Risk of Falls and Motor Vehicle Collisions in Glaucoma

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Purpose. To investigate the risk of falls and motor vehicle collisions (MVCs) in patients with glaucoma.

Methods. The sample comprised 48 patients with glaucoma (mean visual field mean deviation [MD] in the better eye = −3.9 dB; 5.1 dB SD) and 47 age-matched normal control subjects, who were recruited from a university-based hospital eye care clinic and are enrolled in an ongoing prospective study of risk factors for falls, risk factors for MVCs, and on-road driving performance in glaucoma. Main outcome measures at baseline were previous self-reported falls and MVCs, and police-reported MVCs. Demographic and medical data were obtained. In addition, functional independence in daily living, physical activity level and balance were assessed. Clinical vision measures included visual acuity, contrast sensitivity, standard automated perimetry, useful field of view (UFOV), and stereopsis. Analyses of falls and MVCs were adjusted to account for the possible confounding effects of demographic characteristics, medications, and visual field impairment. MVC analyses were also adjusted for kilometers driven per week.

Results. There were no significant differences between patients with glaucoma and control subjects with respect to number of systemic medical conditions, body mass index, functional independence, and physical activity level ($P > 0.10$). At baseline, 40 (83%) patients with glaucoma and 44 (94%) control subjects were driving. Compared with control subjects, patients with glaucoma were over three times more likely to have fallen in the previous year (odds ratio $[OR]_{adjusted} = 3.71$; 95% CI, 1.14–12.05), over six times more likely to have been involved in one or more MVCs in the previous 5 years ($OR_{adjusted} = 6.62$; 95% CI, 1.40–31.23), and more likely to have been at fault ($OR_{adjusted} = 12.44$; 95% CI, 1.08–143.99). The strongest risk factor for MVCs in patients with glaucoma was impaired UFOV selective attention ($OR_{adjusted} = 10.29$; 95% CI, 1.10–96.62; for selective attention >350 ms compared with ≤350 ms).

Conclusions. There is an increased risk of falls and MVCs in patients with glaucoma. (*Invest Ophthalmol Vis Sci.* 2007;48: 1149–1155) DOI:10.1167/iovs.06-0886

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Irrespective of the cause, visual impairment is associated with increased risk of two major public health problems—falls[1–3] and motor vehicle collisions (MVCs).[4,5] More specifically, studies suggest an increased likelihood of falls and MVCs in patients with glaucoma[6–12] and that shared risk factors may underlie these problems.[13,14]

A diagnosis of glaucoma has been identified as a risk factor for falls in both population-based and hospital-based studies of older persons.[6,8] However, the magnitude of the risk and the underlying factors involved are not fully understood, as there have been only a small number of studies in which the presence of glaucoma was verified and measures of visual impairment considered. In those studies, factors found to be associated with falls were use of nonmiotic glaucoma medication (predominantly β-blockers),[7,15] impaired visual fields,[7,15] visual acuity (VA), and contrast sensitivity (CS).[7] Indeed, the use of nonmiotic medication was associated with twice the likelihood of multiple falls in the previous 12 months,[7] and more than five times the likelihood of a serious fall requiring medical attention or restricted activity.[15] Surprisingly, this was a stronger risk factor for falls than the measures of visual impairment investigated.[7,15] Among the nonmiotics used, systemic absorption and side effects of topical β-blockers has been suggested as an explanation.[7,15] However, scientific evidence to support this view is lacking,[16] and it is possible that the use of nonmiotic medication is a surrogate for other risk factors not previously considered. Measures such as depth perception, useful field of view (UFOV), and alternative methods for quantifying visual field impairment may be more important predictors of falls in glaucoma and require investigation.

