

# Impact of Cataract Surgery on Motor Vehicle Crash Involvement by Older Adults

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**C**ATARACT IS THE LEADING cause of vision impairment in older adults in the United States.<sup>1</sup> Population-based studies indicate that approximately 50% of white adults aged 65 to 74 years have cataract,<sup>2,3</sup> with a higher prevalence of about 60% reported for African Americans.<sup>3</sup> Cataract causes deficits in acuity and contrast sensitivity and increased disability glare.<sup>4</sup> Older drivers with cataract are more likely to have a history of recent crash involvement compared with older drivers who are cataract-free,<sup>5</sup> which is mediated by severe contrast sensitivity impairment secondary to increased lens opacity.<sup>6</sup>

Fortunately, cataract is highly treatable in the majority of cases through surgical removal of the crystalline lens followed by intraocular lens (IOL) insertion. Cataract surgery leads to improvements in visual acuity and contrast sensitivity and a reduction in disability glare problems,<sup>4,7</sup> and following surgery, older adults report decreased difficulty with visual tasks.<sup>8-10</sup> However, nothing is known about the impact of cataract surgery on driver safety. Since cataract and the visibility problem it engenders increase crash risk in older drivers, a question is whether surgical removal of the cataract and IOL

**Context** Motor vehicle crash risk in older drivers is elevated in those with cataract, a condition that impairs vision and is present in half of adults aged 65 years or older.

**Objective** To determine the impact of cataract surgery on the crash risk for older adults in the years following surgery, compared with that of older adults who have cataract but who elect to not have surgery.

**Design, Setting, and Patients** Prospective cohort study of 277 patients with cataract, aged 55 to 84 years at enrollment, who were recruited from 12 eye clinics in Alabama from October 1994 through March 1996, with 4 to 6 years of follow-up (to March 1999).

**Main Outcome Measure** Police-reported motor vehicle crash occurrence involving patients who elected to have surgery compared with those who did not.

**Results** Comparing the cataract surgery group (n=174) with the no surgery group (n=103), the rate ratio for crash involvement was 0.47 (95% confidence interval, 0.23-0.94), adjusting for race and baseline visual acuity and contrast sensitivity. The absolute rate reduction associated with cataract surgery was 4.74 crashes per million miles of travel.

**Conclusions** In our sample, patients with cataract who underwent cataract surgery and intraocular lens implantation had half the rate of crash involvement during the follow-up period compared with cataract patients who did not undergo surgery. Cataract surgery thus may have a previously undocumented benefit for older driver safety, reducing subsequent crash rate.

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implantation reduces the likelihood of crashing.

Drivers older than 60 years have the lowest crash rate when measured on the basis of licensed drivers—approximately 40 crashes per 1000 licensed drivers compared with approximately 140 crashes per 1000 licensed drivers among those younger than 25 years.<sup>11</sup> However, when measured on a per-mile-driven basis, older adults have a crash rate nearly equivalent to that of younger drivers whose crash rate is the highest among all age groups (approximately 15 crashes per million miles of travel). Once in a crash, older adults are more likely to incur a disabling injury or die than are younger drivers.<sup>12,13</sup> Older adults are the fastest growing group of drivers on the road today, both in terms of the total number of drivers

and the number of miles driven annually.<sup>14</sup> Thus, there is a pressing need to identify ways to lower the rate of crash involvement among older drivers.

We report the results of the Impact of Cataracts on Mobility (ICOM) project that was designed to address the question, for those older drivers who have cataract, what is the impact of cataract surgery on crash rate in the 4 years

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following surgery compared with those who have cataract who do not elect surgery? Strengths of this study design are the use of a comparison group of patients with cataract who do not undergo surgery followed prospectively over the same time period and the statistical adjustment for potential differences in the surgery and no surgery groups at baseline that could serve as confounders for the hypothesized effect. Using a randomized design would have been unethical since cataract surgery with intraocular lens implantation is an accepted and proven standard of care.

## METHODS

### Subjects

Two groups of older adults with cataract were recruited through 10 ophthalmology and 2 optometry clinics in Birmingham, Ala. The surgeons affiliated with practices used for recruitment had operating privileges at the Callahan Eye Foundation Hospital, a university-affiliated eye hospital. Potential subjects were identified through consecutive chart review for patients seen in these clinics in the prior 6-month period. Surgeons had no role in the selection of patients during recruitment.

