Early Age-related Maculopathy and Self-reported Visual Difficulty in Daily Life

Kay Scilley, PhD,[1] Gregory R. Jackson, PhD,[1] Artur V. Cideciyan, PhD,[2] Maureen G. Maguire, PhD,[2] Samuel G. Jacobson, MD, PhD,[2] Cynthia Owsley, PhD, MSPH[1]

Purpose: To determine whether early age-related maculopathy (ARM) is associated with visual difficulty in daily activities beyond the difficulty that would be expected based on normal retinal aging; to determine whether scotopic sensitivity and visual acuity are associated with visual difficulties in these older adults.

Study Design: Comparative, cross-sectional questionnaire study.

Subjects: Ninety-two older adults with early ARM in at least one eye as defined by one or more large (>63 μm) drusen and/or focal hyperpigmentation but no choroidal neovascularization or geographic atrophy, acuity of 20/60 or better, and a reference group of 55 older adults in the same age range without these fundus features and acuity of 20/35 or better in each eye.

Method: Tests of visual acuity and scotopic sensitivity and a general health questionnaire were carried out. The Activities of Daily Vision Scale (ADVS) was administered to assess self-reported visual difficulties in everyday tasks and expressed on a scale of 0 (extreme difficulty) to 100 (no difficulty). Fundus photographs were taken and graded to characterize the presence and severity of ARM to determine eligibility.

Results: For purposes of analysis, the early ARM group was divided into those whose fellow eye (FE) was 20/60 or better and those whose FE was worse than 20/60. ADVS subscale scores were substantially lower in the early ARM group with FE worse than 20/60 (medians, 58–83) compared with the normal retinal health group (medians, 97–100). Even for those with early ARM with FE 20/60 or better, four of five subscale scores were lower (medians, 81–97), albeit slightly in some cases, than those of the reference group. For both ARM subgroups, the night driving subscale had the lowest scores of all subscales. Persons with early ARM with FE 20/60 or better were more likely to report difficulty on the night driving (odds ratio [OR], 4.3; 95% confidence interval [CI], 1.6–11.4), near vision (OR, 5.0; 95% CI, 1.9–12.9), and glare disability (OR, 2.7; 95% CI, 1.1–6.3) subscales compared with those in normal retinal health, adjusting for age, gender, medical comorbidities, and lens density. For early ARM patients with FE worse than 20/60, there was widespread reporting of difficulty on all subscales (ORs ranging from 4.7–52.9). Poor scotopic sensitivity was highly associated with difficulty on the night driving subscale (OR, 6.6; 95% CI, 1.2–35.5) but not with any other subscale. Acuity worse than 20/25 in both eyes was significantly associated with difficulty on all ADVS subscales; when this acuity impairment was present in one eye only, associations were still significantly present on some subscales, although they were weaker.

Conclusions: Persons in the early phases of ARM, even when their fellow eye has relatively good acuity, are more likely to experience difficulty in night driving, near vision tasks, and glare disability compared with those in good retinal health. Scotopic dysfunction, a functional marker of early ARM, is linked to reported night driving problems. Even when acuity impairment occurs in one eye only, patients report difficulties with day driving and near and far vision tasks. *Ophthalmology 2002;109:1235–1242 © 2002 by the American Academy of Ophthalmology.*

Age-related maculopathy (ARM) is the leading cause of blindness among older adults in the United States and many developed countries.[1–3] Exudative disease and geographic atrophy, the advanced forms of ARM causing severe central vision loss, have adverse consequences for quality of life in that they are associated with severe difficulties in the performance of daily tasks,[4,5] emotional distress,[6] and driving cessation.[7] The early, nonexudative form of the condition is more common than both exudative disease and geographic atrophy combined, yet little is known about whether early

Originally received: August 6, 2001.
Accepted: October 10, 2001. Manuscript no. 210705.

[1] Department of Ophthalmology, School of Medicine, University of Alabama at Birmingham, Birmingham, Alabama.

[2] Department of Ophthalmology, Scheie Eye Institute, University of Pennsylvania, Philadelphia, Pennsylvania.

Supported in part by National Institutes of Health grants R01-AG04212, R01-EY05627, R01-EY13203, P30-EY03039, T32-EY07033, Bethesda, Maryland; Research to Prevent Blindness, Inc., New York, New York; the EyeSight Foundation of Alabama, Birmingham, Alabama; Macula Vision Research Foundation, Bala Cynwyd, Pennsylvania; Macular Disease Foundation, Virginia Beach, Virginia; and Foundation Fighting Blindness, Owings Mill, Maryland.

Artur V. Cideciyan is a Research to Prevent Blindness William and Mary Greve Scholar, and Samuel G. Jacobson and Cynthia Owsley are Research to Prevent Blindness Senior Scientific Investigators.

The authors have no commercial interests in any device or product mentioned in this article.

