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Glaucoma Severity and Medication Adherence in a County Hospital Population

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Abstract

Objective—To assess the association between disease severity and adherence with glaucoma medications in a county hospital population.

Design—Cross-sectional study.

Participants—One hundred and twenty-six patients diagnosed with glaucoma receiving intraocular pressure (IOP) lowering medication were recruited from the San Francisco General Hospital Ophthalmology Clinic.

Methods—Subjects completed an oral questionnaire to assess demographic information, knowledge of glaucoma, and perceptions of glaucoma medication adherence. Glaucoma disease severity was classified according to the American Academy of Ophthalmology's Preferred Practice Pattern guidelines. Medication adherence was measured for each patient by obtaining pharmacy refill data and calculating medication possession ratio (MPR)—ratio of total days' supply of medication during a 365-day period. Adherence was measured retrospectively over the 18-month period prior to study entry. Subjects with a MPR > 80% were considered adherent.

Main Outcome Measure—Medication adherence

Results—Subjects with mild or moderate glaucoma were more likely to be non-adherent to their prescribed glaucoma medications than those with severe disease (adjusted odds ratio (OR), 1.54; 95% confidence interval (CI), 1.03–2.31; $P = 0.04$). Age, gender, race, education level, years of glaucoma, number of medications and glaucoma diagnosis were not found to be statistically significantly associated with adherence.

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Shan Lin is a consultant for Merck and Allergan. Kuldev Singh is a consultant for Alcon and Allergan. No other authors have conflicts of interest.

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Conclusion—Patients with severe glaucoma were more likely to adhere to their topical IOP lowering medication regimen than those with milder glaucomatous disease.

Introduction

Multiple studies have shown that topical ocular hypotensive agents can prevent or delay optic nerve damage and the consequent visual field loss associated with glaucomatous disease.[1–4] However, few studies have robustly examined the association between glaucoma severity and medication adherence. Prior work has often been limited by small sample size and has produced conflicting results including direct association,[5–8] indirect association[9,10] or no association[11–13] between glaucoma severity and medication adherence. Only one study to date has shown a significant and direct association between poor glaucoma medication adherence and severity of visual field loss.[14] Several such studies, however, were conducted on glaucoma patient populations that may not have been representative of all those with the disease. For example, 89% of the subjects in one study were classified as being adherent with 68.6% having been diagnosed with mild visual field defects.[14] The large proportions of subjects with mild disease and good adherence in that study may have increased the likelihood of finding an association between these two parameters due to chance alone.

To our knowledge, glaucoma medication adherence has never been assessed in a low socioeconomic population despite evidence that individuals in such populations face greater barriers to adherence than those who are more affluent.[15] This study, conducted at a county hospital serving an indigent, ethnically diverse population, was designed to assess the impact of variables such as demographic factors and glaucoma severity, on medication adherence, the primary outcome variable.

Methods

Study Design

This retrospective cross-sectional study included individuals with the diagnoses of a primary or secondary glaucoma as well as those categorized as “glaucoma suspects” who were undergoing treatment with intraocular pressure (IOP) lowering medication. All subjects had been examined at the San Francisco General Hospital (SFGH) Glaucoma Clinic in San Francisco, California, between June 1, 2011 and October 31, 2011. This clinic is located in a hospital that is administered by the county of San Francisco and serves the indigent and underinsured residents of the city of San Francisco. Human subject approval for this study was obtained from the institutional review boards of SFGH, the University of California, San Francisco and the Stanford University School of Medicine.

Study Population

Patients were considered for inclusion in the study if they had: 1) an International Classification of Diseases (ICD-9) diagnosis of primary open-angle glaucoma (POAG), primary angle-closure glaucoma, exfoliative glaucoma, low-tension glaucoma or glaucoma suspect for more than one year, 2) an age of 40 years or older, and 3) filled a prescription for a topical ocular hypotensive agent within 18 months prior to the recruitment date. Patients who had undergone prior glaucoma procedures such as laser trabeculoplasty or incisional glaucoma surgery (trabeculectomy, tube implantation, etc.) were excluded, as such interventions might preclude the future necessity for continued medical therapy for glaucoma. Individuals receiving free medication samples were also excluded.