One group consisted of older adults with cataract who met the following inclusion criteria at enrollment: (1) cataract in one or both eyes with acuity of 20/40 or worse (best-corrected, distance) as indicated by the medical record; (2) no previous cataract surgery in either eye; (3) cataract surgery in at least one eye had been previously recommended by an ophthalmologist as a treatment for the patient's visual problems and the subject elected to have the surgery; (4) health insurance, either Medicare and/or a private plan, (5) at least 55 years old, (6) living independently in the community, and (7) licensed to drive in the state of Alabama and had not given up driving. A second group of older adults with cataract were also recruited who met the criteria as outlined above, except that the patients did not elect cataract surgery as a treatment for their visual prob-

lems (even though they were made aware by the ophthalmologist or optometrist that it was an option). In both groups the primary cause of vision loss had to be cataract as judged by the ophthalmologist or optometrist.

Exclusion criteria were amblyopia, use of a wheelchair for mobility, and diagnoses of dementia, Parkinson disease, psychosis, or any illness that would likely preclude annual clinic visits for the follow-up period. Candidates for enrollment were contacted by a letter describing the study, followed by a telephone call from the study coordinator. Those who agreed to participate were scheduled for an appointment at the Clinical Research Unit in the Department of Ophthalmology, University of Alabama at Birmingham. Target enrollment (130/group) was based on sample size calculations using data from a previous cross-sectional study<sup>15,16</sup> with the goal of having power of 80% to detect a 2-fold difference in crash rate between those who do and do not elect cataract surgery.

Information on key variables was obtained by telephone from those who declined to participate in the ICOM project in order to facilitate the generalizability of findings. As described in the baseline report,<sup>5</sup> "refusers" were on average 3 years older, had slightly worse visual acuity, were more likely to have low driving exposure, and were less likely to have been involved in a crash in the prior 5 years, compared with those who enrolled.

### Protocol

The Institutional Review Board for Human Use at the University of Alabama at Birmingham approved the study protocol. After the purpose of the study was explained, each subject was asked to sign a document of informed consent before enrolling. For subjects who had elected cataract surgery, the initial (baseline) visit for the protocol was before their surgery date. The baseline protocol was as described below for all enrollees. Test examiners were masked to the crash histories of all subjects. Demographic data and driving status dur-

ing the prior 5 years were obtained through interview.

Three types of visual function were assessed for each eye separately: acuity, contrast sensitivity, and disability glare. Visual function measurements were made while subjects wore the lens correction they typically used during the performance of everyday distance activities, including driving. This lens correction was the refractive correction prescribed at the most recent eye examination (within 6 months prior to enrollment). Distance acuity was measured using the Early Treatment Diabetic Retinopathy Study (ETDRS) letter chart and its standard protocol (Lighthouse Products, Long Island City, NY).<sup>17</sup> Contrast sensitivity was measured with the Pelli-Robson Contrast Sensitivity chart and its standard protocol<sup>18</sup> and was expressed as log contrast sensitivity. Disability glare was estimated with the Brightness Acuity Tester (BAT) as the subject viewed the Pelli-Robson Chart and was defined as the Pelli-Robson score without the BAT minus the Pelli-Robson score with the BAT.<sup>19,20</sup> Lens photographs were taken for both eyes and evaluated for the presence and severity of nuclear sclerotic, cortical, and posterior subcapsular opacities by a trained grader using the Lens Opacities Classification System III (LOCS III) protocol.<sup>21</sup> Retinal fundus photographs were also taken for both eyes and assessed by a trained grader for the presence and severity of age-related maculopathy using a macula grading scale based on the international classification and grading system.<sup>22</sup> The graders were masked with respect to demographic, functional, medical, and crash characteristics of subjects and whether or not cataract surgery had been elected.

Cognitive status, visual processing speed/attentional ability, depression, and general health were assessed because they have been associated with crash involvement in older drivers and thus are potential confounders.<sup>16,23,24</sup> Cognitive function was evaluated by the Mattis Organic Mental Syndrome Screening Examination (MOMSSE),<sup>25,26</sup> a 20-

minute test for assessing cognitive function in elderly people. It provides a composite score that reflects performance in 14 domains of cognitive functioning, with scores ranging from 0 to 28 (best score). Visual processing and attention were assessed by the useful field of view test (Visual Awareness, Inc, Chicago, Ill) where scores represent the percentage reduction (0-90) in visual attention capability under brief target durations.<sup>27</sup>