Glaucoma has also been associated with an increased risk of MVCs.[9–12] In a study of older drivers, subjects involved in injurious MVCs were over three times more likely than those not involved in MVCs to have a confirmed diagnosis of glaucoma.[10] However, not all findings have been consistent. McGwin et al.[17] reported no difference between the at-fault crash rate of patients with glaucoma and patients without glaucoma. Furthermore, when all MVCs were considered, regardless of fault, patients with glaucoma were less likely to have been involved in MVCs. These results were not explained by limited driving exposure or avoidance of difficult driving situations, but may have been due to patients having only mild visual impairment.[17] In a recent follow-up study, McGwin et al. investigated visual field impairment and found that glaucoma patients with a moderate to severe defect in the worse eye were over three times more likely to have been involved in MVCs and over four times more likely to have been at fault than were patients with glaucoma who had no defect.[14] Associations between other measures of visual impairment and MVCs were not considered and have yet to be investigated comprehensively in a glaucoma sample. An additional finding that warrants further consideration was the tendency of patients with glaucoma involved in an at-fault MVC to have experienced a fall,[14] as there may be shared risk factors that could lead to an integrated preventative strategy for both falls and MVCs.[13]

The purpose of our study was to evaluate the risk of falls and MVCs in a clinical sample of patients with glaucoma compared with a control group and to investigate associated factors. We add to previous research by investigating both problems in a single cohort and incorporating a more comprehensive set of vision measures.

METHODS

Subjects

The sample comprised 48 patients with glaucoma and 47 healthy control subjects who are participating in an ongoing prospective study of falls, MVCs, and on-road driving performance in glaucoma. Patients with glaucoma were recruited from the Glaucoma Clinic of the Eye Care Centre, Queen Elizabeth II Health Sciences Centre (Halifax, Nova Scotia). Control subjects were recruited by public notice within the Centre and by spoken communication. To be eligible for inclusion, all subjects had to be older than 50 years. For the glaucoma group, the inclusion criteria were a glaucoma specialist's diagnosis of glaucoma, glaucomatous optic disc damage (e.g., notching or progressive thinning of the neuroretinal rim), and corresponding visual field damage detected with standard automated perimetry (Humphrey Field Analyzer [HFA]; Carl Zeiss Meditec, Inc., Dublin, CA). Inclusion criteria for the control group were a normal ocular examination and VA better than 0.30 logMAR (20/40) in each eye. Exclusion criteria for both groups were nursing home residence, use of a mobility device, cognitive impairment (more than two errors on the Short Portable Mental Status Questionnaire),[18] systemic disease or medication known to affect the visual field, cataract (worse than grade II using the Lens Opacities Classification System II),[19] and concomitant ocular disease.

Data Collection and Measures

Demographic and Medical Data. Demographic and medical data were collected from subjects by using structured questions and checklists that included age, gender, body mass index, medical conditions, and systemic medications.

Functional Measures. Functional independence was assessed with the Duke Older Americans Resources and Services Multidimensional Functional Assessment Questionnaire (MFAQ),[20] which comprises 14 items on ability to perform activities of daily living, such as meal preparation, shopping, and dressing. Physical activity level was assessed with the Physical Activity Scale for the Elderly (PASE),[21–23] a weighted 10-item questionnaire on participation in activities such as leisure interests, sports, work, and household tasks. Both questionnaires were administered in person by a trained interviewer. In addition, basic mobility/balance was evaluated with the Timed Up and Go (TUG) test,[24,25] which involves measuring the time taken to rise from a chair, walk 3 m, return, and sit down.