Reprint requests to Dr. Kay Scilley, Department of Ophthalmology, University of Alabama at Birmingham, 700 S. 18th Street, Suite 609, Birmingham, AL 35294-0009.

ISSN 0161-6420/02/$–see front matter
PII S0161-6420(02)01060-6

Table 1. Description of the Macula Grading System

Grade	Description
0	≤ 5 small (≤ 63 μm) drusen
1	> 5 small (≤ 63 μm) drusen
2	≥ 1 large (> 63 μm) drusen and/or focal hyperpigmentation
3	Drusen and choroidal neovascularization
4	Drusen and geographic atrophy
5	Drusen and choroidal neovascularization and geographic atrophy

ARM causes visual difficulties in daily life that are serious enough to bother patients. Prior studies on vision-specific quality of life in ARM have included patients representing a broad spectrum of disease severity,[5,8] but none have specifically focused on the impact of early disease on visual difficulties compared with those older adults who are in good retinal health. Ultimately, the most effective treatments for ARM from a blindness prevention perspective will be targeted at the earliest phases of ARM, before severe, irreversible vision loss has occurred. Health-related quality-of-life instruments are an integral part of evaluating the effectiveness of treatments in clinical trials.[9] However, at present we know little about whether early ARM has any measurable impact on the self-reported ability to perform routine visual activities, over and above that which would be expected from normal aging of the retina and other aspects of the visual system.

This study examined whether early ARM is associated with self-reported difficulty in the visual activities of daily living compared with a reference group of older adults who are in good retinal health. Because recent research has indicated that rod photoreceptor loss and scotopic dysfunction are early markers of ARM,[10–13] we specifically addressed to what extent impairments in scotopic sensitivity are associated with visual difficulties. The impact of acuity impairment in one eye only and in both eyes was also addressed.

Material and Methods

A convenience sample of persons with early ARM was recruited over a 6-month period from the Retina and Vitreous Service of the Department of Ophthalmology at the University of Alabama at Birmingham and the Scheie Eye Institute of the University of Pennsylvania. Inclusion criteria were as follows: (1) at least 50 years old; (2) 20/60 visual acuity or better (best corrected, distance) in at least one eye; and (3) a diagnosis of ARM in this eye based on fundus photography. Fundus photographs taken within 6 months of study enrollment were evaluated by a trained grader using a standardized scale of macular health (Table 1) based on the international classification system[14,15] and as described in our previous work.[16,17] The central 3000 μm diameter area of the macula was evaluated by the grader. To be classified as eligible for the early ARM group, at least one eye had to have one or more large (>63 μm) drusen and/or focal hyperpigmentation (grade 2 in Table 1), but the eye could have no choroidal neovascularization or geographic atrophy. From here on, this eye will be referred to as the eligibility eye. The grader was unaware of each subject's visual functional status, prior ocular diagnoses, and age. The fellow eye could have any level of acuity and macula grade. Exclusion criteria were glaucoma; ocular hypertension; diabetes; or any other ocular, neurologic, or systemic disease that would compromise vision in either eye, as indicated by a comprehensive eye examination within 6 months of enrollment, and the use of medications that would complicate interpretation of the visual function data (e.g., retinotoxic drugs).

Older-adult subjects in good retinal health were recruited from the primary care clinics at the same institutions and underwent fundus photography within 1 month of study enrollment. Subjects had 20/35 or better visual acuity in each eye (best corrected, distance), and the fundus of each eye exhibited any number of small (≤63 μm) drusen (grades 0 or 1 in Table 1), but no large drusen, focal hyperpigmentation, choroidal neovascularization, or geographic atrophy. Other inclusion and exclusion criteria were as described previously for the early ARM group. For those in the normal reference group, the eye with better acuity was defined as the eligibility eye for scotopic testing purposes. There were no a priori power calculations used to determine sample size for either the early ARM group or the normal reference group.

Written informed consent was obtained from all subjects before the protocol began, and approval for the study was obtained from the Institutional Review Board for Human Use at both the University of Alabama at Birmingham and the University of Pennsylvania.

Visual acuity (distance) for each eye was assessed using the Early Treatment of Diabetic Retinopathy Study chart and its standard protocol.[18,19] Subjects wore their best correction as indicated from their most recent eye examination, within 1 month of their enrollment. Scotopic (dark adapted) light sensitivity was measured using a modified Humphrey Field Analyzer (HFA; Zeiss Humphrey Systems, Dublin, CA) and procedures described in detail in our earlier work.[12,16,20,21] The eligibility eye, as defined previously, was tested. The pupil of the test eye was dilated with tropicamide 1% and phenylephrine hydrochloride 2.5%, and subjects viewed targets through their best correction for the test distance. Thresholds were measured with a 4 dB/2 dB staircase bracketing procedure using a narrow band (~15 nm full-width half-maximum) stimulus (blue-green, 500 nm). Subjects were dark adapted for ≥40 minutes before testing. Thresholds were measured at 27 extrafoveal loci in the central 36° diameter of the field and summarized as mean sensitivity across all test points. Lens density was estimated for each subject using a psychophysical technique described in detail in our prior work,[16] which is an adaptation of the lens density estimation procedures developed by Sample et al[22,23] and Johnson et al.[24] The lens density index was used in statistical analyses to adjust for the impact of lens opacity on self-reported visual difficulty, because the focus here is on the impact of ARM.