The presence of depressive symptoms was assessed by the Center for Epidemiological Studies Depression Scale (CES-D),<sup>28</sup> where participants rated 20 items based on how often they felt the way described in each item in the last week (responses on a 4-point scale from "none of the time" to "all of the time"). Total scores ranged from 0 to 60 (higher number signifies more depressive symptoms). An estimate of general health was provided through a questionnaire<sup>5</sup> that asked about the presence vs absence of problems in 17 areas (eg, heart disease, cancer, diabetes). Current prescription medication usage was obtained from subjects by requesting that they bring all prescription medications to the visit. Medication names were transcribed from medicine containers and then converted into American Hospital Formulary Service codes. Six medication classes known to have an association with crash involvement<sup>29</sup> were selected for analysis (benzodiazepines; anxiolytics, sedatives, and hypnotics; psychotherapeutics; antihistamines; hypoglycemics; opioid analgesics). The above protocol, except for the lens and fundus photography, was repeated at 2 subsequent follow-up visits at annual intervals. For subjects who underwent cataract surgery, information about the date of surgery and the existence of complications was obtained from the medical record.

The Alabama Department of Public Safety, the state agency in charge of compiling crash records, provided information on collisions incurred by each study participant for a 5-year period prior to study enrollment. This in-

formation was used in combination with driving exposure information (estimated miles driven per week) obtained through the Driving Habits Questionnaire<sup>5</sup> to calculate crash rates per million miles of travel for the surgery and no surgery groups for the period prior to enrollment. Earlier work has demonstrated that older adults can provide valid estimates of driving exposure.<sup>30</sup>

### Outcomes

The primary outcome of interest was involvement in a police-reported motor vehicle collision between the date of study enrollment (between 1994 and 1996) and either date of driving cessation, date of death, or March 1, 1999, whichever came first. Information about the number of crashes was obtained through reports made available by the Alabama Department of Public Safety. A secondary outcome was self-reported driving difficulty, obtained through the Driving Habits Questionnaire, an interviewer-administered instrument mentioned above and described previously for which reliability and validity have been established.<sup>5</sup> Subjects rated the degree of difficulty they experienced during the previous 3 months when driving in 8 challenging situations (eg, at night, in the rain, making left turns, in rush hour) on a 5-point scale (from "no difficulty" to "so difficult that I no longer drive in that situation"). A composite score of driving difficulty was computed across items and scaled on a 100-point scale (lower scores indicating greater difficulty). Driving difficulty was assessed at baseline and at the 2 annual follow-up visits.

### Data Analysis

Descriptive statistics were generated for demographic, medical, visual function, and crash rate and compared between cataract patients who did and did not undergo cataract surgery using *t* and  $\chi^2$  tests for continuous and categorical variables, respectively. The dependent variable to test the primary hypothesis of the study was crash rate per

person-miles of travel. The numerator of this variable is the number of motor vehicle collisions, for which collection is described above. For the denominator, person-miles of travel during the follow-up period was based on driving exposure information (estimated miles driven per week) obtained through the Driving Habits Questionnaire.<sup>5</sup> Driving exposure was estimated at baseline and at the 2 annual follow-up visits. Each subject's person-miles of travel was calculated by summing the estimated miles driven per week from the time of enrollment until the date of driving cessation, date of death, or March 1, 1999, whichever came first. Mileage information from the baseline interview was used for the first year of person-mileage calculations while information from the first and second annual follow-ups was used for the second and third years of calculations, respectively, when necessary (eg, patient died before second visit). For patients who failed to return for the first and second annual visits for reasons other than death, baseline mileage information was used for all years of calculation. For these calculations, it is assumed that the estimated miles driven per week provided as part of the Driving Habits Questionnaire is consistent throughout the year. Poisson regression was used to calculate the crude and adjusted rate ratio (RR) and 95% confidence interval (CI) for the association between crash rate and cataract surgery.

Prior to the selection of potential confounding variables for the adjusted analyses, it was necessary to evaluate the form of several candidate variables (age, education, cognitive status, depression, chronic medical conditions, useful field of view, visual acuity, contrast sensitivity, disability glare) to determine if these variables performed better in their natural form or as categorical measures. Using previously established cutpoints for the variables in question,<sup>5</sup> 2 separate models were constructed for each variable. One model contained the variable in its continuous form while the other model con-

tained the categorical variable. The 2 models were then compared using the likelihood ratio test. In all instances, the results indicated that the continuous forms of the variables provided no better model fit than the categorical forms and thus the former were used in all subsequent analyses.

For the adjusted analyses, candidate demographic, medical, and visual function variables were evaluated as potential confounding variables for the association between cataract surgery and crash involvement using the

change-in-estimate strategy.<sup>31</sup> For a variable to be included in the adjusted analysis, the RR for the association between surgery and crash involvement had to change by at least 10% following adjustment for the candidate variable. Each candidate variable was evaluated individually and then those that met the 10% criteria were included in a single multivariable model. Those variables that met this criterion included race, visual acuity (better and worse eye), and contrast sensitivity (better and worse eye).