Glaucoma Disease Severity Classification

The chief of the SFGH Glaucoma Service (SL) classified each study subject into one of three categories of disease severity: mild, moderate or severe. Patients considered to have "mild" glaucoma were those who had at least one eye with (1) a structural abnormality of the optic disc or retinal nerve fiber layer consistent with glaucoma (i.e., focal notching of optic disc rim, thinning of the neuroretinal rim with increased cupping of the disc, neuroretinal rim or peripapillary retinal nerve fiber layer hemorrhages) and (2) a normal Humphrey visual field examination (i.e., not meeting the criteria for a glaucoma defect as defined below). "Moderate" glaucoma was the classification for patients with (1) optic nerve abnormalities consistent with glaucoma as detailed above and (2) the presence of a glaucomatous visual field defect that did not cross the horizontal meridian and was not within 5 degrees of fixation. A glaucomatous visual field defect was considered present when a reliable Humphrey visual field test demonstrated 3 or more abnormal non-edge contiguous points not crossing the horizontal meridian, with a probability of <5% based upon comparison with age-matched non-glaucomatous individuals in the pattern deviation plot. Reliable visual fields were those with fixation loss, false-negative, and false-positive values of 33% or less.[16–18] If a visual field was unreliable, the subject then completed testing during study enrollment to achieve a reliable field. A patient was considered to have "severe" glaucoma if either eye had (1) optic nerve abnormalities consistent with glaucoma as detailed above and (2) visual field abnormalities in both hemifields and/or loss within 5 degrees of fixation in at least one hemifield in the worse eye or (3) visual acuity so severely diminished by glaucoma that HVF testing could not be performed (in this latter case, the cup-to-disc ratio was required to be 0.9 or greater).[19] Subjects were required to have at least one reliable HVF in both eyes unless they were unable to complete this test due to severe disease. In circumstances when both eyes of the same patient were eligible for the study, the eye with the worse visual field mean deviation was selected. Patients whom a diagnosis of glaucoma was made, but who upon chart review were found to have normal visual fields and optic nerve examinations were excluded.

Oral questionnaire

After written informed consent had been obtained, all study subjects were interviewed in their preferred language: English, Spanish, Mandarin, Cantonese, Vietnamese, or Tagalog, by a trained member of the research team. An oral questionnaire was administered to assess subject demographic information, knowledge of glaucoma, perceptions pertaining to glaucoma medication adherence, and perceived barriers to such adherence. Additional information relating to each subject's past medical history, prescription data and health insurance was obtained from the medical record. All eligible patients who agreed to participate were enrolled into the study.

Assessment of Medication Adherence using Pharmacy Data

Pharmacy data was used to ascertain the frequency of filled prescriptions and the number of days for which each prescription was filled or refilled. At SFGH, prescription refill orders are sent electronically to the patient's desired pharmacy. This method of "e-prescribing" prevents patients from obtaining refills from other pharmacies without a request being made by the ophthalmologist or SFGH staff member. Any changes in pharmacy location were recorded in the subject medical record from which the study data was obtained. For the small number of subjects receiving refills from multiple pharmacies, refill data was obtained from each pharmacy. Health Insurance Portability and Accountability Act (HIPAA)-compliant consent forms, which had been obtained from study subjects, were faxed to all pharmacies at which glaucoma medications had been acquired based upon information noted in subjects' medical records. Pharmacy dispensing records were traced from the date of the interview to 18-months prior to the recruitment date.

Medication adherence was estimated using the medication possession ratio (MPR) for the 1-year period prior to the subject recruitment date. MPR was calculated as the sum of days of prescription supply dispensed divided by 365 days for each medication used, a method that has been described in previous studies.[20] Prescriptions filled before the beginning of a particular interval were counted as being used in that interval if the days supplied extended into this interval period. If a subject was simultaneously using multiple medications, the MPR for each was averaged to obtain a single MPR measure for that individual. Only medications initially prescribed at least one year prior to the recruitment date were included in the calculations for the final MPR measure. Patients were classified as "nonadherent" or "adherent" based on a MPR < 0.80 or > 0.80 respectively, which is consistent with a dichotomization of medication adherence reported in prior studies.[21,22]

Assessment of Medication Adherence using Self-Reports

Medication adherence was also measured through self-reporting. Subjects were asked, via questionnaire, to provide the percentage of time they were compliant with their glaucoma medications in the 12 months prior to the survey. The question used for this assessment was as follows: "We understand that many individuals who have been prescribed glaucoma medications find it very difficult to take them regularly and often miss doses. On a scale from 0 to 100, with 0% being you never take your medications to 100% being you always take your medications and never miss a dose, how often did you take your medications?" The interview process was undertaken in the patient's native language to assure that he or she understood the nature of the question. Guidance was provided for those who may have had difficulty with understanding the nature of the question. Subjects who reported greater than 80% adherence were considered as adherent and those who reported less than 80% were considered non-adherent for purposes of this analysis. Agreement between medication adherence by self-report versus pharmacy data was assessed using correlation coefficients and kappa statistics.