A questionnaire called the Activities of Daily Vision Scale (ADVS)[25] was used to assess the extent to which subjects experienced difficulty with the visual activities of daily living. Although the ADVS was developed for use with cataract patients, its validity has also been established for other eye conditions, including ARM.[5,26,27] The ADVS was administered by a trained interviewer. The questionnaire consists of 22 items that assess the extent of visual difficulty experienced in doing each activity, with responses ranging on a 5-point scale from "no difficulty" to "unable to do the activity because of visual problems." Item responses are organized into five subscales—daytime driving, night driving, near vision, far vision, and glare disability. Each subscale is scored between 100 (no visual difficulty) and 0 (inability to perform the activity because of visual difficulty). The recommended ADVS scoring procedure was used[25] (i.e., subjects who did not complete at least half the items of a subscale did not have a score computed for that subscale). An ADVS item cannot be scored if the responder has never performed the activity described in the item

Table 2. Characteristics of the Sample on Demographic, Health, and Vision Variables

	Early Age-related Maculopathy with Fellow Eye Worse than 20/60 n = 36 *n (%)*	Early Age-related Maculopathy with Fellow Eye 20/60 or Better n = 56 *n (%)*	Old-Normal n = 55 *n (%)*	*P* Value*
Gender				
Male	14 (39)	31 (55)	26 (47)	0.30
Female	22 (61)	25 (45)	29 (53)	
Race				
White	36 (100)	52 (93)	53 (96)	0.24
Black	0 (0)	4 (7)	2 (4)	
	Median (25%/75%)	Median (25%/75%)	Median (25%/75%)	
Age, yrs	75 (69/83)	71 (66/75)	68 (57/74)	<0.01
Comorbidity score	8 (5/12)	6 (2/8)	2 (1/4)	<0.01
Acuity, logMAR				
Eligibility eye†	0.22 (0.10/0.40)	0.08 (−0.01/0.20)	−0.04 (−0.10/0.04)	—‡
Fellow eye	1.02 (0.86/1.40)	0.10 (0.00/0.20)	0.04 (−0.04/0.10)	—
Scotopic sensitivity, dB§	40.6 (32.4/44.3)	43.5 (41.0/46.2)	44.2 (41.5/46.0)	<0.01
Lens density index§	1.3 (0.9/1.8)	1.2 (0.8/1.7)	1.1 (0.8/1.6)	0.49

*For comparisons among the groups, chi-square tests were used for categorical variables and Kruskal-Wallis tests for continuous variables, two-tailed.

†For the early age-related maculopathy groups, this was defined as the eye that met the eligibility requirement for early age-related maculopathy (see text). For the normal group, both eyes were required to meet the eligibility criteria, so the eligibility eye for the purpose of the protocol was defined as the eye with better acuity (see text).

‡Statistical evaluation of acuity differences among the three groups would have little meaning, because acuity was part of the case definition of each group.

§Tested for the eligibility eye only.

dB = decibel; logMAR = logarithm of the minimum angle of resolution.

(e.g., someone who has never driven) or if the responder has stopped doing the activity for reasons other than vision problems (e.g., severe arthritis). An overall ADVS score (based on all the individual items, not the subscales) is also expressed on a scale of 0 to 100. General health was assessed by a questionnaire[28] that asked about the presence/absence of health problems in 17 areas, and, if present, to what extent the respondent was bothered by the condition on a 3-point scale (1 = not bothered at all, 2 = bothered a little, 3 = bothered a great deal). To generate a comorbidity index, each medical condition indicated by the respondent as

Table 3. Activities of Daily Vision Scale Subscale and Overall Scores for Early Age-related Maculopathy and Old-Normal Subjects

Activities of Daily Vision Scale Subscale*	Early Age-related Maculopathy with Fellow Eye Worse than 20/60		Early Age-related Maculopathy with Fellow Eye 20/60 or Better		Old-Normals		*P* Value†
	N	*Median 25%/75%*	*N*	*Median 25%/75%*	*N*	*Median 25%/75%*	
Day driving	33	83.3 70.8/100	55	100 91.7/100	53	100 100/100	<0.001‡
Night driving	29	58.3 37.5/75	49	81.3 68.8/93.8	52	100 87.5/100	<0.001§
Near vision	34	73.4 45.5/87.9	56	96.6 90/100	54	100 96.6/100	<0.001§
Far vision	33	66.7 47.5/85	53	91.7 77.5/100	48	100 90.4/100	<0.001§
Glare	36	64.6 50/93.2	56	91.7 75/100	54	100 91.7/100	<0.001§
Overall	36	74.0 53.5/83.4	56	93.1 82.4/97.3	55	96.7 93.3/100	<0.001§

*N is slightly reduced for some subscales, because there were a few subjects with less than half of the items as scorable (see text for details).