*P* values of  $\leq .05$  were considered statistically significant. All data analyses were conducted using SAS v8.0 (SAS Institute Inc, Cary, NC).

## RESULTS

Between October 1994 and March 1996, 277 subjects with cataract were enrolled in the ICOM project. At enrollment there were 140 subjects who were scheduled for surgery and 137 subjects who decided against surgery. However, over the course of the study 34 patients with cataract who originally at enrollment did not elect surgery subsequently changed their decision, and in fact underwent cataract surgery. Person-miles accumulated by these 34 subjects from the date of enrollment to the date of surgery were allocated to the no surgery group whereas those accumulated post-surgery were allocated to the surgery group. This subset of subjects experienced no collisions between the time of enrollment and the date of surgery. Thus the final sample for the cataract surgery group was 174, and for the no surgery group, 103.

Demographic, medical, and visual characteristics for patients who did or did not elect surgery by the end of the study period are presented in TABLE 1. There were no differences between the groups with respect to age, years of education, or annual mileage. The surgery group was less likely to be male and more likely to be white compared with the no surgery group. There were no differences between the groups with respect to the mean number of medical conditions or CES-D scores. The surgery group had lower MOMSSE scores compared with the no surgery group (5.0 vs 6.2,  $P = .001$ ). Thirteen percent of subjects electing cataract surgery and 25% of subjects deciding against surgery had secondary ocular conditions (nonexudative age-related maculopathy [ARM], primary open glaucoma, or nonproliferative diabetic retinopathy). With respect to the presence and severity of ARM as determined by fundus photograph grading, there was no significant difference between the groups. Useful field of view

**Table 1.** Baseline Demographic, Medical, and Visual Function Characteristics Among Impact of Cataract on Mobility Project Subjects, According to Surgery Status\*

Characteristic	Surgery (n = 174)	No Surgery (n = 103)	<i>P</i> Value
<b>Demographic</b>			
Age, mean (SD), y	71.2 (6.6)	71.5 (5.4)	.66
Men, No. (%)	82 (47.1)	67 (65.1)	.004
White, No. (%)	157 (90.2)	83 (80.6)	.02
Years of education, mean (SD)	12.7 (3.0)	12.4 (3.2)	.42
<b>Medical</b>			
Chronic medical conditions, mean (SD)	4.4 (2.2)	4.1 (2.3)	.36
CES-D score, mean (SD)	7.4 (7.9)	7.8 (7.3)	.65
MOMSSE score, mean (SD)	5.0 (2.7)	6.2 (3.4)	.001
Secondary eye conditions, No. (%)	23 (13.2)	26 (25.2)	.01
<b>Age-related maculopathy, No. (%)</b>			
None	70 (4.2)	37 (35.9)	.13
Early	71 (40.8)	55 (53.4)	
Intermediate	32 (18.4)	11 (10.7)	
Advanced	1 (0.6)	0	
<b>Medication use, No. (%)</b>			
Benzodiazepines	16 (9.2)	9 (8.7)	.90
Anxiolytics, sedatives, hypnotics	27 (15.5)	16 (15.5)	>.99
Psychotherapeutics	13 (7.5)	14 (13.6)	.14
Antihistamines	11 (6.3)	3 (2.9)	.27
Hypoglycemics	18 (10.3)	14 (13.6)	.44
Opioid analgesics	11 (6.3)	8 (7.8)	.65
<b>Visual function, mean (SD)†</b>			
<b>Worse eye</b>			
Visual acuity	0.56 (0.25)	0.35 (0.21)	<.001
Contrast sensitivity	1.18 (0.33)	1.33 (0.23)	<.001
Disability glare	1.01 (0.33)	1.15 (0.25)	<.001
<b>Better eye</b>			
Visual acuity	0.26 (0.20)	0.16 (0.14)	<.001
Contrast sensitivity	1.33 (0.20)	1.41 (0.13)	<.001
Disability glare	1.00 (0.39)	1.21 (0.22)	<.001
Useful field of view, mean (SD)	2.0 (5.1)	3.0 (6.9)	.18
<b>Driving</b>			
Annual mileage, mean (SD)	9599 (13 698)	8600 (8849)	.46
Crash rate per million person-miles for prior 5 years	4.6	5.2	.63

\*CES-D indicates Center for Epidemiological Studies–Depression Scale; MOMSSE, Mattis Organic Mental Syndrome Screening Examination.

