The Association between Primary Open-Angle Glaucoma and Motor Vehicle Collisions

Sachiko Tanabe,1,2 Kenya Yuki,1 Naoki Ozeki,1 Daisuke Shiba,1 Takayuki Abe,3 Keisuke Kouyama,3 and Kazuo Tsubota1

PURPOSE. To investigate and compare the prevalence of motor vehicle collisions (MVCs) in individuals with or without primary open-angle glaucoma (POAG).

METHODS. A total of 265 subjects were consecutively enrolled: 121 (79 men, 42 women; age, 62.1 ± 8.0 years) with POAG; and 144 (95 men, 49 women; age, 61.2 ± 7.9 years) who were free of ocular disease. Participants answered a questionnaire on MVC experience during the previous 10 years, past driving experience, and daily driving habits. The POAG group was subdivided into three groups according to disease severity (mild, moderate, or severe), to assess the relationship between POAG severity and MVC.

RESULTS. A statistically significant association between POAG severity and MVC frequency was observed; 3.5% of the controls, 0.0% of the mild POAG group, 3.9% of the moderate POAG group, and 25.0% of the severe POAG group had experienced MVCs (P = 0.007, Cochran-Armitage trend test). The severe POAG group had experienced a much higher frequency of MVCs during the surveyed period than had the control group (P < 0.01; Fisher’s exact test). Logistic regression analyses accounted for confounding factors (age, presence of diabetes mellitus, driving history, time spent driving per day, and best corrected visual acuity in the better or worse eye) produced consistent results.

CONCLUSIONS. Advanced POAG with marked visual field defects may be a risk factor for MVCs. (Invest Ophthalmol Vis Sci. 2011;52:4177–4181) DOI:10.1167/iovs.10-6264

Motor vehicle collisions (MVCs) are among the most serious public health concerns in the world: estimates put the number killed in MVCs annually at 1 to 2 million, with a further 50 million injured, costing the global community about US $518 billion.1,2 Information conveyed via the visual senses is the most relevant to a driver’s assessment of the road situation at any given time, and proper visual function is essential for avoiding MVCs. Therefore, it is reasonable that many countries mandate a visual function examination of some sort for all driver’s license applicants.3,4

As the number of elderly drivers continues to grow both in developed and developing countries, so will the higher prevalence of age-related ophthalmic diseases, such as cataracts, macular degeneration, and glaucoma increase the population of visually impaired drivers.5 Glaucoma is the second leading cause of blindness in the world, affecting approximately 5 million adults globally; it is the leading cause of blindness in Japan.3 A previous study reports that glaucoma is not actually diagnosed in 93.3% of Japanese with the disease, even though they have significant visual field defects. Furthermore, many of those with diagnosed glaucoma have little awareness of the disease, probably because visual field loss in many cases occurs only in peripheral areas, and visual acuity is preserved for a relatively long period. This fact implies that many patients with glaucoma are driving without realizing that they have visual field defects. Such suspicions are supported by Johnson and Keltner,6 who reported that approximately 50% of glaucoma patients with abnormal visual fields are unaware of any problem with their peripheral vision.

The association between MVCs and glaucoma has been investigated in several preceding studies,9–17 but their conclusions are mixed. McGwin et al.10 reported that patients with glaucoma are less likely to be involved in traffic accidents, because they tend to avoid dangerous roads and high-risk situations. Conversely, Haymes et al.7 found a higher risk of MVCs in patients with glaucoma than in control subjects. McGwin et al.11 later reported that glaucoma patients with severe visual field defects are at increased risk for MVCs. However, these studies had several limitations: the use of International Classification of Diseases (ICD) codes to review the diagnosis of glaucoma10,11, self-reported diagnosis of glaucoma12; a low participation rate among the target subjects10; a telephone-based survey design11; reliance on state reports of MVCs10;13,14,16,17; and a small number of glaucoma patients among the subjects.9,15

The use of ICD codes or self-reported diagnosis in glaucoma screening entails misclassification risks. We also think that information collected via telephone surveys is likely to be more limited in terms of both detail and accuracy than that obtained in face-to-face interviews in an outpatient clinic. Reliance on state reports means that some MVCs not meeting the criteria for reporting in a particular jurisdiction may be missed. However, self-reported records of MVCs may be limited by recall inaccuracy and a reluctance to provide information. Self-reported and state records provide complementary information for the ascertainment of MVCs, but self-reported records have yielded more events than state records in previous reports.9,18 A low level of participation by target subjects mean that the information obtained is limited, which is likely to reduce the generalizability of the study results. Furthermore, a low enrollment inevitably limits the statistical power of the study. To address these limitations of previous studies, we enrolled a larger sample of subjects, and a single experienced glaucoma specialist used definitive diagnostic criteria to classify the subjects.