Vision Measures. Distance VA was measured monocularly using Early Treatment Diabetic Retinopathy Study (ETDRS) logMAR (logarithm of the minimum angle of resolution) charts,[26] with a termination rule of 4 of 5 letters named incorrectly[27] and letter-by-letter scoring.[28,29] CS was measured using the Pelli-Robson CS Chart (also monocularly), with a termination rule of 2 of 3 letters named incorrectly,[30] and letter-by-letter scoring.[31] Visual fields were assessed with the HFA Swedish Interactive Threshold Algorithm (SITA) 24-2 program, and the binocular Esterman program.[32] The UFOV test (Visual Awareness Inc., Birmingham, AL) was also administered.[33–35] It comprises three subtests, each yielding a measure of visual information-processing speed under increasingly difficult conditions. The subtests include (1) central vision and processing speed, (2) divided attention, and (3) selective attention. The first subtest requires the identification of a central target (outline of a car or truck). The second requires identification of the central target, as well as localization of a peripheral target (car) presented simultaneously at one of eight radial locations 11 cm from the center of the screen. In the third subtest, the central and peripheral targets are embedded among visual distractors (triangles). Targets are displayed for between 17 and 500 ms using a double-staircase method, and the score for each subtest is expressed as the display duration for which the subject achieves a 75% correct response rate. Subjects performed the UFOV test binocularly, 50 cm from the screen. The Randot Circles Test (Stereo Optical Co., Chicago, IL) was used to measure stereopsis.[36] All vision tests were performed with optimal spectacle refractive error correction, under standardized conditions, as recommended by the manufacturers.

Clinical Data. For the patients, data on glaucoma duration, eye drops, and glaucoma surgery were obtained from clinical records.

Falls and Motor Vehicle Collisions. Main outcome measures were number of falls in the previous 12 months and number of MVCs in the previous 5 years. Falls were defined as, "Unintentionally coming to rest on the ground or at some lower level, not as the result of a major intrinsic event (such as stroke) or overwhelming hazard,"[37] and self-reported data on number, cause, month, time, location, and injuries were collected. MVCs were defined as, "Any collision with another car, object, or person, while driving a motor vehicle, regardless of damage or fault." To acquire data on all previous MVCS, we chose to use both self-report and police-report, as there is conflicting evidence regarding which of the two sources is more valid.[11,38,39] Self-reported data on number, fault, cause, month, time, location, conditions, injuries, and damage were collected. Police-reported data were obtained from Service Nova Scotia and Municipal Relations Motor Vehicle Records and Compliance, who provided hard-copy abstracts of accident reports. Fault was not explicitly indicated in these abstracts. Therefore, for police-reported data, we assigned fault only in conclusive cases of self-admission or when the report stated that a vehicle being driven by the subject had collided with a parked vehicle. Other cases were considered indeterminate and were excluded from police-reported at-fault analyses. To account for on-road driving exposure, the Driving Habits Questionnaire was used to estimate number of kilometers driven per week.[40]

Protocol

The protocol first involved a review of clinical records and an interview to obtain demographic, medical, glaucoma, falls, and MVC data, followed by all questionnaires. Subjects then underwent a full ocular examination including refraction, slit lamp biomicroscopy, ophthalmoscopy, and intraocular pressure measurement. Vision tests and the TUG were then applied. This procedure was conducted at baseline and is being repeated at 6 and 12 months. Subjects were issued a calendar diary in which to record falls and MVCs occurring during the study, with monthly follow-up. This article reports on baseline findings. The study design and protocol was approved by the Institutional Ethics Review Board and adhered to the tenets of the Declaration of Helsinki. Subjects gave informed written consent before participation.

Statistical Analysis

Data were analyzed on computer (SPSS ver. 12.0 for Windows; SPSS Inc., Chicago, IL). Descriptive statistics were calculated for demographic, medical, functional, vision, clinical, and driving exposure characteristics. Group comparisons were made using *t*-tests, Mann-Whitney tests, and χ^2 tests for continuous, ordinal, and nominal data, respectively. Analyses were two-tailed and $P < 0.05$ was considered statistically significant.

The proportion of subjects who self-reported one or more previous falls, involvement in one or more MVCs (regardless of fault) and one or more at-fault MVCs, was calculated for the glaucoma and control group. In addition, the proportion of subjects with police-reported MVCs was calculated for each group. Agreement between self-report and province-recorded police-report was analyzed using the κ coefficient.

