of system employed (hand held, headborne, full field, bioptic, etc.) and on patient selection.

Cosmesis is a major drawback for all of the systems tried except the reversed contact lens telescope (contact lens field expander) and many patients have refused to use field expanders for this reason.[2,3,4,5] In addition to improved cosmesis, the contact lens field expander has the advantage of an increased field of view relative to other field expanders due to its proximity to the eye's nodal point. The contact lens field expander should have a field of view which is 30% to 50% larger than that of a hand held model for a given magnification.[1] When compared to field expanders mounted on spectacles, the contact lens field expander is much lighter than reversed full field telescopes. One patient found wearing the reversed full field telescopes extremely helpful but had to limit wearing time to four hours a day due to the weight.[1] Bioptic field expanders worn binocularly would decrease this weight in addition to allowing "normal" visual acuity when not looking through the field expander. However, alignment of the bioptic system was critical and patients found it necessary to use a head band to keep the system in line[3] which decreased its aesthetic value and therefore its chance of acceptance.

The contact lens field expander is certainly not without limitations. First of all, the patient must be able to wear and handle contact lenses. Second, the device cannot be rapidly removed if better visual acuity is desired. Perhaps a hand-held spotting telescope would solve this problem for some patients. Another possible solution which has worked well in at lease one case is to fit the field expander monocularly and have the patient alternately suppress one eye depending on the task.[8] But this would eliminate stereo depth perception which can be achieved when the device is fitted binocularly[3] and also decreases the expanded field of view. Third, the contact lens field expander has a limited range of field expansion which is much less than the optimum proposed by Drasdo.[2] This limitation may not be as severe as some suggest. One study found that patients with a very limited field of view got an increased field of view much greater than would be theoretically predicted for a given magnification and referred to this occurrence as anomalous magnification.[5] Also, because the retinitis pigmentosa patient has had to make repeated adjustments to his decreasing field of view, it is not necessary to expand the field to a full 150 degrees. The patient may be quite pleased if his field can be restored to its size a few years previous.[5]

The purpose of our study is to determine the usefulness of the contact lens field expander for patients with severely constricted visual fields and reasonably good central visual acuity. Our study will determine the effect of a high and low power contact lens field expander on "normal" subjects. Visual acuity will be measured at 6 meters with and without the aid using a projected chart of Snellen letters and standard room illumination. Visual acuity will also be measured at 40 cm using a standard Snellen near point card in standard room illumination with and without the aid. Monocular visual fields will be measured by arc perimetry in 8 meridians with and without the contact lens field expander. From the visual acuity and visual field measurements the visual efficiency[6] will be determined for each subject and magnification. Tasks such as walking around obstacles, climbing stairs and picking up small objects will be attempted with the contact lens field expander in place. Testing will conclude by having normal subjects report their subjective feelings about the contact lens field expander after a brief period of adaptation.

METHODS

Subjects

All of the subjects participating in this study were third and fourth year optometry students between 22 and 31 years of age. The refractive error of their right eyes ranged from +1.25 D to -6.00 D equivalent sphere while astigmatic errors ranged from 0.0 D to -2.50 D X008. Their right eyes' best corrected visual acuity at near and far was 20/20 or better and no one was aware of any defect in their visual field.

Materials

Two contact lens field expanders were used in this study. A low power system employing a +22 D contact lens with a -25 D spectacle lens and a high power system using a +30 D contact lens with a -38 D spectacle lens. Both contact lenses were American Hydron polymacon, with an overall diameter of 15 mm. Each lens was lenticular with a 6 mm optic zone. The base curves of the +22 D and +30 D lenses were 9.6 mm and 9.3 mm respectively. The spectacle lenses were designed and manufactured by a local optical lab and were made of CR-39 to avoid excessive weight. See Table 1 for spectacle lens specifications.

Table 1

Lens Power	Mass	Center Thickness	Edge Thickness	Base Curve	Back Curve
-25 D	14.8 gm	2.24 mm	14 mm	-6.00 D	-19.05 D
-38 D	18.9 gm	2.11 mm	17 mm	-12.00 D	-26.20 D

Each lens was edged to fit into a 46/22 Yeoman frame which was used because of its strength and versatility.

A Selsi 2.2 x expandable field telescope was used as a spotting scope over the contact lens field expanders.

Procedures

Each subject's left eye was patched for the duration of testing except during the biocular comparison phase.

