AGE RELATED MACULAR DEGENERATION: A LOOK AT PERIPHERAL VISUAL FUNCTION

MARY JO HORN
SENIOR RESEARCH PROJECT
DR. C.A. UNIACKE, ADVISOR

Abstract

Peripheral visual function was measured on twenty-five normal, non-presbyopic patients (ranging in age from fourteen to forty-three) using a perimeter arc and Snellen acuity letters. The results from this testing were then compared to similar peripheral testing of five age-related macular degeneration (ARMD) patients in an attempt to assess peripheral visual function capabilities in this population. Peripheral function was reduced in both sensitivity and field size in the ARMD patients. However, a cause and effect relationship could not be drawn due to many variables and the need for further testing.

Introduction

One out of every eight United States citizens is over the age of sixty-five. The current growth rate in this age group is twice that of the general population.[1] The leading cause of blindness in the United States in people over the age of sixty years old is age-related macular degeneration.[2] This condition affects the central retina and therefore causes a decrease in central retinal function. Thus, peripheral visual function becomes an increasingly important issue for eye care providers of today.

Peripheral visual acuity has been measured quantitatively by numerous investigators for over one hundred years and had been studied for many years prior to these investigations. Many variables come into play with peripheral visual function and with its testing. It is difficult to compare the results of different studies directly because of differences in stimulus characteristics and technique variations.[3] Thus, despite the increasing importance of peripheral visual function and the numerous studies that have been performed, there is an apparent paucity of concrete evidence about functional peripheral vision.[4]

The center of the fovea is the only retinal area to allow maximum visual acuity.[5] All investigators agree that acuity decreases with increasing eccentricity from this point. Wertheim in 1894, using a grating target, showed that visual acuity is at maximum at the fovea and declines in a continuous gradient with eccentricity. Wertheim's data shows that acuity drops quickly

within five degrees from the foveal center and then drops at a slower rate from five degrees out to the far periphery.[6] Weymouth confirmed Wertheim's measurements in 1958.[7] Wertheim's determination of visual acuity in the periphery is considered a classic and is still found in standard textbooks of today.[5]

Static perimetry studies show sensitivity losses in the central twenty degrees of affected age-related macular degeneration patients. Normal thresholds were found in these patients peripheral to the twenty degrees. Also, in these patients, electrooculogram Arden Ratios were normal and electroretinograms were normal except for a small sensitivity loss most likely reflecting aging changes and yellowing of the crystalline lens.[8] Spalton states that a large central scotoma may extend up to twenty degrees from fixation in patients who are severely affected with ARMD.[9] In view of this loss of central vision in patients with ARMD and the lack of extensive knowledge about peripheral visual function, I investigated peripheral visual potential utilizing a select group of conventional Snellen acuity letters. I initially tested twenty-five young non-pathology subjects to help determine a baseline for Snellen peripheral function. I then tested a small population of ARMD patients using the same principles.

Methods

Monocular peripheral visual function was assessed for twenty-five non-presbyopic, non-pathology subjects. All patients

were corrected to 20/20 or better. The vast majority of the patients were either emmetropic or were corrected with contact lenses at the time of testing. Patients were tested without the use of mydriatic or cycloplegic drugs. The patient's non-preferred eye was patched.

A perimeter arc (330 mm test distance) was utilized for the peripheral visual function testing. The test targets were Snellen letters of a selected size and shape attached to standard tongue depressors. The size of the Snellen letters to be used was initially determined by trial. Black letters on a white background were constructed using random letters from the Snellen chart. The six letter sizes presented to the initial subject were equivalent to 20/271, 20/355, 20/566, 20/715, 20/874, and 20/1102. The letters were pasted to the tongue depressors and presented from non-seeing to seeing to the unoccluded eye of a patient properly aligned in the perimeter arc with standard lighting. The patient was instructed to fixate straight ahead at a fixation object and to attend to his peripheral vision. The above listed letters were presented to the patient at 0, 45, 90, 135, 180, 225, 270, and 315 degrees. The patient was instructed to call out the letter he believed was being slowly (4-5 degrees/sec) and steadily presented from non-seeing to him as soon as it could be identified. Advice was given not to immediately look over toward the letter being presented and to continue guessing until the experimenter acknowledged the correctness of his identification. Realizing that ARMD can affect a ten to twenty degree central radius of vision, the acuity

equivalents 20/355, 20/715, and 20/1102 were selected from this initial trial for further testing. The three letter sizes were then tested in the same manner on eleven more subjects in an effort to discern any real discrepancies with the angle being tested (every 45 degrees) and to further evaluate the effectiveness of the sizes of the letters. The sizes were subsequently altered to 20/333, 20/437, and 20/686, because the larger letters were placing recognition further peripheral than deemed necessary. Temporal and nasal function were the only meridians tested from this point on due to their apparent superiority in function.