Statistical Analysis

The impact of baseline demographic factors and comorbidities on adherence was assessed using the chi-square test for categorical variables and the Student's t-test for continuous variables.

Multivariate logistic and linear regression models were used to assess the adjusted association between disease severity and medication adherence. These models were adjusted for demographic characteristics (age, gender, race, education level) and clinical features such as the number of medications being used and the number of years since the initial diagnosis of glaucoma.

All comparisons were presented as odds ratios (OR) with 95% confidence intervals (CI). *P* values of less than .05 using two-sided tests were deemed to represent a statistically significant association. All statistical analyses were conducted using IBM SPSS Statistics statistical software, version 19.0 (SPSS Inc, Chicago, Illinois).

Results

Of the 146 subjects found to be eligible for the study, all of whom were offered enrollment, 15 chose not to participate on initial contact and another 5 decided to withdraw during the interview. One hundred and twenty-six subjects completed the questionnaire, of which 63 were classified as having acceptable medication adherence based upon the previously mentioned 80% cutoff for this parameter, and 63 subjects were found to have poor medication adherence using pharmacy refill data.

Table 1 presents baseline characteristics of adherent and non-adherent subjects. Overall, the study population had a mean age of 63 years and approximately 60% of subjects were women. A majority of the patients were unemployed and had some form of government-sponsored health insurance. Of the subjects classified as having good adherence, 8 (12.7%) were White, 11 (17.5%) were Black, 16 (25.4%) were Latino and 28 (44.4%) were Asian.

Table 2 compares the clinical characteristics of mild/moderate and severe glaucoma subjects. Subjects with severe glaucoma were more likely to be taking multiple glaucoma medications than those with mild/moderate disease. Furthermore, severely diseased patients were more likely to be taking alpha-agonists, carbonic anhydrase inhibitors, and beta blockers, which are commonly used second and third line medications used adjunctively with prostaglandin analogs, than mild/moderate patients. Disease severity was found to be associated with medication adherence, with subjects classified as having mild disease being more likely to be non-adherent than those with severe disease.

Potential predictors of poor medication adherence relating to knowledge regarding glaucomatous disease are shown in Table 3. In the unadjusted analysis, adherent patients were more likely to have been counseled by the clinic staff regarding the implications of a glaucoma diagnosis including the natural history and treatment of the disease, relative to those who were non-adherent (OR 2.15, 95% CI 0.99–4.71, $P = 0.05$). Upon further analysis, patients with severe glaucoma were no more likely to have received counseling regarding a glaucoma diagnosis relative to those with less severe disease (OR 1.15, 95% CI 0.53–2.47, $P = 0.85$). There was no statistically significant association found between adherence and basic knowledge of glaucoma as represented by an understanding of the lifelong necessity for glaucoma treatment and the possibility that glaucoma can cause blindness.

Table 4 presents the concordance of medication adherence as assessed by self-reporting versus filled prescriptions. There was poor concordance between these two measures with subjects self-reporting better adherence with their medications than was supported by pharmacy information (kappa= 0.21; 95% CI0.05–0.36, $P = 0.02$).

Multivariate Logistic and Linear Regression Analyses

The adjusted association between disease severity and medication adherence is presented in Table 5. In the multivariate analysis, which adjusted for potential confounding variables, the association between disease severity and medication adherence showed a statistically significant odds ratio of 1.54 (95% CI, 1.03–2.31; $P = 0.04$) with subjects with mild or moderate glaucomatous disease more likely to be non-adherent with prescribed glaucoma therapy relative to those with severe disease. Age, gender, race, education level, years of glaucoma, number of medications and glaucoma diagnosis were not found to be statistically significantly associated with non-adherence.