Visual acuity measurements were taken at 6 M, at 40 cm, and at "near" through the subject's habitual correction, through each field expander, and through the spotting scope over the field expanders. Distance visual acuity measurements were taken using a standard Snellen chart projected onto a screen 6 M from the subject. All visual acuity measurements at 40 cm and at "near" were taken using a standard Snellen near point card with a 60 watt incandescent bulb combined with a 20 watt circular fluorescent tube above and behind the subject at the same distance from the reading material for each subject. All "near" visual acuity measurements were taken allowing the subject to vary the chart distance until the best acuity was attained. When acuities were taken through a field expander, the patient was asked to vary the vertex distance of the spectacle lens until the best visual acuity was attained. This was done to compensate for variations in refractive error and facial structures. Correction of astigmatism of 1.50 D or more was attempted using trial lenses, however, no improvement in visual acuity was noted.

Kinetic visual fields were plotted using a Bausch and Lomb projection perimeter with a working distance of 33 cm and a 3 mm white circle of light as a target. Subjects were instructed to hold their heads stationary and to maintain central fixation while measurments were made in eight meridians. The background illumination was seven footcandles or more and subject response consistency was checked by repeating measurements in at least two meridians on each plot. These fields were taken once through each field expander and through an aperture. The aperture was formed by placing an 8 mm wide strip of flexible plastic around the inside circumference of the eyewire. It extended 4 mm in front of the eyewire as did the lenses. Therefore, the edges of both lenses and the aperture represent equal visual field restrictions and the difference between any of the field measurements for a given subject should be of optical rather than mechanical origin.

In an effort to obtain an indirect measurement of the increase in visual field caused by the field expanders, a biocular comparison of image size formed by the unaided left eye and the right eye with the field expander was performed by each subject. If the estimation were accurate, the inverse of the magnification of the image formed by the right eye relative to the image formed by the left eye should be equal to the increase in visual field caused by the field expander. The projected Snellen chart at 6 M made a convenient target for these comparisons.

Each subject was warned that items seen through the field expander would seem farther away than they really were. After each subject had worn the field expander for at least ten minutes and had walked at least forty feet through two open doorways, they were asked to walk through a maze of stools and tables and to go up and down a flight of stairs. This procedure was performed using both field expander systems in an attempt to determine their effect on the subject's ability to move around after a short adaptation period. The experimenters observed this activity and rated each subject's performance using the following scale:

1. unable to perform
2. performed, but very slowly with excessive tactile aid
3. performed, but very slowly with occasional extra tactile aid
4. performed, but slowly with no extra tactile aid
5. performed at a normal speed with no extra tactile aid

Hand-eye coordination was rated on this scale also. Subjects were asked to remove numerous small objects from a table top and from the experimenter's hand at varying distances.

After both field expanders had been worn for a total of 30 to 45 minutes by each subject, they were asked to briefly answer each of the following questions: (Subject's answers summarized in Table 2.)

1. Did you experience dizziness or an upset stomach at any time while wearing the field expander or after removing it?
2. How long did it take to get used to your vision through the field expander, e.g. how long before your vision became functional?
3. In your opinion, how much did the field expander increase your field of view relative to your habitual prescription?
4. Was the decrease in visual acuity through the field expander a serious handicap?
5. Was the spotting telescope helpful for viewing distant objects?

Table 2

Summary of Subjects' Answers to Questions 1-5

Subject	Q1	Q2	Q3	Q4	Q5
1	no	5 min	20%	no	no
2	no	5 min	30%	no	yes
3	yes	<5 min	0	no	yes
4	yes	<5 min	10%	LP no HP yes	yes
5	no	<5 min	20-25%	no	yes
6	yes	1 day	increase but can't quantify	no	yes
7	yes	5 min	0	no	no
8	yes	10-15 min	0	no	yes
9	yes	15-20 min	25-33%	no	no
10	no	15 min	20%	no	yes
11	yes	not sure	30%	no	yes
12	yes	<5 min	12-25%	no	yes
13	yes	LP <5 min HP --?	LP .66-.75 HP .5-.66	LP no HP yes	yes
14	no	10-15 min	0	no	yes
15	no	<15 min	15-20%	no	yes
16	no	10 min	0	LP no HP yes	yes
17	yes	<15 min	0	no	yes
18	no	5-10 min	50%	no	yes

LP = Low Power

HP = High Power

The visual acuity and visual field measurements for each subject were used to calculate a visual efficiency score at near and far by the method proposed by Spaeth[6]. In this method the product of the percent visual acuity, visual field, ocular motility and binocularity is equal to the visual efficiency. However, in this study, binocularity was not a factor and no one had any restrictions in gaze. Therefore, these two components of the calculation were eliminated, leaving only visual acuity and visual fields as variables as has been done in earlier studies[7].

Results

The visual field and visual acuity measurements as well as the visual efficiency scores for each subject are listed in Table 3.

The t statistic was used to determine the significance of average values compared in this study and discussed below. (See Table 4.)