From the 1Department of Ophthalmology and 2The Center for Clinical Research, Keio University School of Medicine, Tokyo, Japan; and the 3Tanabe Eye Clinic, Yamanashi, Japan.

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Corresponding author: Kenya Yuki, Department of Ophthalmology, Keio University School of Medicine, 35 Shinanomachi, Shinjuku-ku, Tokyo, 160-8582, Japan; yukikenya@a6.keio.jp.
The objective of this study was to survey the prevalence of MVCs involving patients with primary open-angle glaucoma (POAG), aged over 40 and living in a suburban area of Japan, in comparison with that in control subjects comparable in age, and subsequently to analyze any association between POAG severity and MVC risk.

METHODS

The procedures used in this study conformed to the tenets of the Declaration of Helsinki and to national (Japanese) and institutional (Keio University School of Medicine) regulations. This study was approved by the Ethics Committee of the Keio University School of Medicine.

Study Design and Subject Enrollment

The design of this cross-sectional study and subject enrollment procedures are summarized in Figure 1. A total of 4360 consecutive patients who visited Tanabe Eye Clinic (Yamanashi, Japan) between January 1 and March 30, 2009, were screened for eligibility by means of an ophthalmic examination that included slit-lamp biomicroscopy, funduscopy, gonioscopy, intraocular pressure measurements with Goldmann applanation tonometry, and visual field examination with a static visual field analyzer using the 30-2 Swedish Interactive Threshold Algorithm Standard Strategy (Carl Zeiss Meditec, Dublin, CA) when necessary. Patients with ophthalmic diseases that could compromise visual acuity or visual field loss, such as age-related macular degeneration and any fundus disease apart from POAG, were excluded. Patients younger than 40 years were also excluded. Subjects who had never held a driver’s license were excluded from the analyses. The study methods were explained to every patient who met the inclusion criteria, and all of them agreed to participate. The answers to the questionnaire were collected and analyzed in a masked fashion, to avoid any observation bias.

Written informed consent was obtained from all those enrolled. A single ophthalmologist (ST) subspecializing in glaucoma performed all the examinations.

Diagnostic Criteria of POAG

POAG was diagnosed in 144 patients on the basis of the presence of the following three findings: (1) glaucomatous optic cupping represented by notch formation, generalized enlargement of cupping, senile sclerotic disc or myopic disc, or nerve fiber layer defects; (2) typical glaucomatous visual field defects, such as Bjerrum scotoma, nasal step, or paracentral scotoma, compatible with optic disc appearance; and (3) an open, nonoccludable angle observed on gonioscopy. All patients with POAG underwent a visual field examination to assess POAG severity. For the purposes of this study, we defined mild POAG as a visual field defect corresponding to a mean deviation (MD) of −5 dB or better in both eyes, moderate POAG as corresponding to an MD of −5 to −10 dB in the worse eye, and severe POAG as an MD of −10 dB or worse in the worse eye.9

We chose MD as a grading criteria rather than any of the standard methods, such as The Advanced Glaucoma Intervention Study score (AGIS score), because calculation of AGIS scores is not common clinical practice in Japan, especially in ophthalmic outpatient clinic settings. In fact, the majority of Japanese clinics do not have the necessary software to calculate AGIS scores. We considered it appropriate to try to reveal the association between glaucomatous visual field defects and MVCs by means of methods widely used in Japanese clinics.

Our criteria for mild, moderate, and severe visual field loss were based on the study by Haymes et al.,9 who reported that glaucoma patients with visual field defects corresponding to an MD of less than −10.86 dB in the worse eye were six times more likely to have been involved in self-reported MVCs. Therefore, we selected −10 dB to represent severe glaucoma and −5 dB as the median level to classify mild and moderate glaucoma.
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Table 1. Demographic Characteristics by Group