†Based on Kruskal-Wallis test evaluating whether scores among the three groups are different.

‡Between-group comparisons were significant based on the Mann–Whitney test, $P < 0.001$, except for the comparison between the early age-related maculopathy group with fellow eye 20/60 or better and old-normals, which was nonsignificant.

§All between-group comparisons were statistically significant based on the Mann–Whitney test, $P < 0.05$.

Table 4. Associations between Reported Difficulty on the Activities of Daily

Variable	Day Driving (N = 141)		Night Driving (N = 130)		Near Vision (N = 144)	
	$n^{\dagger}$ (%)	*Odds Ratio (95% Confidence Interval)*	$n^{\dagger}$ (%)	*Odds Ratio (95% Confidence Interval)*	$n^{\dagger}$ (%)	*Odds Ratio (95% Confidence Interval)*
Diagnosis						
Normal	10 (19)	Referent	24 (46)	Referent	17 (31)	Referent
Early ARM FE 20/60 or better	17 (31)	1.5 (0.6, 3.9)	40 (82)	4.3 (1.6, 11.4)	38 (68)	5.0 (1.9, 12.9)
Early ARM FE worse than 20/60	23 (70)	6.3 (1.9, 21.3)	27 (93)	8.7 (1.6, 46.5)	33 (97)	52.9 (5.6, 501.0)
P for trend		0.003		0.001		<0.001
Scotopic sensitivity[‡]						
>45	14 (29)	Referent	28 (62)	Referent	24 (50)	Referent
40.01–45	18 (30)	0.9 (0.4, 2.3)	36 (64)	1.1 (0.4, 2.8)	39 (63)	1.4 (0.6, 3.4)
≤40	18 (55)	1.8 (0.6, 5.3)	27 (93)	6.6 (1.2, 35.5)	25 (74)	1.5 (0.5, 4.9)
P for trend		0.303		0.048		0.447

* All models are adjusted for age, gender, comorbidity index, and lens density.

[†] The number of subjects in each group reporting difficulty. The sum of n across groups will not be equal to the total N, because total N also includes

[‡] Decibels (dB) of sensitivity.

ARM = age-related maculopathy; FE = fellow eye.

present was weighted by the "bothersomeness" index, and then all were summed.

Statistical Analysis

For purposes of analysis, the early ARM group was divided into those whose fellow eye (FE) was 20/60 or better and those whose FE was worse than 20/60. Recall that the eligibility eye, regardless of group, was 20/60 or better. Most variables had a skewed distribution, so nonparametric tests were used. Measures of frequency, central tendency (medians), and dispersion (25th and 75th percentiles) were used to describe the characteristics of each group (early ARM with FE worse than 20/60, early ARM with FE 20/60 or better, those with normal retinal health) on demographic, health, visual function variables (visual acuity, scotopic sensitivity), and the ADVS subscale and overall scores. For categorical variables, the three groups were compared using chi-square tests, and for continuous variables, Kruskal-Wallis tests followed by Mann–Whitney tests for specific between-group comparisons.

The main analyses focused on the association between the primary outcome variables—reported difficulty as assessed by the ADVS—and diagnosis of early ARM and scotopic sensitivity (independent variables). Acuity was not used as a separate independent variable in this set of analyses, because acuity level was part of the case definition of both early ARM and normal retinal health. Preliminary analysis indicated that the ADVS scores were strongly skewed toward the ceiling of the scale (i.e., 100; consistent with previous findings[26]), which was not surprising, given the sample consisted of persons in normal retinal health or in the early stages of ARM in the eligibility eye. Thus, in all regression analyses, the outcome variable was defined dichotomously as an ADVS score of less than 100, which corresponds to experiencing any difficulty whatsoever on the domain being addressed in the item(s). Logistic regression was used to evaluate in separate analyses associations between each ADVS subscale and each independent variable. The variable of diagnosis had three levels—those with normal retinal health, those with early ARM whose FE was 20/60 or better, and those with early ARM whose FE was worse than 20/60. Scotopic sensitivity was entered into analyses as ordered categorical variables based on tertiles of its distribution. Tests of linear trend (Wald chi-square tests) were also performed. All associations were adjusted for age, gender, medical comorbidities, and lens density, because these factors are known to have an impact on older adults' scores on questionnaires on the instrumental activities of daily living.