†Better and worse eye are defined on the basis of visual acuity.

scores as well as the frequencies of medication use were also similar.

Compared with the no surgery group, visual acuity and contrast sensitivity were worse in both the better and worse eyes in the surgery group at baseline, whereas disability glare was more accentuated in the no surgery group compared with the surgery group. There was no difference between the groups in the motor vehicle crash rate in the 5 years preceding study enrollment.

For the surgery group, slightly over half of subjects (55.7%) had surgery in both eyes. On average, surgery on the first eye took place 2.2 months from the time of enrollment; 50% of subjects had first eye surgery less than 2 weeks from enrollment. For those who had surgery in both eyes, the mean interval of time between first and second eye surgery was 8.9 months (median, 4.7 months). For both first and second eyes, the most common type of extraction procedure was phacoemulsification (95%). The incidence of intraoperative and postoperative complications was low (3.0%). For the majority of subjects (93.2%), the primary reason for cataract surgery cited in the medical record was difficulty with non-driving-related activities (eg, reading, work). By visit 2, the surgery group averaged a 2-line (10 letters, 0.2 log<sub>10</sub> minimum angle resolvable [logMAR]) acuity improvement on the ETDRS chart for both the right and left eyes (SD, 0.3 logMAR). For the no surgery group at visit 2, acuity declined on average by 2 letters in the right eye and 1 letter in the left eye (SD, 0.13 logMAR for both right and left eyes).

TABLE 2 presents the LOCS III grades for the surgery and no surgery groups for the worse and better eyes (defined by visual acuity). Cortical opacities were of similar magnitude in the 2 groups. For the worse eye, the surgery group had more severe nuclear sclerotic and posterior subcapsular grades than did the no surgery group. For the better eye, the surgery group had more severe posterior subcapsular grades but not nuclear sclerotic grades. The data are also stratified by right and left eyes. The

results are similar to those just described. In the right eye, the mean nuclear sclerotic and posterior subcapsular grades were significantly higher in the surgery group compared with the no surgery group. For the left eye, the only difference between groups was for the posterior subcapsular grade.

TABLE 3 presents the postbaseline crash rates for the surgery and no surgery groups and associated RRs and 95% CIs. Despite the 2 groups accumulating a similar number of collisions in aggregate, the surgery group had nearly twice as many subjects and person-miles of travel. Thus, the unadjusted RR comparing the surgery with the no surgery group was 0.64 (95% CI, 0.37-1.13). Following adjustment for race, visual acuity, and contrast sensitivity, the RR was 0.47 (95% CI, 0.23-0.94), indicating approximately half the rate of subsequent crash involvement for those who had cataract surgery compared with those who did not have surgery. This RR estimate translates to an absolute rate reduction of 4.74 crashes per million miles of travel from a base rate of 8.95 crashes per million miles of travel (ie, the crash rate among the no surgery group).

In addition to evaluating crash rates during the follow-up period, analyses were also conducted to compare crash rates during the 5 years prior to study enrollment and during the study follow-up period within the no surgery and surgery groups. For the no surgery group, there was a significant 72% increase (95% CI, 1.00-3.10) in crash rate while the surgery group experienced a statistically nonsignificant 27% increase (95% CI, 0.80-2.10).

The FIGURE presents visual and driving characteristics for the 2 groups measured at each of the 3 annual study visits. Visual acuity in the worse eye was worse for the surgery group at baseline compared with the no surgery group, but then was notably improved at visit 2, not unexpectedly due to the fact that 86% of surgery patients had their first eye surgery prior to visit 2. A similar pattern was observed for contrast sensitivity. Visual acuity and contrast sensitivity data for the better eye for both groups showed similar trends over the 2 years of follow-up. At baseline, the driving difficulty composite score was lower for the surgery group compared with the no surgery group, ie, they reported more difficulty

**Table 2.** Lens Opacity Classification System (LOCS) III Grades for the Surgery and No Surgery Groups\*

Lens Opacity	Surgery	No Surgery	P Value	Worse Eye		
				Surgery	No Surgery	P Value
				Better Eye		
Nuclear sclerotic	2.3 (1.1)	1.9 (1.1)	.01	1.9 (1.0)	1.7 (1.0)	.20
Cortical	0.5 (0.9)	0.7 (1.0)	.11	0.5 (1.0)	0.6 (1.0)	.26
Posterior subcapsular	0.7 (1.3)	0.2 (0.5)	<.001	0.3 (0.8)	0.1 (0.5)	.02
				Left Eye		
Nuclear sclerotic	2.7 (1.1)	2.4 (1.1)	.09	2.5 (1.1)	2.2 (1.0)	.01
Cortical	0.8 (1.0)	1.0 (1.2)	.08	0.8 (1.1)	1.0 (1.2)	.14
Posterior subcapsular	0.6 (1.1)	0.4 (0.6)	.02	0.8 (1.3)	0.4 (0.6)	<.001

\*All values are mean (SD).