Associations between glaucoma and falls and glaucoma and MVCs were evaluated with logistic regression analysis. First, unadjusted odds ratios (ORs) and 95% confidence intervals (CIs) were calculated. Second, analyses were performed to obtain adjusted ORs and 95% CIs, which accounted for the possible confounding effects of demographic, medical, vision, and driving characteristics. Logistic regression analysis was also used to explore possible associations between visual factors and the main outcome measures in the glaucoma group. For this analysis, vision measures were dichotomized using criteria considered to be clinically important, and adjustments were made for possible confounders.

Results

Subject Characteristics

Baseline demographic, medical, and functional characteristics of the study sample are presented in Table 1. The mean age of the patients with glaucoma was 69 ± 9 years (SD), mean time since diagnosis was 13 ± 8 years, 47 (98%) used a median of two types of glaucoma eye drops, and 27 (56%) had undergone previous glaucoma surgery. The control subjects were staff members, friends or family of staff members, volunteer workers, or spouses of patients of the Eye Care Centre (not patients themselves and not related to subjects with glaucoma). There were no significant differences between the glaucoma and control group with respect to age, gender, body mass index, number of medical conditions, number of systemic medications, functional independence, and level of physical activity ($P > 0.10$). With respect to mobility/balance, as measured using the TUG test, the difference between groups was statistically significant ($P = 0.01$); however, the mean value for each group was within the normal range for age.[25] The proportion of drivers in each group was similar ($P = 0.66$), and although patients with glaucoma tended to drive less than control subjects, the difference was not statistically significant (mean difference in driving exposure = 69 km/wk; $P = 0.09$).

The baseline vision measures for each group are given in Table 2. Compared with control subjects, patients with glaucoma had significantly worse VA ($P \leq 0.05$), CS ($P \leq 0.001$), HFA MD (mean MD better eye, −3.58 dB [SD, 5.08] and +0.10 dB [SD, 1.76] for the glaucoma and control groups, respectively; $P < 0.001$) and worse HFA binocular Esterman score ($P < 0.001$). In addition, mean visual processing speed was significantly less in the glaucoma group compared with the control group (all UFOV subtests, $P = 0.01$). The difference in stereopsis was of borderline significance ($P = 0.07$).

Glaucoma and Falls

At baseline, 17 (35%) patients with glaucoma and 6 (13%) control subjects reported one or more falls in the previous 12 months (Fig. 1). Patients with glaucoma were over three times more likely to have had a fall (OR = 3.75; 95% CI, 1.32–10.61), even after adjustment for age, gender, body mass index, number of systemic medications and better eye HFA MD (Table 3).

Glaucoma and Motor Vehicle Collisions

The number of drivers in the glaucoma and control group was 40 (83%) and 44 (94%), respectively. Province records were obtained for all but two subjects (patients with glaucoma who declined to give permission for release of their records). Eleven (27%) patients with glaucoma and three (7%) control subjects self-reported involvement in one or more MVCs in the previous 5 years, with eight (20%) glaucoma patients reporting having been at fault compared with one (2%) control subject (Fig. 2). Unadjusted and adjusted ORs, given in Table 3, indicate that patients with glaucoma were over five times more likely to have been involved in MVCs ($OR_{self\text{-}report}$ = 5.18; 95% CI, 1.33–20.24) and over 10 times more likely to have been at fault ($OR_{self\text{-}report}$ = 10.75; 95% CI, 1.28–90.34). These associations remained strong after adjustment for age, gender, number of systemic medications, better eye HFA MD and on-road driving exposure.