The last set of logistic regression analyses examined associations between ADVS difficulty and acuity impairment in both eyes and one eye only compared with no impairment in either eye. The rationale for this analysis is that the impact of monocular impairment on self-reported visual difficulty has not been adequately

Table 5. Association between Reporting Difficulty on the Activities of

Variable	Day Driving (N = 137)		Night Driving (N = 126)		Near Vision (N = 140)	
	$n^{\ddagger}$ (%)	*Odds Ratio (Confidence Interval)*	$n^{\ddagger}$ (%)	*Odds Ratio (Confidence Interval)*	$n^{\ddagger}$ (%)	*Odds Ratio (Confidence Interval)*
Visual acuity impairment						
No impairment	16 (9)	Referent	57 (33)	Referent	34 (20)	Referent
Impairment in 1 eye	37 (15)	3.6 (1.2, 10.8)	71 (25)	1.3 (0.4, 3.8)	71 (29)	4.3 (1.5, 11.8)
Impairment in both eyes	66 (25)	9.3 (2.5, 34.1)	97 (32)	10.5 (1.2, 93.6)	95 (38)	23.7 (4.2, 133.0)
P for trend		<0.001		0.035		<0.001

*Acuity impairment is defined as worse than 20/25.

[†]All models are adjusted for age, gender, and comorbidity index.

[‡]The number of subjects in each group reporting difficulty. The sum of n across groups will not be equal to the total N, because total N also includes

Vision Scale and Age-related Maculopathy Diagnosis and Scotopic Sensitivity*

Far Vision (N = 134)		Glare Disability (N = 146)		Overall Score (N = 147)	
$n^{\dagger}$ (%)	*Odds Ratio (95% Confidence Interval)*	$n^{\dagger}$ (%)	*Odds Ratio (95% Confidence Interval)*	$n^{\dagger}$ (%)	*Odds Ratio (95% Confidence Interval)*
21 (44)	Referent	19 (35)	Referent	33 (60)	Referent
30 (57)	1.4 (0.6, 3.5)	36 (64)	2.7 (1.1, 6.3)	50 (89)	4.7 (1.6, 13.7)
31 (94)	12.0 (2.2, 64.9)	29 (81)	4.7 (1.4, 15.3)	35 (97)	11.5 (1.3, 103.2)
	0.005		0.006		0.002
25 (52)	Referent	26 (54)	Referent	34 (69)	Referent
34 (62)	1.1 (0.4, 2.6)	32 (52)	0.9 (0.4, 2.0)	50 (81)	1.4 (0.5, 3.8)
23 (74)	1.4 (0.4, 4.3)	25 (72)	1.8 (0.6, 5.2)	34 (94)	3.9 (0.7, 21.0)
	0.623		0.350		0.110

subjects who reported no difficulty.

addressed in the literature. For the purposes of these analyses acuity impairment was defined as worse than 20/25. In all analyses, α was 0.05, two-tailed.

Results

The distributions of males and females and of whites of non-Hispanic origin and blacks were similar in all three groups (Table 2). Early ARM patients were on average 4 years older than persons in the old-normal reference group. ARM patients had higher comorbidity scores than did old-normal subjects on average. The ARM groups had worse visual acuity on average relative to the old-normal group for both the eye that met the eligibility requirements and the fellow eye, which was expected given the inclusion criteria and the rule for subdividing the early ARM patients. Scotopic sensitivity tended to be worse in the early ARM patients whose FE was worse than 20/60 than in the old-normal group and in the early ARM group whose FE was 20/60 or better. The distribution of the lens density index was similar among the three groups.

Table 3 summarizes ADVS scores in the three groups. There were significant differences on all subscales among the three groups. For the old-normal group the median score for all subscales was 100, indicating no difficulty, whereas the lowest median scores were for the early ARM group with FE worse than 20/60, with subscale medians ranging from 58.3 to 83.3. For the early ARM group with FE eye 20/60 or better, scores on four of five subscales (81–97) were slightly lower than for the old-normal subjects, differences that were small but statistically significant. For both early ARM subgroups, the subscale with the lowest score was night driving, with day driving having the highest subscale score.

Because scores were skewed, the primary analyses focused on a dichotomously defined outcome variable—reported difficulty (scores less than 100) versus no difficulty (scores of 100). In evaluating associations between reported difficulty and ARM diagnosis and scotopic sensitivity, adjustments were made for the potentially confounding effects of age, gender, medical comorbidity, and lens density. Table 4 lists the odds ratios and the 95% confidence intervals for these relationships. Persons with early ARM with FE 20/60 or better were several times more likely to report difficulty on the night driving (odds ratio [OR], 4.3; 95% confidence interval [CI], 1.6–11.4), near vision (OR, 5.0; 95% CI, 1.9–12.9), and glare disability (OR, 2.7; 95% CI, 1.1–6.3) subscales compared with those in normal retinal health; however, there were no associations between the ARM subgroup with FE 20/60 or better and the subscales of day driving and far vision. For early ARM patients with FE worse than 20/60, there was a widespread reporting of difficulty on all subscales (ORs ranging from 4.7–52.9) compared with the normal reference group. Linear trends for diagnosis on all subscales were highly significant, re-