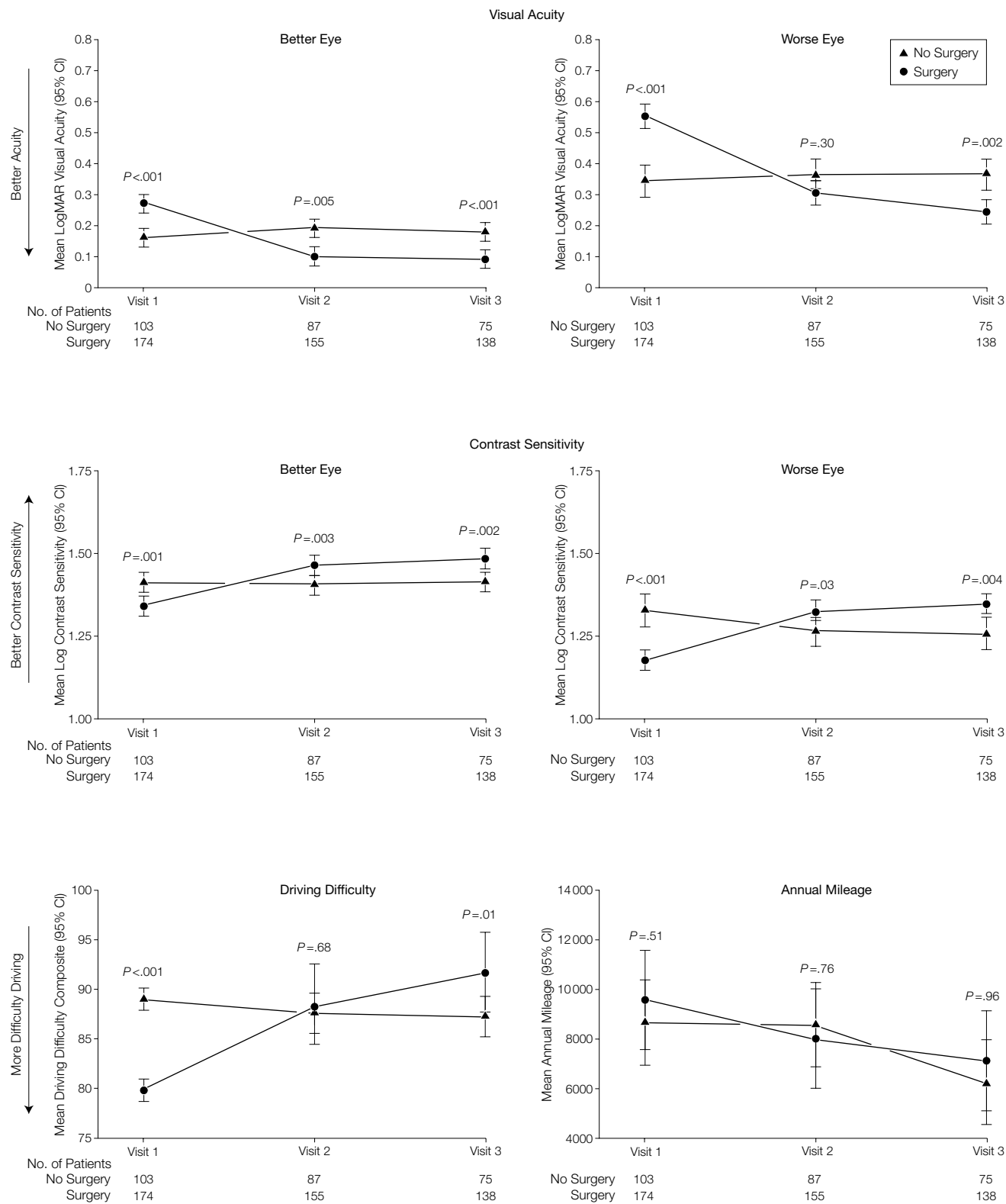
**Table 3.** Crash Rates During Follow-up\*

	Surgery	No Surgery	RR (95% CI)	
			Crude	Adjusted†
No. of crashes	27	23	...	...
Person-miles of travel	4 677 867	2 569 639	...	...
Crash rate (crashes per million person-miles)	5.77	8.95	0.64 (0.37-1.13)	0.47 (0.23-0.94)

\*RR indicates rate ratio; CI, confidence interval; and ellipses, not applicable.