Police-reported results from province records were similar to self-reported results (Fig. 2), although the associations were not as strong, with wide 95% CIs that included 1.00 (Table 3). Compared with self-report, there were fewer police-reported MVCs (Table 4). A total of 15 (18%) subjects were identified as having been involved in one or more MVCs, either by self-report or police-report (11 patients with glaucoma and 4 control subjects). Self-reported and police-reported findings were concordant for 11 (73%) cases and discordant for 4 (27%). Of the discordant cases, three patients with glaucoma self-reported MVCs that were not province-recorded (minor MVCs not requiring police-report), and one control subject failed to self-report an MVC that was province-recorded. Of the remaining subjects, 67 (82%) neither reported an MVC nor had a police-reported MVC. Although there were fewer subjects with police-reported MVCs, agreement between self-reported and police-reported MVCs was high ($\kappa = 0.82$, $P < 0.001$). Considering individual MVCs (20 in total, across all subjects), the agreement was less, yet remained high ($\kappa = 0.74$, $P < 0.001$).

Associated Risk Factors

Except for a diagnosis of glaucoma, there were no significant associations between other factors investigated and previous falls. However, other factors were associated with previous

Table 1. Demographic, Medical and Functional Characteristics of Study Sample

Characteristic	Glaucoma (n = 48)	Normal Control (n = 47)	P
Age (y), mean (SD)	69 (9)	67 (7)	0.11
Time since glaucoma diagnosis (y), mean (SD)	13 (8)	NA	—
Current use of glaucoma eye drops (yes), n (%)	47 (98)	NA	—
Glaucoma eye drops (count), median (range)	2 (0–5)	NA	—
Previous glaucoma surgery (yes), n (%)	27 (56)	NA	—
Gender (female), n (%)	24 (50)	27 (57)	0.67
Body mass index (kg/m^2), mean (SD)	27.4 (4.5)	26.8 (4.2)	0.52
Medical conditions (count), median (range)	3 (0–10)	2 (0–11)	0.11
Systemic medications (count), median (range)	2 (0–8)	2 (0–11)	0.11
MFAQ score (of a possible 28), median (range)	28 (26–28)	28 (24–28)	0.88
PASE (weighted score), median (range)	117 (25–253)	126 (31–393)	0.39
TUG test (seconds), mean (SD)	11 (3)	10 (2)	0.01
Driving (yes), n (%)	40 (83)	44 (94)	0.66
On-road driving exposure (km/wk), mean (SD)	131 (113)	200 (238)	0.09

NA, not applicable.

Table 2. Vision Characteristics of Study Sample

Characteristic	Glaucoma (n = 48)	Normal Control (n = 47)	P
Distance visual acuity (logMAR)			
Better eye	0.05 (0.14)	0.01 (0.08)	0.05
Worse eye	0.15 (0.18)	0.07 (0.09)	0.01
Contrast sensitivity (log CS)			
Better eye	1.60 (0.12)	1.68 (0.10)	0.001
Worse eye	1.43 (0.28)	1.63 (0.09)	<0.001
HFA mean deviation (dB)			
Better eye	−3.85 (5.08)	+0.10 (1.76)	<0.001
Worse eye	−10.86 (7.79)	−0.92 (1.60)	<0.001
HFA binocular Esterman (% detected)	93 (9)	99 (2)	<0.001
Useful Field of View (ms)			
Processing speed	40.0 (52.8)	19.3 (5.1)	0.01
Divided attention	199.3 (185.2)	112.7 (122.8)	0.01
Selective attention	314.3 (133.2)	244.6 (116.0)	0.01
Stereopsis (seconds of arc), median (range)	40 (20 to none)	40 (20 to none)*	0.07

Data are expressed as the mean (SD), unless otherwise indicated.
* One normal control subject had no stereopsis due to anisometropia following cataract surgery.