<table>
<thead>
<tr>
<th>Group</th>
<th>Control (n = 144)</th>
<th>Mild POAG (n = 50)</th>
<th>Moderate POAG (n = 51)</th>
<th>Severe POAG (n = 20)</th>
<th>P*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>61.2 ± 7.9</td>
<td>59.8 ± 8.2</td>
<td>62.8 ± 6.7</td>
<td>66.1 ± 8.5</td>
<td>0.01</td>
</tr>
<tr>
<td>Sex, male/female</td>
<td>95/49</td>
<td>31/19</td>
<td>35/16</td>
<td>13/7</td>
<td>0.91</td>
</tr>
<tr>
<td>Diabetes mellitus, n (%)</td>
<td>23 (16.0)</td>
<td>8 (16.0)</td>
<td>9 (17.6)</td>
<td>1 (5.0)</td>
<td>0.75</td>
</tr>
<tr>
<td>Hypertension, n (%)</td>
<td>16 (11.1)</td>
<td>4 (8.0)</td>
<td>3 (5.9)</td>
<td>4 (20.0)</td>
<td>0.44</td>
</tr>
<tr>
<td>BCVA (right eye), logMAR</td>
<td>0.02 ± 0.08</td>
<td>0.01 ± 0.04</td>
<td>0.04 ± 0.05</td>
<td>0.22 ± 0.36</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>MD value (right eye), dB</td>
<td>2.0 ± 1.3</td>
<td>1.5 ± 1.2</td>
<td>1.7 ± 1.5</td>
<td>2.0 ± 1.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>MD value (left eye), dB</td>
<td>2.0 ± 1.3</td>
<td>1.5 ± 1.2</td>
<td>1.7 ± 1.5</td>
<td>2.0 ± 1.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>History of driving, y</td>
<td>36.8 ± 7.6</td>
<td>55.8 ± 9.5</td>
<td>37.2 ± 8.5</td>
<td>34.6 ± 8.5</td>
<td>0.55</td>
</tr>
<tr>
<td>Time spent driving per day, min</td>
<td>27.2 ± 14.3</td>
<td>25.9 ± 17.3</td>
<td>25.7 ± 18.1</td>
<td>16.3 ± 13.1</td>
<td>0.04</td>
</tr>
</tbody>
</table>

* ANOVA and Fisher’s exact test were used depending on the variable (e.g. continuous and categorical variables).

Inclusion Criteria of Control

The 157 control participants were mostly outpatients who visited the clinic for such purposes as annual ophthalmic check-ups, screening, and correction of refractive errors or treatment of external ophthalmopathy. All control participants were free of fundus disease and cataracts affecting visual acuity.

Questionnaire

All participants were asked to complete a questionnaire (see the Appendix) that elicited information on (1) whether they had been involved in one or more MVCs over the past 10 years while driving (yes or no); (2) current daily driving habits (time spent driving per day); (3) number of years since acquisition of first driver’s license; (4) current illnesses and medical history; and (5) the demographic characteristics age and sex. Patients were excluded from the study if (1) they had never held a driver’s license, and/or (2) if they had any mental disease(s) that prevented them from understanding the questionnaire. These criteria resulted in the exclusion of 25 subjects from the POAG group and 13 from the control group.

Although previous studies of the association between glaucoma and MVCs that relied on self-reported incidence data used shorter recall periods, we decided on 10 years, because the rate of MVCs is significantly lower in Japan than in other countries such as the United States. The relatively low rate of MVC incidence in Japan is partly illustrated by the International Road Traffic Analysis Database (IRTAD; http://internationaltransportforum.org/irtad/index.html, established by the International Traffic Safety Data and Analysis Group, Organization for Economic Co-operation and Development, Paris France). According to their 2009 Road Safety Annual Report, the number of road deaths per 100,000 population in Japan was approximately one third that in the United States in 2008 (4.7 in Japan vs. 12.25 in the United States). The same trend can be observed when multiple countries are compared. As this is the first study in Japan to evaluate the association between glaucoma and MVCs, we had to use a relatively long study reference period so that we could include enough MVC events for statistical analysis.

Statistical Analysis

Descriptive statistics were calculated for the demographic, medical, and visual function variables. Homogeneity of distributions between the POAG and control groups was examined with ANOVA or Fisher’s exact test, depending on the variables. The association between POAG severity and the occurrence of MVCs was evaluated with the Cochran-Armitage trend test, for which exact statistics were used. Pairwise comparisons of the occurrence of MVCs between the control group and each of the three POAG groups were performed with Fisher’s exact test. For sensitivity analyses, adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were estimated with logistic regression models (factors: age, concomitance of diabetes, driving history, time spent driving per day, and either best corrected acuity in the better eye or that in the worse eye), to examine the effects of the confounding factors on the unadjusted results.