A linear regression analysis was also performed to confirm an association between disease severity and adherence, with MPR used as a continuous surrogate variable for adherence (Table 6). This analysis revealed an association between disease severity and adherence with subjects having more severe disease demonstrating better adherence (β=0.088; $P = 0.04$).

Discussion

It is widely assumed that poor outcome amongst those with glaucomatous disease is associated with poor adherence to medications because IOP lowering with medications has been shown to be effective in slowing disease progression.[23,24] This hypothesis, as well as quantification of the relationship between severity of glaucomatous disease and adherence,

is difficult to study. [25,26] Several studies have failed to conclusively show an association between disease severity and objective measures of medication adherence.[11–13]

Our study is the first to show that mild glaucomatous disease is associated with poor adherence to glaucoma medications. These results differ from those of *Sleath et al*, who showed a significant and direct association between more severe glaucoma and medication adherence. There may be several explanations for these disparate results, including demographic differences between the populations ascertained in the respective studies. While *Sleath et al.* enrolled individuals from a predominately white (67%) private practice setting, our subjects were recruited from a public county hospital population with greater ethnic diversity. Ninety-eight percent of our study subjects had some form of government-issued health insurance. The two study populations also differed with regard to the distribution of disease severity and adherence status. While 68.6% of subjects in *Sleath et al*'s study had mild glaucoma, 44% of those in our study were classified as having mild/moderate disease. The approximate equal split in our study population with regard to disease severity and adherence status optimizes the likelihood of finding a true association between these two parameters, if one exists.

The two studies also differed with regard to how medication adherence was quantified. We relied on the medication possession ratio from patients' most-recent pharmacy records as a surrogate measure of adherence, while *Sleath et al.* used an electronic medication monitor. There is no universally accepted gold standard for assessing medication adherence, which further limits the conduct of, and comparison between, such studies. While electronic medication monitors provide an objective way to measure adherence, these devices are expensive, costing approximately $120 per unit,[27] and their use in a study setting may impact compliance due to subjects knowing that they are being monitored. Pharmacy refill data overcomes the potential bias associated with patient monitoring but may have other associated limitations such as patients refilling their prescriptions but not taking the medications as prescribed. Medication possession ratio (MPR) ascertained from pharmacy data is a particularly robust measure of adherence as it reflects a wide range of refilling behaviors, including the use of multiple medications and non-continuous refilling of medications.[20] MPR has been a commonly used parameter for quantifying glaucoma medication adherence in several studies utilizing large insurance claims databases.[12,20,28]

Our method of quantifying glaucoma disease severity also differed slightly from that used by *Sleath et al* who classified severity based solely on visual field defects. Our study screened for the presence of both structural and functional optic nerve abnormalities that characterize glaucomatous disease. All patients, regardless of disease severity, were only deemed eligible for the study if they had structural optic nerve abnormalities, a criteria which is based on the American Academy of Ophthalmology Preferred Practice Patterns (PPP) guidelines for primary open-angle glaucoma,[29] and has been used by several other studies that have aimed to comprehensively characterize glaucoma severity in specific populations.[15,17,18] It is well known that visual field abnormalities mimicking glaucoma can be caused by other ocular conditions.[30] It is also accepted that glaucomatous changes in the ONH may precede the development of reproducible glaucomatous visual field defects.[31–36] Thus our classification of disease based upon structural optic nerve findings in addition to visual field testing may have allowed us to include more subjects with early glaucoma, and also to exclude those who had visual field defects secondary to diseases other than glaucoma.

While our study showed that greater disease severity was associated with better adherence, disease symptoms were not found to correlate with adherence. Subjects in our study varied with regard to the time between initial diagnosis and recruitment into the study with an

average duration of 6.5 years. Given that all subjects had been diagnosed with glaucoma for at least a year prior to recruitment, many, as expected, had difficulty being certain whether or not they were symptomatic upon presentation. It is possible that this difficulty in recall may contribute to our finding that the presence of symptoms at presentation did not predict better adherence to glaucoma medications.

One limitation of our study was that given our public county hospital setting with a predominantly indigent population, we did not have access to the large insurance claims databases that represent patients in private insurance or managed care settings. Glaucoma patients at SFGH receive their medications from several different pharmacies in the San Francisco area and without a single comprehensive pharmacy database, our study population was limited to those patients who gave consent for review of their pharmacy records. In all, 91% of eligible subjects provided such consent, suggesting that selection bias likely had a small impact on our study results.