Daily Vision Scale and Acuity Impairment in One Eye and Both Eyes*,†

Far Vision (N = 130)		Glare Disability (N = 142)		Overall Score (N = 143)	
$n^{\ddagger}$ (%)	*Odds Ratio (Confidence Interval)*	$n^{\ddagger}$ (%)	*Odds Ratio (Confidence Interval)*	$n^{\ddagger}$ (%)	*Odds Ratio (Confidence Interval)*
36 (20)	Referent	41 (24)	Referent	68 (40)	Referent
73 (27)	4.5 (1.6, 12.3)	59 (24)	2.0 (0.8, 5.3)	86 (36)	1.5 (0.5, 4.9)
92 (34)	14.6 (3.3, 64.9)	83 (35)	5.1 (1.5, 17.3)	98 (41)	5.2 (0.6, 48.5)
	<0.001		0.008		0.132

subjects who reported no difficulty.

flecting that those patients with FE acuity worse than 20/60 were much more likely to report difficulty on the ADVS than were those with FE acuity of 20/60 or better.

With respect to scotopic sensitivity, moderate scotopic impairment (scores of 40.01–45 dB) was not associated with reported difficulty on any ADVS subscale or the overall instrument. However, more severe scotopic sensitivity impairment (scores ≤40 dB) was highly associated with reported difficulty on the night driving subscale (OR, 6.6; 95% CI, 1.2–35.5), but not with any other subscale. The association with night driving difficulty became stronger after further adjusting for diagnosis (OR, 8.0; 95% CI, 1.3–48.2).

For the final analyses, subjects were regrouped by visual acuity. Table 5 presents the impact of acuity impairment in one eye only and in both eyes on reported difficulty on the ADVS, with adjustments for age, gender, and medical comorbidities. For these analyses acuity impairment is defined as worse than 20/25. Monocular visual acuity impairment was associated with reported difficulty on the subscales for day driving (OR, 3.6; 95% CI, 1.2–10.8), near vision (OR, 4.3; 95% CI, 1.5–11.8), and far vision (OR, 4.5; 95% CI, 1.6–12.3) but not for night driving or glare disability. Visual acuity impairment in both eyes was highly associated with reported difficulty on all subscales (ORs ranging from 5.1–23.7), with significant linear trends on each subscale, indicating that the impact of both eyes impaired was stronger than for one eye impaired only.

Discussion

Persons in the early stages of ARM, even when their fellow eye has relatively good acuity (20/60 or better), are more likely to experience difficulty in night driving, near vision activities, and glare disability compared with those older adults who are in normal retinal health. For those with early ARM whose fellow eye was worse than 20/60, these effects were larger and more widespread across visual tasks (day and night driving, near and far tasks, glare disability). A low-luminance activity, night driving seems to be among the most seriously hampered tasks in early ARM from the patient's perspective. The lowest subscale scores in both subgroups of early ARM patients, regardless of the severity of acuity loss in the fellow eye, were for the night driving domain. What was particularly interesting is that reports of night driving difficulty were linked to scotopic sensitivity impairment. No other ADVS subscales exhibited an association with scotopic sensitivity. This pattern implies that certain psychophysical mechanisms may selectively underlie certain types of everyday difficulties but not others, consistent with other studies showing specificity between types of visual impairment and visual task problems.[29–31] Our results are also consistent with recent work showing that rod photoreceptors, which mediate night vision, are vulnerable early in ARM pathogenesis.[10–13] These findings further imply that the emergence of night driving problems in these patients, even when acuity is relatively good, may be an early functional manifestation of the ARM disease process. Our results are in agreement with earlier work indicating that difficulty with near vision tasks is a common problem for persons with ARM[5] and extend this work by demonstrating that near-task difficulty emerges very early on in this disease and is more serious than the near vision difficulty that would be expected on the basis of normal aging. Early ARM patients were also more likely to report difficulty on the glare disability subscale than were older adults in good retinal health. The items in this ADVS subscale address an assortment of visual activities (e.g., seeing faces, road visibility when confronted with oncoming headlights, reading) whose underlying theme may be their reliance on good contrast sensitivity, which is known to be impaired in early ARM.[32,33] A question for further investigation is whether the pattern of daily task difficulties reported here for early ARM patients is unique to this patient population or whether they exist for patients in the earliest stages of other retinal diseases.

Our data further suggest that health-related quality-of-life instruments used to evaluate treatments for early ARM need to include items that comprehensively address low-luminance/nighttime activities and visual symptoms under poor lighting and should not be limited to tasks largely performed in photopic environments. Currently available instruments focus primarily on night vision problems in the driving context.[8,25,34] A problem with these instruments is that many older adults have already stopped driving for other health reasons,[7,35] so they do not answer these items because they do not apply to them. As a result, the night/low-luminance domain remains entirely unaddressed by many research participants, creating missing data for a task domain important for everyday life. The critical role of low-luminance vision in daily life is underscored by previous work demonstrating that, when performing visual tasks in dimly lit environments, older adults are at higher risk for reading difficulty,[36] falls,[37] and motor vehicle collisions[38,39] compared with younger adults.