†Adjusted for race, visual acuity (better and worse eye), and contrast sensitivity (better and worse eye). All measures are baseline.

**Figure.** Visual Function and Driving Characteristics Over Study Visits Among the Surgery and No Surgery Groups



P values in each figure refer to between-group comparisons for the corresponding visit. LogMAR indicates log<sub>10</sub> minimum angle resolvable.

driving. By the second study visit the 2 groups were highly similar and by visit 3 the cataract surgery group reported less difficulty, ie, they had a higher score, compared with the no surgery group. For the no surgery group, the driving difficulty composite remained at a moderately high score (indicating little difficulty) throughout the 2 years of follow-up. Self-reported annual mileage declined over the course of the study for both groups in a similar fashion. Some subjects did not return for visits 2 and 3 (Figure), thus introducing the potential for improvements being the result of subjects in poorer health not being followed up. Among those not returning for visit 2 (35 subjects), the most common reasons cited were subject or spouse had a serious illness (30%), no longer wanted to participate (22%), death (14%), or could not contact or moved away (8%). The visit 3 reasons for the 2 groups were very similar. When analyses were limited to only those subjects who completed all 3 visits, the pattern of results was the same as displayed in the Figure.

## COMMENT

In the 5 years before study enrollment, older drivers with cataract who elected surgery and those who declined surgery had similar rates of crash involvement. Subsequent to enrollment, those who had cataract surgery had half the crash rate over the 4- to 6-year period following surgery compared with those who decided against surgery. During follow-up, crash rate for those having surgery increased only 27%, whereas for those who decided against surgery, crash rate increased nearly 75% during this period. There were small, but significant, baseline differences between the surgery and no surgery groups in race, comorbid eye conditions, visual function, mental status, and cataract severity, and the no surgery group was more likely to be male, all of which are known risk factors for crash involvement. However, only 3 variables—race, visual acuity, and contrast sensitivity—proved to be

potentially confounding factors and were included in the adjusted analysis. It is worth noting that crash rate increased for both the surgery and no surgery groups during the prospective period compared with their pre-enrollment rate, reflecting the well-documented trend of increasing crash rate in the later decades of life.<sup>11,14</sup> However, the increase was not statistically significant in the surgery group whereas the no surgery group did experience a significant increase. Our result that the cataract surgery intervention slowed the rate of increasing crash rate is reminiscent of other effects in gerontology for which the positive impact of intervention in older adults is a slowing of the rate of decline, rather than a dramatic reversal of dysfunction or disease.<sup>32,33</sup>

Over 10 years of outcomes research on cataract surgery has clearly demonstrated that the vast majority of older patients experience positive effects after cataract surgery and IOL implantation, including improvements in visual acuity and contrast sensitivity,<sup>4,7,34,35</sup> decreased difficulty (by self-report) in the tasks of daily living,<sup>8-10</sup> and improvements in visual task performance such as reading.<sup>7</sup> The present study suggests that cataract surgery has a previously undocumented benefit for everyday life, namely, preventing the increased crash rate that would be expected in future years without cataract removal. This information could be useful when ophthalmologists and patients discuss the benefits vs risks of cataract surgery, and could be critical information for patients contemplating surgery who want a lifestyle that heavily depends on driving. The present study was not designed to determine whether cataract surgery in one eye is sufficient to generate a protective effect from crashing or whether cataract removal in the second eye provides further benefits for driver safety, an issue for further study. Second-eye surgery may be a practically important consideration for patients with bilateral cataract, since previous findings indicate that crash risk in older adults with cataract is more strongly

linked to vision in the worse functioning eye than in the better eye.<sup>6</sup>

Those patients who elected surgery expressed serious difficulty with driving, which may have contributed to their decision for surgery. Following surgery, they reported that driving was less difficult, in agreement with earlier work.<sup>8,9,36</sup> Those with cataract who declined surgery reported little driving difficulty at baseline, which remained relatively stable throughout 2 years of follow-up. Their driving difficulty composite scores were similar to those previously published for older drivers who were free of cataract.<sup>5</sup> It is interesting that even though they believed that they had little difficulty with driving they had double the crash rate during follow-up, compared with those who had surgery. These findings suggest that insight into how vision impairment impacts driving, and the decisions and behaviors that result from this self-awareness, may play a key role in understanding crash risk in older drivers. Previous studies have shown that older drivers who are keenly aware of their visual processing impairments including acuity and contrast sensitivity deficits are more likely to avoid challenging driving situations.<sup>26,37</sup>