The ethnic diversity of our study population allowed for the first examination of adherence as a possible correlate with disease severity in Black and Latino populations, which together comprise approximately half of the subjects in the study. While the prevalence of glaucoma is estimated to be approximately four times greater in Blacks and Latinos relative to White populations in the United States,[37,38] most adherence studies have not included enough subjects from these former groups to draw meaningful conclusions regarding relationships between ethnicity, disease severity, and adherence. We did not find race to be a predictor of non-adherence but acknowledge that the study may not have been adequately powered to show such a relationship. Furthermore, low socioeconomic status, which has previously been reported to be associated with poor adherence,[39] could not be assessed as a risk factor for adherence in this study as nearly all patients fell into this socioeconomic category and thus there was no appropriate comparator group.

Our results support the hypothesis that self-reporting is associated with an over estimation of adherence relative to results from pharmacy data (Table 4). Self-reported adherence is a commonly employed measure of adherence used in the clinical care of patients and this is the first study to measure its reliability in a county hospital population. Patients may overestimate compliance for several reasons including the desire to please a treating physician or a study investigator.[40] We explored the association between self-reported poor adherence and adherence assessed by pharmacy data and found poor concordance, approximately 40%, between these two measures. It is noteworthy, however, that our findings do not necessarily disprove the commonly held belief that subjects overstate good adherence, but more accurately report poor adherence as the study was not designed to specifically address this issue.

As with any cross-sectional study, a cause-and-effect relationship between glaucoma severity and non-adherence to medications cannot be established from our data. Nonetheless, this study provides the first evidence suggesting glaucoma severity may impact patient adherence to glaucoma medications. Given the weight of evidence showing the benefits of IOP lowering therapy in preventing glaucomatous disease progression, it is far more likely that greater disease severity results in better adherence, rather than greater adherence resulting in more severe disease. The psychological theory of treatment motivation suggests that one of the biggest determinants of a patient's likelihood of following a treatment plan is awareness regarding disease pathogenesis.[41] It can be postulated that those with mild glaucoma commonly do not fully understand the severity of vision loss that can occur with glaucomatous disease—only becoming more adherent to their medication regimen when the disease state is severe enough to cause a visual disturbance. Such a hypothesis could also explain the finding in our study that patients who were

adherent were more likely to have been counseled regarding glaucoma natural history, diagnosis and treatment by clinic staff relative to non-adherent patients.

In summary, we found that increased disease severity was associated with greater medication adherence in the setting of a county hospital caring for an ethnically diverse indigent population. The several limitations of our study, including small sample size and the assumptions regarding the validity of parameters being used as surrogates for adherence, must be considered when drawing such conclusions. While further prospective confirmatory work in this area will be made much easier as the metrics for measuring adherence continue to be refined, studies attempting to correlate disease outcomes with adherence will likely remain difficult to validate in the near future.

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Table 1

Demographic Characteristics of Adherent and Non-Adherent Subjects

Characteristic	No. of Adherent Individuals (*n*=63)	No. of Non-Adherent Individuals (*n*=63)	Unadjusted OR for Poor Medication Adherence (95% CI)	*P* value
Age, mean (SD), y	64.1 (10.3)	61.3 (9.0)		0.11
Gender				
Male	26 (41.2)	25 (39.7)	1 [Reference]	NA
Female	37 (58.7)	38 (60.3)	1.07 (0.52–2.18)	0.85
Race/Ethnicity				
White	8 (12.7)	10 (15.9)	1 [Reference]	NA
Black	11 (17.5)	16 (25.4)	1.16 (0.35–3.89)	0.81
Latino	16 (25.4)	17 (27.0)	0.85 (0.27–2.69)	0.78
Asian	28 (44.4)	20 (31.7)	0.57 (0.19–1.70)	0.32
Education Level[a]				
Low	20 (31.7)	22 (34.9)	1 [Reference]	NA
Medium	22 (34.9)	21 (33.3)	0.87 (0.37–2.03)	0.74
High	21 (33.3)	20 (31.7)	0.87 (0.37–2.05)	0.74
Employment Status				
Employed	23 (36.5)	20 (31.7)	1 [Reference]	NA
Not working/retired/unemployed/laid off	40 (63.5)	43 (68.3)	1.24 (0.59–2.59)	0.57
Health insurance status				
Government coverage (Medicare, MediCal, SF Health Plan)	62 (98.4)	60 (95.2)	1 [Reference]	NA
Private	0 (0)	2 (3.2)	1.66E +09	1
No Insurance	1 (1.6)	1 (1.6)	1.03 (0.06–16.89)	0.98
Pharmacy Location[b]				
SFGH Pharmacy	9 (14.3)	15 (23.8)	1 [Reference]	NA
Walgreens	53 (84.1)	44 (69.8)	0.50 (0.20–1.24)	0.07
Other	4 (6.3)	7 (11.1)	1.05 (.24–4.61)	0.79
Size of Household, mean (SD)	2.47 (1.65)	2.53 (1.34)		0.81
Single	15 (23.8)	17 (27.0)	1 [Reference]	NA
Two	27 (42.9)	15 (23.8)	0.49 (0.19–1.25)	0.14
Three or more	18 (28.6)	26 (41.3)	1.28 (0.51–3.19)	0.61
Did not answer	3 (4.8)	5 (7.9)	1.47 (0.30–7.21)	0.75
Comorbid Conditions				
Diabetes (yes vs. no)	21 (33.3)	27 (42.9)	1.5 (0.73–3.09)	0.27
Hypertension (yes vs. no)	36 (57.1)	30 (47.6)	0.68 (0.34–1.38)	0.29