Utilizing the letters from the Snellen visual acuity chart (A,C,D,E,F,H,L,N,O,P,S,T,V,Z) in the above noted medium size, I attempted to come up with a group of letters that were equally identifiable for all subjects. Six subjects were presented the potpourri of letters randomly. Although there were no clear cut groupings for the letters, A and N were found to be among those that proved easiest for most of the subjects to see while the letters H and L stood out as being more difficult for the subjects to identify. The letter Z was moderately difficult for most of the subjects, thus, the letters A,H,L,N, and Z were selected for subsequent use.

With the appropriate size and letters, I proceeded to test peripheral visual function nasally and temporally in the twenty-five non-presbyopic, non-pathological subjects. In order to account for any familiarization or learning taking place, I presented the A,H,L,N and Z each in the 20/333, 20/437, and 20/686 in a randomly numbered sequence to each patient. Filler

letters were included in the sequence, but were not scored. These were added to help insure that the subject was not simply memorizing my letter sequence. The presentations varied whether the temporal or nasal field was tested first, with a heavy bias toward testing the temporal field first. Also, the initial four letter presentations were repeated as the last four presentations to help evaluate the role of learning. This data was statistically analyzed and will be presented in the results section.

After analyzing the above results, the same letters in the same sequence were presented to five ARMD patients. Because it was not convenient to test these patients at the perimeter arc, a mobile unit, consisting of a black tangent screen, a meter stick, a patch, and a light meter was constructed. Initially the letters were simply statically presented to these patients in the mean positions found with the above population as they fixated on a large X on the tangent screen. However, this did not provide satisfactory results and thus the letters were moved from peripheral non-seeing toward seeing as done in the baseline study.

Results

The results of the baseline peripheral visual function testing are illustrated in Tables 1a, 1b, 2a, and 2b. Table 1a contains data from twenty-one patients who were presented the ordered set of letters to their temporal field first. Table 1b contains the data presented subsequently to the nasal field of

the same twenty-one patients. Tables 2a and 2b contain data from four patients who were presented the set of letters to their nasal then temporal fields, respectively. Table 3 presents the results from the learning control (first four letters repeated as the last four letters). The data collected on the age-related macular degeneration patients is exhibited in Table 4.

Discussion

The results in Tables 1 and 2 exemplify several factors. First, the sizes of the larger letters were consistently seen more peripherally than the medium letters and the medium letters were seen more peripherally than the smaller letters. Johnson et al[4] concluded that a decrease in target size correlates with a decrease in detection sensitivity and they further stated that effects of target size are much more pronounced with resolution sensitivity with stimulus eccentricity. Secondly, the data shown in Tables 1 and 2 indicate that the various Snellen acuity letters used did not tend to show any significant pattern as a whole in their difficulty of identification. This is stated with the possible exception of H being consistently more difficult for the subjects. My initial data, as revealed in my methods, indicated from limited testing that H and L were the most difficult Z, N, and A progressively less difficult. This did not prove to be strikingly true. However, other researchers have indicated a predilection for certain letters. Sheard classifies L with group 1 (easiest to identify) letters, Z and N

with group 3 (next to the most difficult) and H in the most difficult group 4 category.[10] Ludvigh also indicates L should be an easier letter to identify.[11]

As far back as Wertheim's 1891 study, it has been noted that the temporal portions of the visual field are the most sensitive.[6] This was once again confirmed in my study. One striking point of interest from my data was noted when comparing Table 1a to Table 2b. This comparison seems to indicate that there may be a learning factor or a psychological factor coming into play. Although the relatively smaller temporal fields noted with presentation subsequent to nasal presentations could just be a fluke related to the small population size (n = 4).

Practice is a factor in peripheral vision. Low found that with twenty-five to thirty hours of training with forty-three subjects that their acuity increased to 334 percent of the initial mean with a range from 200 to 1200 percent.[12] He went on further to state that the peripheral acuity transferred to different test objects, as well as to everyday life. My data in Table 3 indicate that learning did occur in the temporal field even in the very short thirty minute testing period. The learning aspect of peripheral vision could be prove to be interesting with ARMD. With further knowledge of peripheral visual function, patients may well benefit from the option of training from the outset of their diagnosis of ARMD.