These data also provide new information about the impact of monocular acuity loss on self-reported difficulty in daily tasks. Not surprisingly, patients with visual acuity deficits worse than 20/25 in both eyes were more likely to report visual difficulty in the activities of daily living than those with no acuity deficit in either eye. It is interesting that when their acuity deficit was in one eye only, patients also expressed difficulty in day driving and near and far vision tasks. A commonsense notion in clinical practice is that as long as a patient has one "good" eye, visual performance for most tasks of daily life would be largely unhampered. However, our data suggest that monocular acuity impairment in older adults, even when relatively moderate, does engender difficulty in task performance that is sufficiently noteworthy to patients that they report it.

A strength of this study is the focus on self-reported task difficulty in the earliest stages of ARM, whereas prior work has focused largely on patients whose ARM is more severe than those studied here.[4,5,8] In addition, this study used a reference group of older adults in good retinal health. Other strengths include the use of a standard fundus grading scale to define the presence versus absence of early ARM rather than relying on clinically subjective techniques and the adjustment of associations for the impact of lens density that can also have an impact on ADVS scores apart from early ARM.[25] A weakness is the use of a questionnaire developed primarily for use with patients with cataract; however, recent work has confirmed its validity with ARM patients as

well.[5] The status of the fundus was not available on the fellow eye; however, visual acuity in the fellow eye was measured, and its impact on the results was explicitly examined.

In summary, patients in the earliest phases of ARM express difficulty with the visual activities of daily living compared with those older adults in good retinal health. Even for our early ARM patients whose fellow eye had moderately good acuity, difficulty in night driving, near vision, and glare disability was noteworthy from the patient's perspective. These associations were independent of the impact of increased lens density, a common characteristic among older adults that causes visual problems. Difficulty with night driving was related to scotopic sensitivity impairment, which is not routinely evaluated in a clinical examination and thus would typically remain undetected. Health-related quality-of-life instruments designed to evaluate treatments for early ARM should not only address near and far tasks relying on good acuity but also activities performed under low-luminance conditions. Monocular acuity impairment, even when moderate, is sufficient to engender visual difficulties from the patient's perspective.