Characteristic	No. of Adherent Individuals (*n*=63)	No. of Non-Adherent Individuals (*n*=63)	Unadjusted OR for Poor Medication Adherence (95% CI)	*P* value
Arthritis (yes vs. no)	10 (15.9)	20 (26.3%)	2.47 (1.04–5.82)	0.04
Cardiovascular Disease (yes vs. no)	8 (12.7)	11 (17.5)	1.45 (0.54–3.90)	0.46
Asthma (yes vs. no)	2 (3.2)	8 (12.7)	4.44 (0.90–21.79)	0.07
Hypercholesteremia (yes vs. no)	27 (42.9)	21 (33.3)	0.67 (0.32–1.37)	0.27

[a] Low: no formal education beyond primary school; medium: secondary school education or equivalent certification; high: undergraduate university or community college coursework

[b] Some patients received pharmacy records from multiple pharmacy locations.

OR = odds ratio; CI= confidence interval; SD= standard deviation; NA= not applicable SF= San Francisco; SFGH= San Francisco General Hospital

Table 2

Clinical Characteristics of Mild/Moderate and Severe Glaucoma Subjects

Characteristic	No. of Mild/Moderate Individuals (*n*=56)	No. of Severe Individuals (*n*=70)	Unadjusted OR for Severe Glaucoma Disease (95% CI)	*P* value
Years with a glaucoma diagnosis, mean (SD)	6.62 (4.83)	6.29 (6.06)		0.74
Diagnosis of glaucoma				
POAG	26 (46.4)	40 (57.1)	1 [Reference]	NA
PACG	7 (12.5)	16 (22.9)	1.49 (0.54–4.10)	0.62
NTG/LTG	1 (1.8)	9 (12.9)	5.85 (0.70–48.95)	0.09
PXFG	0 (0)	5 (7.1)	2.60 (0.28–24.58)	0.15
Glaucoma suspect	22 (39.3)	0 (0)	.07 (0.01–0.30)	0.01
Number of glaucoma medications, mean (SD)	1.80 (0.98)	2.75 (1.13)		0.05
One	30 (53.6)	14 (20.0)	1 [Reference]	NA
Two	10 (17.9)	17 (24.3)	3.64 (1.33–9.96)	0.02
Three or more	16 (28.6)	39 (55.7)	5.22 (2.21–12.32)	0.01
Medication Adherence				
Adherent	22 (39.3)	41 (58.6)	1 [Reference]	NA
Non-adherent	34 (60.7)	29 (41.4)	0.46 (0.22–0.94)	0.05
Drug Therapeutic Category				
Prostaglandins (yes vs. no)	43 (76.8)	60 (85.7)	1.81 (0.73–4.51)	0.25
Alpha-Agonists (yes vs. no)	13 (23.2)	33 (47.1)	2.95 (1.35–6.42)	0.01
CAI (yes vs. no)	13 (23.2)	30 (42.9)	3.06 (1.42–6.60)	0.02
Beta Blockers (yes vs. no)	29 (51.8)	58 (82.9)	4.5 (2.00–10.10)	0.01
Combination (yes vs. no)	1 (1.8)	1 (1.4)	0.79 (0.05–13.02)	1.00