Pearson’s correlation coefficient was used to analyze the association between driving frequency and age, between best corrected visual acuity in the better and worse eye, and visual field defects in the better and worse visual field eye in the subjects with glaucoma (SAS, ver. 9.1, SAS, Cary, NC).

Results

A total of 157 control subjects (98 men, 59 women; age, 62.5 ± 8.5 years) and 144 POAG patients (86 men, 58 women; age, 64.0 ± 9.1 years) were recruited. All participants were Asians. Thirteen of the control subjects and 23 of the POAG subjects had never obtained a driver’s license and were therefore excluded from the study. The remaining 144 control subjects (95 men, 49 women; age, 61.2 ± 7.9 years) and 121 POAG subjects (79 men, 42 women; age, 62.1 ± 8.0 years) were evaluated. The demographic characteristics of the control, and mild, moderate, and severe POAG subjects are summarized in Table 1. There were statistically significant differences in age and best corrected visual acuity between the severe POAG group and the other groups.

The self-reported prevalences of MVCs were 3.5% (5/144) in the control group, 0% (0/50) in the mild POAG group, 3.9% (2/51) in the moderate POAG group, and 25.0% (5/20) in the severe POAG group (Table 2). The association between the occurrence of MVCs and severity of POAG was statistically significant (P = 0.007, Cochran-Armitage trend test) when the severe POAG and control groups were compared (P < 0.001, Fisher’s exact test). No significant differences in MVC occurrence
rence were observed between the control group and the mild or moderate POAG groups. For sensitivity analyses, adjusted ORs and 95% CIs were estimated with logistic regression models (factors: age, concomitance of diabetes, driving history, time spent driving per day, and best corrected acuity in the better eye or that in the worse eye) to examine the effects of the confounding factors on the unadjusted results. The adjusted ORs for the occurrence of MVCs in the severe POAG group compared with that in the control group were 7.9 (95% CI, 1.7–37.1) and 9.9 (95% CI, 2.1–47.8), respectively (adjusted for best corrected acuity in the better eye or that in the worse eye, in addition to the above-mentioned factors), which was consistent with the crude OR of 9.3 (95% CI, 2.4–35.7).

Visual field defects in the worse visual field eye (P = 0.01, R = 0.225) were significantly associated with driving frequency in the glaucoma subjects. Age (P = 0.80, R = −0.029), visual field defects in the better visual field eye (P = 0.10, R = 0.152), best corrected visual acuity in the better eye (P = 0.24, R = −0.108) and in the worse eye (P = 0.23, R = −0.109) were not correlated with driving frequency in subjects with glaucoma.

DISCUSSION

This is the first report to confirm an association between POAG and MVCs among Japanese eye clinic patients. The present study demonstrated that severe POAG with extensive visual field defects may be associated with MVC prevalence. This result supports those of previous studies.9,11 Haymes et al.9 reported that patients with significant visual field impairment (average MD in the worse eye = −10.86 ± 7.79 dB, Humphrey Visual Field Analyzer; Carl Zeiss Meditec) were more than six times more likely to have been involved in self-reported MVCs than were the controls. In a study using AGIS scores, McGwin et al.10 reported that patients with moderate and severe MD defects were likely to be involved in MVCs (OR for moderate defects, 4.2; for severe defects, 9.0). Bechetoille et al.20 showed that self-reported driving ability declines in glaucoma patients with an MD of −12 dB or worse in the more severely affected eye. In the present study, we showed that the subjects with severe POAG (visual field defects corresponding to an MD of −10 dB or worse in the worse eye) had higher odds of being involved in MVCs than did the subjects with mild or moderate POAG, and the controls subjects. These results suggest that the possibility of being involved in MVCs increases when the degree of visual field defects exceeds a certain threshold. In a prospective population-based study of glaucoma and other eye diseases, Rubin et al.17 reported that a reduced visual field was paradoxically associated with a reduction in crash risk for patients with moderate or better vision, but that the risk for those with severe visual defects was increased. Therefore, it is reasonable to assume that there is a certain threshold for visual field defects beyond which compensatory efforts such as avoiding high-risk situations are no longer effective, resulting in compromised driving safety.21

Our data suggest that patients with severe POAG drive less frequently than those with mild to moderate POAG and individuals without POAG. The reasons for this are not clear from the present study, but it is reasonable to assume that the extent and nature of visual field loss, as well as impaired bestcorrected visual acuity and aging,22,23 are responsible for the tendency.24,25 Glaucoma and visual field loss have been reported to be associated with decreased frequency and cessation of driving.10,24–26 Driving cessation is reported to be associated with decreased independence in daily living, depression,27 and a greater likelihood of nursing home admission.28 If glaucoma-related visual field defects are indeed a cause of driving cessation, this is yet another social issue facing patients with glaucoma.