MVCs. Patients who had undergone glaucoma surgery were less likely to have been involved in MVCs, an association that remained strong after adjustment for age, gender, number of systemic medications, better eye HFA MD and on-road driving exposure ($OR_{self\text{-}report,\ all}$ = 0.15; 95% CI, 0.03–0.87 and $OR_{self\text{-}report,\ at\text{-}fault}$ = 0.05; 95% CI, 0.00–0.65). Also, there was a borderline association between stereopsis worse than 40 seconds of arc and self-reported at-fault MVCs for the glaucoma group (OR = 5.73; 95% CI, 0.99–33.25). Patients with greater visual field impairment (worse eye HFA MD ≤ -10 dB), were over four times more likely than those with less impairment to have been involved in self-reported at-fault MVCs after adjustment for age, gender, number of systemic medications and on-road driving exposure, although the 95% CI included 1.00 (OR = 4.97; 95% CI, 0.73–33.81). After adjustment for the same confounders, as well as better eye HFA MD, UFOV selective attention had a stronger association with MVCs. Patients with slower UFOV selective attention processing speeds (>350 ms) were over 10 times more likely to have self-reported MVCs than were patients with faster processing speeds (OR = 10.29; 95% CI, 1.10–96.62).

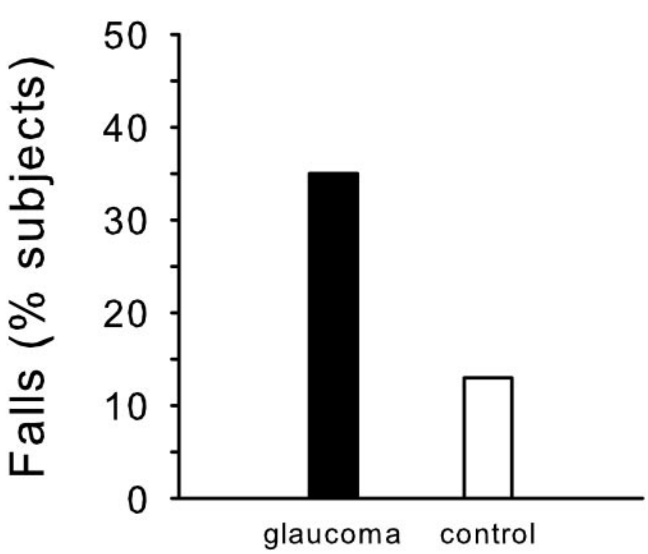

Figure 1. Proportion of subjects in the glaucoma group (n = 48) and the normal control group (n = 47) who reported one or more falls in the previous 12 months.

Discussion

Falls are a leading cause of injury,[41–44] hospitalization,[41,45,46] functional decline,[47,48] nursing home placement,[41,49] and death in older persons.[46,50] Direct medical expenditure has been estimated to be in excess of several billions of dollars per year in Canada and the United States.[51,52] MVCs, too, are a major cause of injury, hospitalization, and death,[44,46,50,53] resulting in great economic burden.[51,54,55] Clearly, intervention programs for these two public health problems are needed and should be based on a comprehensive scientific understanding of associated risk factors. Although studies suggest glaucoma may be a risk factor, further research is necessary to confirm this and to establish the factors underlying the association. In this article, we have presented data on falls and MVCs, comparing patients with glaucoma to normal control subjects.

Patients with glaucoma in this study were over three times more likely than control subjects to have experienced a fall in the previous 12 months, (adjusted for age, gender, body mass index, number of systemic medications, and better eye HFA MD). This is a higher likelihood than found in previous studies,[6,8] and may be due to the different methods used to establish a diagnosis of glaucoma. In previous studies, self-report[6] and hospital diagnostic codes were used,[8] methods that perhaps failed to identify all subjects with glaucoma. Another possibility is that falls were self-reported, a method susceptible to inaccuracies and bias. It might be suggested that the patients with glaucoma in this study were more concerned about falls and therefore more likely to recall falls than were control subjects. However, we found no evidence of this, based on a fear-of-falls questionnaire (P = 0.27).[56] Unlike previous studies of falls,[7,15] we did not find a significant association with use of topical β-blockers or various vision measures, possibly because our sample size was small.

