THE EFFECT OF THE ECHELON BIFOCAL CONTACT LENS ON CONTRAST SENSATIVITY AND BRIGHTNESS ACUITY TESTING

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ABSTRACT

Contrast sensativity and Brightness Acuity testing measurements with Hydron's Echelon Bifocal contact lens and Hydron's spherical non-bifocal contact lens were compared to learn the effect of the diffraction bifocal on contrast sensativity and glare. Six frequencies of sinusoidal gratings were generated with the Optronix Series 200 Vision Tester, a microcomputer based test. Fifteen non-presbyopic subjects were tested for distance contrast sensativity and acuity.

KEYWORDS

contrast sensativity function, Echelon diffraction bifocal, Optronix Series 200 Vision Tester, Brightness Acuity Tester

INTRODUCTION:

The search for an effective bifocal contact lens has led to the introduction of Hydron's Echelon lens, a hydrophilic bifocal lens which uses a diffractive design for simultaneous vision of distance and near images. Diffraction of light responsible for the near image is accomplished by cutting annular grooves (echelletes) on the inner suface of the lens. When filled in by tears, this provides the difference in index necessary for the diffractive phase plate design. Inherent in this design is a loss of light intensity due to its distribution into the various orders of diffraction. The non-alternating profile of grooves concentrates the light equally into the zero order and the first order with each receiving 40% of the incident light. The remaining 20% is lost to higher orders of diffraction which is not useful for vision. The zero order, or undiffracted light, is refracted as with conventional contact lenses to form the distance image. The first order of diffraction represents the near image. Therefore, even in the best case, only 40% of the incident light goes into making each image. The purpose of this study is to determine if there is a loss of contrast sensitivity with this lens, and if so, the spatial frequency most affected. This information would be helpful in determining the viability of the lens.

METHODS:

Set-up:

Contrast sensitivity thresholds were measured using the Optronix Series 200 Vision Tester. The instrument was calibrated for a light intensity of 10 fc. A testing distance of 2.2m was used. A vertical grating of frequencies .5, 1.0, 3.0, 6.0, 11.4, and 22.8 cycles per degree were randomly presented with four trials for each frequency. The method of subject adjustment was used to determine the threshold for each frequency.

Hydron Echelon lenses of distance powers +1.00, +3.00, -1.00 and -3.00 with add powers of +2.00 were used. The Echelon parameters were diameter 13.8mm, base curve 8.7, 38% water and 62% polymacon. Control measurements were made using Hydron's single vision polymacon 38% water lenses of the same parameters and distance powers but without the difractive bifocal.

Subjects:

Twenty non-presbyopic eyes were tested for distance contrast sensitivity. Subject ages ranged from 24-32 years. No subjects had pathology which could have influenced contrast sensitivity functions. Refractive errors ranged from -4.25 to +0.75 with 12 of the 20 eyes requiring cylindrical corrections. Subjects were instructed to view each new frequency on maximum contrast to give them an idea of the target size. After returning the contrast to zero, subjects were asked to alter fixation to eliminate any after images. Then, while viewing the screen, subjects were instructed to slowly increase the contrast to where the grating is first detected. The average of four trials for each frequencty was recorded. Subjects were not informed as to which lens they were wearing, although some were able to correctly identify the lenses on their own.

Procedure:

The lens power closest to the subjects refractive error was inserted and ample time was given to adjust to the lens. The order of presentation of bifocal lens versus single vision lens was randomized. An over refraction was performed with the lenses worn in a trial frame. Visual acuity was measured using a tumbling E chart. Monocular contrast sensitivity threshold readings were made. When both eyes were being tested the subjects often had the bifocal on one eye and the control lens on the other. After running through the frequency settings, the lenses were switched and the settings run through again so each eye had control measurements and bifocal measurements. This required the subject to make a total of 96 settings which caused fatigue resulting in some variability.

Modifications:

Modifications were make to reduce subject fatigue. These included narrowing the range of frequencies studied to the highest three of 6.0, 11.4, and 22.8 cycles per degree since these frequencies appeared to be most affected. Only one eye per subject was used. Light intensity was decreased to no ambient room illumination with subsequent recalibration of instruments due to some problems of glare reported by subjects. For this reason, the affect of glare was also tested using the Brightness Acuity Tester by Mentor. This device consists of a hand held illuminated bowl with a hole to look through to measure the effect of glare on visual acuity. In addition to the Optronix Series 200 Vision Tester, contrast sensitivity was also measured using the Vistec wall chart.