The temporal visual field between fifteen and thirty degrees showed the most visual function potential in the ARMD patients tested in this study. From the data it can be concluded that the ARMD patient's functional field was reduced in size and

sensitivity from the young normal population tested. A cause and effect relationship cannot however be drawn from this research. If further testing in the area of peripheral function were done on a normal older population, such a relationship may be shown to exist. This would indicate how much, if any, of the functional loss in the ARMD population tested is attributable to normal aging changes versus the diseased retina. There is also a need for a controlled, large scale testing of peripheral visual function in ARMD patients. This controlled environment could include identical testing conditions to the baseline study, as well as complete, well documented ocular health evaluations of each ARMD patient.

Table 1a: Means, Standard Deviations and Ranges of identification points of each letter size presented in the temporal field. *

	Mean	Standard Deviation	Range
Medium L	41.33	11.17	25 to 60
Medium H	40.36	11.47	18 to 63
Medium A	41.36	6.89	25 to 60
Medium N	43.18	13.61	10 to 70
Small A	39.00	6.71	28 to 53
Small N	36.58	10.08	21 to 53
Large Z	47.22	6.80	35 to 66
Small L	35.09	13.70	10 to 60
Small H	31.49	13.25	10 to 58
Large H	49.40	10.35	33 to 68
Large L	50.88	10.12	32 to 70
Medium Z	45.57	9.93	27 to 61
Large A	51.79	9.36	30 to 65
Large N	50.13	10.29	24 to 64
Medium L	49.10	14.56	31 to 76
Medium H	46.27	12.08	30 to 78
Medium N	48.54	12.15	35 to 70
Medium A	48.36	10.43	22 to 65

Table 1b: Means, Standard Deviations and Ranges of identification points of each letter size presented in the nasal field. *

	Mean	Standard Deviation	Range
Medium L	40.64	11.05	26 to 68
Medium H	34.00	9.89	20 to 56
Medium A	39.28	8.28	29 to 56
Medium N	41.59	7.40	30 to 56
Small A	35.54	7.56	26 to 50
Small N	32.25	7.53	23 to 46
Large Z	39.53	8.06	24 to 57
Small L	36.65	8.33	25 to 51
Small H	33.35	9.14	16 to 54
Large H	42.18	7.75	22 to 49
Large L	46.99	5.44	38 to 56
Medium Z	37.28	6.62	25 to 50
Large A	48.55	8.09	37 to 56
Large N	43.53	8.93	26 to 56
Medium L	42.10	9.14	31 to 60
Medium H	39.44	8.22	27 to 52
Medium N	39.14	8.03	27 to 47
Medium A	41.52	7.94	32 to 60

* All values are in degrees. The letters are listed in the order in which they were presented to the subjects. (n = 21)

Letter size equivalents: Small - 20/333
Medium - 20/437
Large - 20/686

Table 2a: Means, Standard Deviations and Ranges of identification points of each letter size presented in the nasal field. **

	Mean	Standard Deviation	Range
Medium L	35.75	8.13	26 to 43
Medium H	26.25	6.72	18 to 31
Medium A	33.00	1.41	26 to 40
Medium N	30.00	11.32	20 to 38
Small A	32.75	1.06	30 to 34
Small N	23.00	2.83	20 to 26
Large Z	35.25	4.60	26 to 40
Small L	30.25	4.60	23 to 34
Small H	22.25	2.48	18 to 26
Large H	34.50	6.36	25 to 41
Large L	34.25	4.60	31 to 40
Medium Z	34.00	4.95	30 to 38
Large A	38.75	2.48	34 to 46
Large N	35.00	3.54	31 to 38
Medium L	34.25	7.43	28 to 46
Medium H	32.25	10.26	22 to 46
Medium N	29.75	10.26	22 to 41
Medium A	33.00	3.54	26 to 38

Table 2b: Means, Standard Deviations and Ranges of identification points of each letter size presented in the temporal field. **