Both field expanders were found to increase the field of view relative to the aperture to a significance level of 0.1%. However, the difference between the visual field with the low power field expander and the high power field expander was found to be insignificant even at a 10% level. But if data from the biocular comparison (see Table 5) is used rather than actual field measurements, the visual field formed by the high power system is greater than that formed by the low power system at a significance level of 1.0%

Differences between visual acuity values at near and far comparing the low and high power systems were found to be insignificant at a 10% level of confidence. Both field expanders did significantly decrease the

Table 3

	Low Power					High Power				
Subjects	VF	VA_d	VA_n	VE_d	VE_n	VF	VA_d	VA_n	VE_d	VE_n
1	147	100	100	147	147	141	95	100	134	141
2	135	95	89	128	120	130	100	100	130	130
3	117	89	100	104	117	109	89	100	97	109
4	112	100	100	112	112	125	95	100	119	125
5	111	95	100	105	111	114	95	100	108	114
6	131	100	100	137	137	122	100	100	122	122
7	119	89	100	106	119	128	100	100	128	128
8	111	89	100	99	111	112	95	100	106	112
9	131	89	100	117	131	135	95	100	128	135
10	129	100	100	129	129	132	75	100	99	132
11	130	85	100	111	130	129	89	100	115	129
12	136	89	100	121	136	131	89	100	117	131
13	133	100	100	133	133	139	64	100	89	139
14	137	89	100	122	137	131	95	100	124	131
15	126	75	100	95	126	117	85	100	99	117
16	113	100	100	133	133	108	95	100	103	108
17	111	95	100	105	111	115	100	100	115	115
18	128	95	100	122	128	115	100	100	115	115

VF = Visual Field %

VA_d = Visual Acuity % at 6 M

VA_n = Visual Acuity % at near

VE_d = Visual Efficiency % at 6 M

VE_n = Visual Efficiency % at near

Ave = Average

SD = Standard Deviation

Table 4

Finding	t	Confidence Level
Visual Field		
LP > HP	0.645	>10.0
LP > Ap	15.358	0.1%
HP > Ap	9.243	0.1%
Biocular comparison magnification^{-1}		
HP > LP	3.151	1.0%
LP > Ap	10.037	0.1%
HP > Ap	8.411	0.1%
Visual acuity at near		
LP > HP	0.451	>10.0%
Ap > LP	0.451	>10.0%
AP > HP	0	>10.0%
Visual acuity at distance		
LP > HP	0.132	>10.0%
Ap > LP	4.346	0.1%
Ap > HP	17.900	0.1%
Visual efficiency at near		
LP > HP	0.290	>10.0%
LP > Ap	11.037	0.1%
HP > Ap	9.243	0.1%
Visual efficiency at distance		
LP > HP	0.269	>10.0%
LP > Ap	5.138	0.1%
HP > Ap	5.586	0.1%

The degree of freedom is 34 in all cases.

LP = Low power field expander

HP = High power field expander

Ap = Aperture

Table 5

Magnification by Biocular Comparison

Subject	Magnification Low Power	Magnification High Power	Calculated Visual Field Low Power	Calculated Visual Field High Power
1	.75	.67	1.33	1.49
2	.67	.60	1.49	1.67
3	.70	.65	1.43	1.54
4	.75	.60	1.33	1.67
5	.70	.50	1.43	2.00
6	.75	.75	1.33	1.33
7	.75	.75	1.33	1.33
8	.82	.70	1.22	1.43
9	.67	.50	1.49	2.00
10	.75	.63	1.33	1.59
11	.75	.67	1.33	1.49
12	.75	.58	1.33	1.72
13	.75	.53	1.33	1.89
14	.67	.67	1.49	1.49
15	.80	.80	1.25	1.25
16	.50	.40	2.00	2.50
17	.75	.75	1.33	1.33
18	.70	.50	1.43	2.00
Ave.	.72	.63	1.40	1.65
SD	.07	.11	0.169	0.322

visual acuity at distance relative to that obtained when the habitual correction was worn.

Visual efficiency scores were increased by both field expanders at near and far relative to those obtained when the aperture was worn. For near and distance visual efficiency scores, the low and high power systems did not differ significantly, even at a 10% level of confidence. For both the high and low power systems, the visual efficiency score at near was significantly greater than at far at the 1% confidence level.

DISCUSSION

With proper patient selection, contact lens fit and careful dispensing, the contact lens field expander should be a useful aid to patients with restricted visual fields.

The contact lens field expander (CLFE) has both cosmetic and functional advantages over most other field expanders because of decreased weight, increased visual efficiency and better cosmesis. Like other field expanders, the CLFE also reduces the accommodative demand for near work, thus making near tasks easier. Since the vertex distance can be varied, presbyopes can slide the spectacles slightly down their nose and be focused without the aid of a reading cap or multifocal system.