RESULTS:

Raw Data:

Table of contrast sensitivity measurements for various frequencies. Control measurements are presented in parenthesis for comparison. A higher control measurement indicates a loss of sensitivity with the bifocal lens.

Initial Data:

0.5	1.0	3.0	6.0	11.4	22.8
31(94)	62(66)	20(195)	133(161)	87(159)	26(60)
55(52)	101(120)	35(219)	155(227)	115(131)	31(87)
67(32)	96(108)	322(221)	227(237)	127(207)	41(38)
53(28)	109(65)	314(200)	185(223)	124(130)	19(33)
52(65)	134(92)	191(198)	138(263)	118(137)	25(43)
90(50)	49(77)	230(194)	200(142)	109(144)	42(26)
73(97)	174(228)	177(293)	108(277)	122(275)	27(84)
120(63)	126(120)	207(153)	285(254)	146(150)	46(48)
77(59)	121(118)	219(284)	227(380)	159(165)	66(57)
74(66)	109(174)	266(309)	224(288)	89(300)	45(67)
86(83)	138(145)	193(237)	124(230)	41(105)	35(55)
33(64)	55(85)	110(309)	131(220)	75(172)	26(49)
69(40)	127(57)	201(181)	197(165)	105(144)	34(71)

Modified Procedure Data:

6.0	11.4	22.8
579(832)	367(432)	72(88)
343(465)	429(627)	196(198)
513(1035)	290(357)	100(137)
232(284)	233(146)	75(143)
572(624)	394(287)	60(74)
613(937)	316(966)	53(140)

Contrast sensitivity functions both with the Echelon and the control lens were normally shaped bell curves peaking at the medium frequencies of 3.0 or 6.0 cycles per degree for all subjects. There was a slight reduction in sensitivity for higher frequencies with the bifocal, however measurements still fell well within the normal range for the subjects studied. Using data gathered from the initial procedure, only four of the thirteen eyes tested showed a loss of sensitivity with the bifocal for the lowest frequency of .5 cycles per degree. Seven showed a loss with both 1.0 and 3.0 cycles per degree. Ten of the thirteen lost sensitivity with the bifocal using 6.0 cycles per degree as the target. All subjects lost sensitivity for 11.4

cycles per degree through the bifocal and for the highest frequency of 22.8, ten lost sensitivity.

Visual acuity was subjectively decreased with the bifocal for most subjects. When measured, however, eight of the thirteen showed no or minimal loss of one letter on the acuity chart. Of the remaining five subjects, one lost two letters, another lost three, and one subject lost four letters, while one subject (two eyes) lost one complete line of acuity. Six eyes were tested using the modified procedure. All six showed a loss of contrast sensitivity with the bifocal for both 6.0 and 22.8 cycles per degree. Four showed a loss at 11.4 cycles per degree. Acuity was the same or one letter less with four eyes while two lost a complete line.

Contrast sensativity measured by the wall chart for the lower frequency (target A) resulted in four subjects losing some ability to correctly identify grating orientation with the bifocal. Medium frequency or grating widths (targets B,C andD) were only decreased with one subject each while wearing the bifocal. The highest frequency or smallest grating was decreased in two of the subjects.

Glare testing with the bifocal versus testing with the control lens resulted in an additional loss of acuity for all subjects. Three subjects lost one more line of acuity with the bifocal. Two subjects lost two additional lines and one subject lost four lines more than testing without the bifocal.

DISCUSSION:

Although the bifocal lens does appear to cause a slight reduction in contrast sensitivity, especially with higher frequencies, the measured sensitivities remained well within normal range for the subjects studied. It is possible that when used by a population who already have some loss of contrast sensitivity (ie. from cataractous changes), this lens may cause an additional drop in sensitivity to a level outside normal ranges.

The slight reduction in measured visual acuity could be related to the decrease in high frequency sensitivity. However, again, this leaves the normal subject in the range of 20/20 to 20/20- which would probably be an acceptable compromise for most patients.

The most significant finding of this study is the loss af acuity with glare testing. One would suspect that the 20% of incident light lost to higher orders of diffraction is scattered similar to the way a cataract scatters light producing a veiling luminance and degraded image resulting the the loss of acuity. Whether this would by tolerable to patients is an individual question.

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