The likelihood of previous MVCs in patients with glaucoma was even higher than for previous falls. Compared with control subjects, we found patients with glaucoma were over five times more likely to have been involved in a self-reported MVC in the previous 5 years, over 10 times more likely to have been at fault, and still more likely to have been involved when factors such as age, gender, number of systemic medications,

TABLE 3. Odds Ratios for Falls and MVCs in Patients with Glaucoma

	Glaucoma *n* (%)	Normal Control *n* (%)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)*
Falls	17 (35)	6 (13)	3.75 (1.32–10.61)	3.71 (1.14–12.05)
Self-reported MVCs†				
All involvement	11 (27)	3 (7)	5.18 (1.33–20.24)	6.62 (1.40–31.23)
At fault	8 (20)	1 (2)	10.75 (1.28–90.34)	12.44 (1.08–143.99)
Police-reported MVCs				
All involvement‡	8 (21)	4 (9)	2.67 (0.73–9.69)	3.21 (0.72–14.27)
At fault§	5 (14)	1 (2)	6.67 (0.74–60.08)	7.21 (0.46–113.40)

* Falls adjusted for age, gender, body mass index, number of systemic medications and better eye HFA MD; MVCs adjusted for age, gender, number of systemic medications, better eye HFA MD and on-road driving exposure (km/wk).

† Of 40 patients with glaucoma and 44 control subjects who were motor vehicle drivers.

‡ Of 38 drivers in the glaucoma group (2 declined to give permission to obtain records) and 44 drivers in the control group.

§ Of 35 and 41 drivers in the glaucoma and control groups, respectively. Three in each group with police-reported MVC involvement were excluded from the analysis because fault was indeterminate.

better eye HFA MD and driving exposure were taken into account. Although this is consistent with most previous studies,[9–12] on the contrary, McGwin et al.[17] recently found that patients with glaucoma were 36% less likely to have been involved in MVCs than were patients without glaucoma, and no difference in rate of at-fault MVCs. However, clinical data were not provided, and it is possible that patients in their study were less visually impaired than patients in our study. Our results are more consistent with their follow-up study, wherein glaucoma patients with moderate to severe visual field impairment had an increased likelihood of involvement in MVCs.[14]

Self-reported findings in this study were stronger than police-reported findings. However, each source of data has limitations, with police-reported data possibly failing to include minor MVCs (not required to be reported) and MVCs occurring outside the province, whereas self-reported data may be limited by recall inaccuracies and reluctance to provide information. As in other studies,[38,39] the number of self-reported MVCs in this study was greater than the number of police-reported MVCs, and we suggest this is the likely reason glaucoma was more strongly associated with self-reported MVCs than with police-reported MVCs. Furthermore, the discrepancy between self-reported and police-reported at-fault results is likely to be because fault was not explicitly stated in the police-reported records available to us, and some cases were excluded from analyses, reducing power to detect a statistically significant OR.

Baseline results of this study indicate some possible associations between clinical factors and MVCs, and between visual factors and previous MVCs. We found patients who had undergone glaucoma surgery were less likely to have been involved in MVCs. The reason for this is not clear from this or previous studies. To our knowledge, glaucoma surgery has not been included in investigations to date. It is possible glaucoma surgery is a surrogate marker for some other aspect of visual function not examined in this study, such as location of visual field damage or an alternative quantification of visual field impairment. Of the vision measures we investigated, the ORs for visual field impairment (worse eye, HFA MD ≤ -10 dB) and reduced stereopsis ($>$40 seconds of arc), indicate they may be risk factors for at-fault MVCs in patients with glaucoma. This is supported by similar findings using the Advanced Glaucoma Intervention Study (AGIS) scoring method to quantify visual field impairment.[14] However, significant results have not been obtained using horizontal visual field extent and percentage points below 10 dB,[12] perhaps because these methods may be insufficiently sensitive to differences between subjects. With regard to stereopsis, we are not aware of any previous studies of patients with glaucoma, and findings in other populations are contradictory.[4] In addition to differences in the driving exposure of the populations studied (taxi drivers[57] and older drivers),[58,59] inconsistent results may be due to the use of different definitions of impaired stereopsis. The strongest factor associated with previous MVCs in the patients with glaucoma we studied was impaired UFOV selective attention ($>$ 350 ms). This is consistent with studies of older drivers[4]; for example, Owsley et al.[59] found persons with ≥40% reduction