The critical question, then, is what type or degree of visual field defect should be examined in glaucoma patients when they renew their driver’s licenses. Like the authors of previous reports,9,11,17 we found that only patients with severe POAG, and not all glaucoma patients, have an increased risk of being involved in MVCs. A certain level of visual acuity must be demonstrated when drivers renew their licenses, but in Japan visual field tests are not required unless visual acuity is more than 0.5 (logMAR) in the worse eye, in which case the range of the visual field must be 150° or more in the better eye. Our study showed an increased risk of MVCs in patients with severe POAG with decreased visual fields in one eye. Therefore, the current criteria for driver’s license renewal may not be stringent enough to identify those at high risk of being involved in MVCs. A large-scale nationwide prospective study that examines the association between visual field defects and MVCs will be necessary to identify effective criteria for issuing driver’s licenses.

In our study, a total of 265 study participants experienced 12 MVCs occurrence over the recall period of 10 years (4.5% for the 10 years; average annual rate, 0.5%). As we expected, the crash rate was lower than that in the United States and other countries (average annual rate: 2.9%9 and 2.3%17). The low prevalence of MVCs in our study may be partially explained by accident proneness (i.e., the fact that multiple accidents are often caused by the same driver).29

The strengths of the present study are that (1) all the subjects with POAG and the controls without POAG were examined by a single glaucoma specialist at a single institution; (2) clear diagnostic criteria for POAG were applied; and (3) a relatively large number of study subjects were enrolled consecutively in a short period compared with those in previous reports.25 The limitations are as follows: (1) The long recall period might have diminished the reporting accuracy. (2) Recall inaccuracies and reluctance to provide information may have affected the self-reported data: The subjects with POAG with visual field defects may have had clearer recall of MVC experiences than those without POAG, which may have increased the number of MVCs reported by the subjects with severe POAG. (3) Visual and ophthalmic data were obtained only after the MVCs had occurred, typically several years later. Therefore, it is possible that the visual acuity or visual field of the subjects who reported MVCs had changed between the time of the MVCs and the time when they were enrolled in the study. Unfortunately, it is impossible after the fact to evaluate each subject’s exact visual acuity or exact visual field when MVCs occurred. This factor may have reduced the accuracy of our results. (4) A relatively small number of participant reported MVCs. (5) It is possible that in some cases the glaucoma stage was misclassified because of the cross-sectional nature of the data and the progression of the disease over the long time frame. With the progression of the disease, some subjects with mild or moderate POAG when they were involved in MVCs may have been misclassified as having severe POAG at the time of the enrollment. Although we cannot gauge the exact disease severity at the time of the MVCs, higher odds of having experienced MVCs were observed in subjects with severe POAG compared with non-POAG subjects diagnosed at the same time. Also noteworthy is that the mean age of the members of the severe POAG group was higher than that of the control, mild POAG, and moderate POAG groups. As increased age is significantly associated with MVC risk,30–32 the higher age of our severe POAG group may have confounded the results.

However, having obtained consistent results after including age as a confounder in our logistic regression analyses, we remain confident in our conclusions.
The present study suggests that the level of glaucoma severity is closely associated with MCVs.

References


APPENDIX

Questions

Age: (_) years
Sex: male/female
Height: (_) cm

Medical History

Current: hypertension/diabetes/heart disease/liver disease/renal disease/others (please specify)
Smoker: yes/no
For smokers only: number of cigarettes smoked per day
Alcohol consumption: almost daily/1–2 times per week/1–2 times per month/never

Have you been injured in any falls in the past ten years? yes/no

Driving History

Do you have a driver’s license? yes/no/yes/yes/yes/never
For those who have or used to have a driver’s license:
How long have you driven/did you drive a car? (——) years
How much time do/did you spend driving per day? (——) minutes/day
Have you been involved in one or more traffic accident in the past ten years? yes/no
For those who have been involved in a traffic accident:
Were you injured in the accident? yes/no
For those who used to hold a driver’s license:
Why did you give up driving? (——)

Thank you for your cooperation.