However, differences in awareness of visual impairment could also partly explain the results of the current study. The patients who elect surgery may be more concerned about the impact their cataract is having on their life and this may reflect broader attitudes or concerns toward safety that are associated with driver performance. This study collected information that may reflect such attitudes toward safety including seat belt use, speeding, and avoidance of difficult driving situations. Adjustment for these characteristics yielded an association (RR, 0.49) that was not appreciably different than that reported in Table 3 (RR, 0.47; 95% CI, 0.23-0.94). Another issue that could partly explain our results is the possibility that those in the no surgery group were more likely to drive at night than were those who had surgery, and this

may have increased their crash risk. At baseline, more surgery participants reported not driving at night because of their vision compared with no surgery participants (8% of no surgery group vs 18% of surgery group). However, by the time of the second visit (the postsurgery visit for surgery participants), these percentages were equivalent in the 2 groups (9% in both groups). Because surgery took place in the surgery group on average within 1 week of enrollment, and because at the first postsurgery follow-up the percentage of participants who stopped driving at night was equivalent, it is unlikely that night driving had an influence on our findings. Finally, alcohol use plays a prominent role in crash risk in younger adults, thus raising the question of its role in the findings reported here. At baseline there were no differences between the surgery and no surgery groups in the number of reported drinks per week of beer, wine, or liquor, and adjusting for alcohol use had no impact on the results reported in Table 3.

Driving exposure (eg, miles driven per week) did not increase following cataract surgery, even though vision improved. Rather, for both those undergoing surgery and those declining surgery, driving exposure declined in a highly similar pattern during the first 2 years of follow-up. These downward trends in driving exposure in these older adults mirror those from national surveys of elderly drivers,<sup>38</sup> and suggest that the amount of driving an older person does may not rebound even when functional impairments are partially reversed as was the case in this study.

It is interesting to consider whether the improvements in vision following surgery underlie the lower crash rate in the cataract surgery group. Previous research has shown that contrast sensitivity impairment due to cataract, but not visual acuity deficit, mediates the association between cataract and a recent history of crash involvement.<sup>6</sup> The present study design does not permit the direct examination of this question because virtually all surgery patients experienced improvements in vi-

sual acuity and contrast sensitivity following surgery while the converse was true for those who did not elect surgery. Therefore, changes in visual function are collinear with surgery status and identifying the independent effect of these measures is statistically unfeasible.

The results of randomized clinical trials represent the highest level of scientific evidence in clinical research. Employing a randomized design to address the relationship between cataract surgery and crash involvement was not possible because cataract surgery is an accepted standard of care. Thus, the design of the present study represents the best available approach. However, because the 2 patient groups were not randomized to receive surgery or to have their surgery delayed, there remains the possibility that the observed results are due to confounding by some unmeasured variable. The evaluation of measured potential confounders revealed only 3 variables—race, visual acuity, and contrast sensitivity—for inclusion in the multivariable analysis, yet the association was still present (RR, 0.47; 95% CI, 0.23-0.94). In further analyses, additional variables were added to the multivariable model because the literature suggests some of these variables increase crash risk in older drivers.<sup>14</sup> These included age, sex, education, chronic medical conditions, depression, cognitive status, comorbid eye conditions, useful field of view, and use of specific medications; however, their inclusion in the model did not appreciably change the association between surgery and crash involvement (RR, 0.53). Finally, an analysis was also conducted wherein the numerator of the crash rate (per mile traveled) was the number of crash-involved subjects rather than the number of crashes, and again, the adjusted RR was similar to that presented in Table 3 (RR, 0.49).

Despite the increased crash rate in older drivers compared with middle-aged adults, there are no primary prevention interventions focused on the older driver that have proven effective-

ness in reducing their crash risk. Several have been proposed, including educational programs<sup>37,39-41</sup> and cognitive training<sup>42,43</sup>; however, their effectiveness in enhancing driver safety has not yet been determined. Another means of reducing crash risk among older drivers may be the treatment of common chronic diseases and conditions in elderly drivers that cause functional impairments. Improvement in vision through cataract surgery and IOL implantation is an example of this approach. The results here suggest that it could have widespread benefit to driver safety in our society given the increase in the older driver population<sup>14</sup> and the high prevalence of cataract in the population older than 65 years.<sup>1-3</sup>

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