References

1. Klein R, Klein BEK, Linton KLP. Prevalence of age-related maculopathy. The Beaver Dam Eye Study. Ophthalmology 1992;99:933–43.
2. Mitchell P, Smith W, Attebo K, Wang JJ. Prevalence of age-related maculopathy in Australia. The Blue Mountains Eye Study. Ophthalmology 1995;102:1450–60.
3. Vingerling JR, Dielemans I, Hofman A, et al. The prevalence of age-related maculopathy in the Rotterdam study. Ophthalmology 1995;102:205–10.
4. 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;128:54–62.
5. Mangione CM, Gutierrez PR, Lowe G, et al. Influence of age-related maculopathy on visual functioning and health-related quality of life. Am J Ophthalmol 1999;128:45–53.
6. Williams RA, Brody BL, Thomas RG, et al. The psychosocial impact of macular degeneration. Arch Ophthalmol 1998;116:514–20.
7. Marottoli RA, Mendes de Leon CF, Glass TA, et al. Driving cessation and increased depressive symptoms: prospective evidence from the New Haven EPES. Established populations for epidemiologic studies of the elderly. J Am Geriatr Soc 1997;45:202–6.
8. Mangione CM, Lee PP, Pitts J, et al. Psychometric properties of the National Eye Institute Visual Function Questionnaire (NEI-VFQ). NEI-VFQ Field Test Investigators. Arch Ophthalmol 1998;116:1496–504.
9. Mangione CM, Lee PP, Hays RD. Measurement of visual functioning and health-related quality of life in eye disease and cataract surgery. In: Spilker B, ed. Quality of Life and Pharmacoeconomics in Clinical Trials, 2nd ed. New York: Lippincott-Raven, 1996;1045–51.
10. Curcio CA, Owsley C, Jackson GR. Spare the rods, save the cones in aging and age-related maculopathy [review]. Invest Ophthalmol Vis Sci 2000;41:2015–8.
11. Steinmetz, RL, Haimovici R, Jubb C, et al. Symptomatic abnormalities in dark adaptation in patients with age-related Bruch's membrane change. Br J Ophthalmol 1993;77:549–54.
12. Owsley C, Jackson GR, Cideciyan AV, et al. Psychophysical evidence for rod vulnerability in age-related macular degeneration. Invest Ophthalmol Vis Sci 2000;41:267–73.
13. Owsley C, Jackson GR, White MF, et al. Delays in rod-mediated dark adaptation in early age-related maculopathy. Ophthalmology 2001;108:1196–202.
14. Bird AC, Bressler NM, Bressler SB, et al. An international classification and grading system for age-related maculopathy and age-related macular degeneration. The International ARM Epidemiological Study Group. Surv Ophthalmol 1995;39:367–74.
15. Klein R, Davis MD, Magli YL, et al. The Wisconsin age-related maculopathy grading system. Ophthalmology 1991;98:1128–34.
16. Jackson GR, Owsley C, Cordle EP, Finley CD. Aging and scotopic sensitivity. Vision Res 1998;38:3655–62.
17. Jackson GR, Owsley C, McGwin G Jr. Aging and dark adaptation. Vision Res 1999;39:3975–82.
18. Ferris FL III, Kassoff A, Bresnick GH, Bailey I. New visual acuity charts for clinical research. Am J Ophthalmol 1982;94:91–6.
19. Ferris FL III, Sperduto RD. Standardized illumination for visual acuity testing in clinical research. Am J Ophthalmol 1982;94:97–8.
20. Jacobson SG, Apathy PP, Parel JM. Rod and cone perimetry: computerized testing and analysis. In: Heckenlively J, Arden G, eds. Handbook of Clinical Vision Testing. St. Louis: Mosby, 1991;475–82.
21. Jacobson SG, Voigt WJ, Parel JM, et al. Automated light- and dark-adapted perimetry for evaluating retinitis pigmentosa. Ophthalmology 1986;93:1604–11.
22. Sample PA, Esterson FD, Weinreb RN, Boynton RM. The aging lens: in vivo assessment in light absorption in 84 human eyes. Invest Ophthalmol Vis Sci 1988;29:1306–11.
23. Sample PA, Esterson FD, Weinreb RN. A practical method for obtaining an index of lens density with an automated perimeter. Invest Ophthalmol Vis Sci 1989;30:786–7.
24. Johnson CA, Adams AJ, Twelker JD, Quigg JM. Age-related changes of the central visual field for short-wavelength-sensitive pathways. J Opt Soc Am A 1988;5:2131–9.
25. Mangione CM, Phillips RS, Seddon JM, et al. Development of the 'Activities of Daily Vision Scale.' A measure of visual functional status. Med Care 1992;30:1111–26.
26. Valbuena M, Bandeen-Roche K, Rubin GS, et al. Self-reported assessment of visual function in a population-based study. The SEE project. Salisbury Eye Evaluation. Invest Ophthalmol Vis Sci 1999;40:280–8.
27. Sherwood MB, Garcia-Siekavizza A, Meltzer MI, et al. Glaucoma's impact on quality of life and its relation to clinical indicators. A pilot study. Ophthalmology 1998;105:561–6.
28. Owsley C, Stalvey B, Wells J, Sloane ME. Older drivers and cataract: driving habits and crash risk. J Gerontol A Biol Sci Med Sci 1999;54:M203–11.
29. Marron JA, Bailey IL. Visual factors and orientation-mobility performance. Am J Optom Physiol Opt 1982;59:413–26.
30. Rubin GS, Roche, KB, Prasada-Rao P, Fried LP. Visual impairment and disability in older adults. Optom Vis Sci 1994;71:750–60.
31. Sloane ME, Ball K, Owsley C, et al. The Visual Activities Questionnaire. Developing an Instrument for Assessing Problems in Everyday Visual Tasks. Technical Digest of the Noninvasive Assessment of the Visual System. Washington DC: Optical Society of America, 1992;1:26–9.

32. Owsley C, Sloane ME, Skalka HW, Jackson CA. A comparison of the Regan low-contrast letter charts and contrast sensitivity testing in older patients. Clin Vis Sci 1990;5:325–34.
33. Sunness JS, Rubin GS, Applegate CA, et al. Visual function abnormalities and prognosis in eyes with age-related geographic atrophy of the macula and good visual acuity. Ophthalmology 1997;104:1677–91.
34. Steinberg EP, Tielsch JM, Schein OD, et al. The VF-14. An index of functional impairment in patients with cataract. Arch Ophthalmol 1994;112:630–8.
35. Campbell MK, Bush TL, Hale WE. Medical conditions associated with driving cessation in community-dwelling, ambulatory elders. J Gerontol 1993;48:S230–4.
36. Kosnik W, Winslow L, Kline D, et al. Visual changes in daily life throughout adulthood. J Gerontol 1988;43:P63–70.
37. McMurdo MET, Gaskell A. Dark adaptation and falls in the elderly. Gerontology 1991;37:221–4.
38. Massie DL, Campbell KL, Williams AF. Traffic accident involvement rates by driver age and gender. Accid Anal Prev 1990;27:73–87.
39. Mortimer RG, Fell JC. Older drivers: their night fatal crash involvement and risk. Accid Anal Prev 1989;21:273–82.