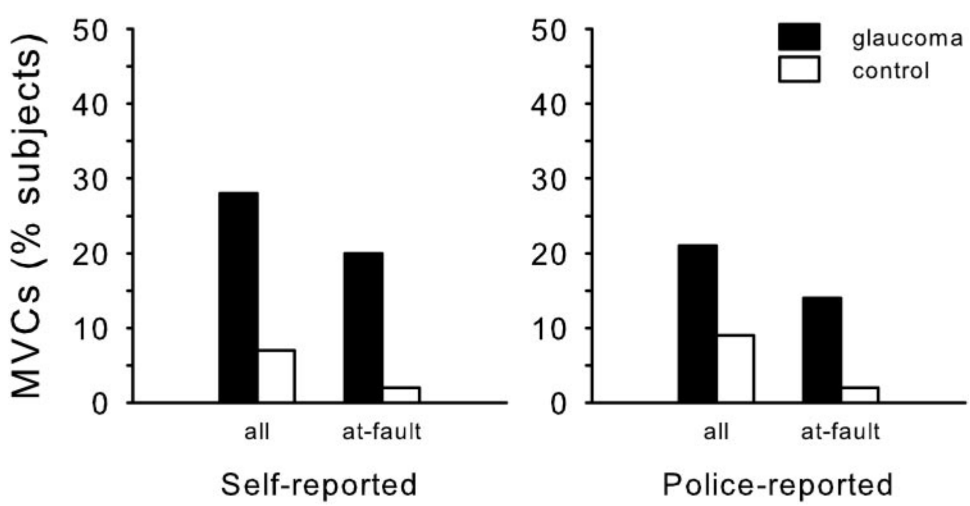

FIGURE 2. Proportion of drivers in the glaucoma group (n = 40) and the normal control group (n = 44) who reported one or more motor vehicle collisions (MVCs) in the previous 5 years. Data shown for self-reported MVCs (*left*) and police-reported MVCs (*right*), for all involvement (regardless of fault), and at-fault involvement. Province-recorded police reports were obtained for 38 and 44 drivers in the glaucoma and control groups, respectively. Police-reported at-fault MVCs were indeterminate for three of eight glaucoma and three of four control subjects with province-recorded involvement.

TABLE 4. Cross-Classification of Subjects Involved in MVCs by Self-Report and Province-Recorded Police-Report*

	Self-Reported MVCs n (% Total)		
	No	Yes	Total
Police-reported MVCs, n (% total)			
No	67 (82)	3 (4)	70
Yes	1 (1)	11 (13)	12
Total	68	14	82

* All glaucoma and control subjects for whom the province record was obtained ($n = 82$) and all involvement in one or more MVCs in the previous 5 years, regardless of fault.

in UFOV were over twice as likely to be involved in MVCs than were those with better UFOV. Although we found some possible factors underlying the risk of falls and MVCs in glaucoma, our sample size was small and visual factors were assessed after the MVCs had occurred. We suggest prospective investigation of a larger sample of patients with glaucoma is required to confirm our findings, determine if location of visual field damage or alternative measures of visual field impairment are important and to establish whether or not there are shared risk factors for falls and MVCs.

The findings of this clinical study indicate there is an increased risk of falls and MVCs in patients with glaucoma. On the basis of this, we have commenced a larger prospective study to investigate the underlying factors further. Potentially, the results have implications for patient education, licensing of drivers, and intervention programs.

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