Among its many uses for tunnel vision patients are: Helping the patient to see his full dinner plate, the entire TV screen, or to recognize people around him and avoid collisions while walking. The possibility exists that this device (in low power) could enable a person who is about to lose his driver's license (due to restricted fields) to attain the required visual field necessary to retain his license to drive.

In spite of its cosmetic appeal and functional qualities, the CLFE is not without a few problems of its own. Since the vertex distance of the glasses can be changed, the adjustment of the frame is crucial to the success of this aid in producing clear vision. We recommend that a frame with a wide bridge and adjustable nose pads be used. Also, the temples should be long enough to hold the spectacles securely in place. A small eye size is needed because of the high minus power and a thick plastic eyewire would be helpful in hiding the edge thickness of the lenses. Edge coat and antireflection coating would help reduce annoying reflections. Distortions might be lessened if an aspheric lens design were used. If the edge thickness was reduced considerably by cutting off the back "rim" of the lens, the patient would not have a sharp rim to contend with, the lens would not fog as easily from evaporation of tears, the weight would be decreased and the cosmetic appeal increased.

Besides the critical vertex distance, another disadvantage of the CLFE arises from the use of contact lenses in the system. Although this does allow "scanning" the objective, it also means that the patient cannot readily remove and replace the entire device, thus it becomes a "full time" field expander. However, if better visual acuity is required at any time, a spotting telescope works very well in conjunction with this system. Most of our subjects said the telescope was helpful to them but a few subjects noted that their acuity through the CLFE was already 20/20 (far and near) and felt no need of the telescope.

The earlier disadvantage of critical vertex distance and frame adjustment is complicated if a binocular system is employed. This requires precise fitting especially in regard to PD and leveling the lenses to avoid vertical prismatic problems. Contact lens centering may also cause problems with prismatic effect.

Proper patient selection is imperative to success with the CLFE. The patient must be able to wear and maintain contact lenses. He must have relatively good visual acuity since the CLFE minifies objects and, therefore, reduces acuity. He must also have the need to increase his field and be motivated by this need to adapt to this system. Adaptation problems were minimal with our subjects and ranged from no problem at all to slight dizziness and nausea with depth perception problems for a short time. Most subjects responded that they could functionally adapt to this device within 20 minutes of wear. All subjects agreed that one day would be sufficient in their estimation to adapt. All subjects were rated in maze walking and hand-eye tasks between 2 and 4 on our scale with the majority scoring a 3.

Looking at clinical data gathered on visual acuity and perimetry, it soon becomes apparent that the data varies widely from one subject to another. Some possible reasons for this variance may include: The subject's refractive error supplemented the contact lens power which altered the magnification and vertex distance of the system which in turn affects acuity and fields. Uncorrected astigmatism may have influenced our acuity measurements as well. The contact lens did not fit many subjects and caused some problems getting stable acuity and the spectacle lens tended to fog being so close to the eye. This fogging from evaporation of tears caused decreased acuity. Steadily fixating eyes vs. moving eyes may have affected perimetry measurements. Any one or combination of these conditions can cause variances in the measurements. By carefully fitting this system to the individual needs of each patient and correcting these problems as much as possible, the resulting visual efficiency would probably be even higher than our values since we used a "one lens fits all" approach.

Our data on biocular comparison of magnification suggests a greater than linear increase in field. Drasdo refers to the increase of field which is greater than the calculated or theoretical increase as being due to anomalous magnification[5]. In calculating field increases we had an 11%

field increase due to anomalous magnification with the low power system when the subjects gave a biocular estimate of magnification looking through the central portion of the spectacle lens. However, we also calculated a 4% "anomalous" decrease in fields by perimetry. This may be due to the subjects' errors in estimating magnification differences especially in the case where the left eye was not corrected and the blurry image seemed larger than it really was. It may also be that the field increase is better in the central portion of the lens than in the far periphery where prismatic effect and distortion are worse. If the latter is true, then retinitis pigmentosa patients would probably have a greater increase in their field (central lens area only) than our subjects did in the periphery by perimetric measurement.

In looking at total visual efficiency, we found that even if we used the "lower" perimetric field increases (rather than the biocular estimate) we found a definite increase in visual efficiency in all subjects wearing the CLFE. The average was 17% increased efficiency at distance and 25% at near using the low power system. Krefman mentions that the four field expanders he tried failed to increase visual efficiency and he therefore questioned their usefulness[7]. Could it be that the CLFE is more useful than many other field expanders? With proper patient selection and careful fitting we feel the CLFE is a very useful low vision aid that practitioners should consider for their patients with severely restricted visual fields.

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