	Mean	Standard Deviation	Range
Medium L	31.25	6.01	26 to 41
Medium H	38.25	6.01	31 to 52
Medium A	46.25	12.38	26 to 52
Medium N	39.00	2.12	37 to 43
Small A	34.75	6.72	30 to 43
Small N	36.50	11.32	22 to 46
Large Z	42.75	10.26	26 to 52
Small L	33.50	9.90	23 to 43
Small H	30.25	7.43	22 to 41
Large H	38.75	10.96	25 to 55
Large L	41.75	8.84	31 to 53
Medium Z	37.25	6.01	30 to 46
Large A	44.50	9.19	34 to 52
Large N	44.50	6.36	34 to 52
Medium L	38.50	4.95	33 to 43
Medium H	33.00	8.49	22 to 40
Medium N	38.75	10.97	22 to 52
Medium A	40.00	8.49	26 to 49

** All values are in degrees. The letters are listed in the order in which they were presented to the subjects. (n = 4)

Letter size equivalents: Small - 20/333
Medium - 20/437
Large - 20/686

Table 3: Data from temporal field learning control testing.*

	Initial presentation	Second presentation approximately 24-28 letters after initial presentation	Apparent net gain with experience
L	40.48 degrees	48.20 degrees	7.72 degrees
H	39.24 degrees	46.65 degrees	7.41 degrees
A	41.71 degrees	47.29 degrees	5.58 degrees
N	44.62 degrees	48.00 degrees	3.38 degrees

* 20/437 size letters

Table 4: Peripheral Visual Function Data For Age-Related Macular Degeneration Observers

Patient	Age	VA	Ocular Health	Results of Testing
#1	76	10/160	ARMD(4yrs)	No letters were recognized at mean values from the normal population. A few of the 20/686 letters were recognized between 20-30 degrees(temporal) Subjectively, the 20-30 degree area was the best. The small and medium letters were recognized.
#2	72	4/200	Unknown	No letters were recognized at mean values for the normal population. The patient noted a black object on a white background, but was unable to identify any letters at any distance. Subjectively, 30-40 degrees(temporal) showed the most potential.
#3	68	10/200	ARMD(3yrs) Pseudophake	No letters were recognized at mean values for the normal population. The patient was able to correctly identify the vast majority of test letters(all three sizes) between 15-30 degrees(temporal).

#4	82	10/200	ARMD(15yrs) Glaucoma(20yrs) Pseudophakia	No letters were recognized at mean values for the normal population. The 20/686 letter identification occured temporal at 15-30 degrees, and nasally at 25-30 degrees.
#5	73	10/400	Unknown	No letters were recognized at mean values for the normal population. No letters were identified nasally or temporally. The patient did black on white subjectively.

* All patients used eccentric viewing to attain these visual acuities with the best of the two eyes being tested. All patients had a spectacle correction that was worn during testing, excluding #2 who does not wear a spectacle correction.

References

1. Rosenbloom A, Morgan M, Vision And Aging: General and Clinical Perspectives. Professional Press, 1986. p.337.

2. Leibowitz HW, Krueger DE, Maunder LR, et al. The Framingham Eye Study monograph. Surv. Ophthal. 1980 24(suppl):335-610.

3. Low FN. Peripheral Visual Acuity. Arch. Ophthal 1951 Vol 45:80-99.

4. Johnson CA, Keltner JL, Balestery F. Effects of Target Size and eccentricity on visual detection and resolution. Vision Research. 1978 Vol 18:1217-1222.

5. Hart WM, Moses RA, Adler's Physiology of the Eye: Clinical Application. 8th Ed. C.V. Mosby, 1987. p.423.

6. Wertheim TH,(1891) (translated by Dunsky IL). Peripheral Visual Acuity. Amer. J. Optom. Phsiol. Opt. 1980 57(12):915-923.

7. Weymouth FW. Visual Sensory Units and the minimum angle of resolution. Amer. J. Ophthal. Vol 46:102-113.

8. Sunness JS, Massof RW, Johnson MA, et al. Peripheral Retinal Function in Age Related Macular Degeneration. Arch. Ophthal. 1985 103(6):811-816.

9. Spalton DJ, Hitchings RA, Hunter PA. Atlas Of Clinical Ophthalmology. J.B. Lippincot, 1984. p.187.

10. Borish IM, Clinical Refraction, 3rd Ed. Professional Press, 1975. Vol.I p.384.

11. Ludvigh E, (1941) Extrafoveal Visual Acuity As Measured With Snellen Test Letters. Am. J. Ophth. 24, 303-310.

12. Low FM, (1946) Some Characteristics Of Peripheral Visual Acuity. Am. J. Physiol. 140, 83-85.