OR = odds ratio; CI = confidence interval; SD = standard deviation; POAG = Primary Open-Angle Glaucoma; PACG = Primary Angle-Closure Glaucoma; NTG/LTG = Normal Tension Glaucoma (also called Low Tension Glaucoma); PXFG = Pseudoexfoliative Glaucoma CAI = Carbonic Anhydrase Inhibitor

Table 3

Association Between Glaucoma Education and Adherence

Predictor	No. of Adherent Individuals (*n*=63)	No. of Non-Adherent Individuals (*n*=63)	Unadjusted OR for Poor Medication Adherence (95% CI)	*P* value
Recollection of being counseled regarding glaucoma by clinic staff				
Yes	49 (77.8)	39 (61.9)	1 [Reference]	NA
No	14 (22.2)	24 (38.1)	2.15 (.99 – 4.71)	0.05
Knowledge of IOP-glaucoma relationship				
Yes	50 (79.4)	45 (71.4)	1 [Reference]	NA
No	13 (20.6)	18 (28.6)	1.54 (.68–3.49)	0.3
Knowledge of glaucoma being a disease defined by optic nerve damage				
Yes	30 (47.6)	32 (50.8)	1 [Reference]	NA
No	33 (52.4)	31 (49.2)	.88 (.44–1.77)	0.72
Glaucoma Symptoms at diagnosis				
Symptomatic	31 (49.2)	25 (39.7)	1 [Reference]	NA
Asymptomatic	28 (44.4)	30 (47.6)	1.33 (.64–2.78)	0.45
Missing	4 (6.3)	8 (12.7)	2.48 (.67–9.20)	0.17
Understanding regarding duration of glaucoma treatment				
Permanent	33 (52.4)	30 (47.6)	1 [Reference]	NA
Until Symptoms Resolve	6 (9.5)	7 (11.1)	1.28 (.39–4.25)	0.68
Not Sure	24 (38.1)	26 (41.3)	1.19 (.57–2.51)	0.64

OR = odds ratio

CI = confidence interval

SD = standard deviation

IOP = intraocular pressure

Table 4

Self-Reporting vs. Pharmacy Record Confirmation of Adherence

	Pharmacy Records			
	Adherent (*n*=63)	**Non-Adherent (*n*=63)**	**Kappa (95% CI)**	***P* value**
Self Report				
Adherent	51 (81.0)	38 (60.3)	0.21 (0.05–0.36)	0.02
Non-Adherent	12 (19.0)	25 (39.7)		

CI = confidence interval

Table 5

Multivariable Logistic Regression Analysis of Factors for Poor Medication Adherence

Variable	Unadjusted OR	P value	Adjusted OR	P value
Age (per year)	1.03 (0.99–1.07)	0.11	1.03 (0.99–1.07)	0.22
Gender (male vs. female)	1.07 (0.52–2.18)	0.85	1.07 (0.50–2.29)	0.87
Race (Asian vs. non-Asian)	0.58 (.28–1.20)	0.14	0.61 (0.27–1.39)	0.24
Education (less than high school vs. more)	0.93 (0.44–1.96)	0.85	0.77 (0.34–1.74)	0.53
Diagnosis of glaucoma (POAG vs. other)	0.88 (0.43–1.78)	0.72	0.85 (0.40–1.81)	0.67
Number of medications (1 vs. ≥ 2)	0.87 (.42–1.81)	0.71	0.66 (.28–1.57)	0.35
Years of having glaucoma (per year)	1.00 (.94–1.07)	0.95	1.00 (.93–1.08)	0.92
Disease severity (mild/moderate vs. severe)	2.19 (1.07–4.47)	0.03	1.54 (1.03–2.31)	0.04

OR = odds ratio

POAG = Primary Open-Angle Glaucoma

Table 6

Multivariable Linear Regression* Analysis of Factors for Poor Medication Adherence

Variable	β	95% CI	P value
Age (per year)	.004	(−.004, .012)	0.37
Gender (male vs. female)	−.013	(−.173, .148)	0.88
Race (Asian vs. non-Asian)	−.073	(−.245, .099)	0.40
Education (less than high school vs. more)	.040	(−.130, .209)	0.65
Diagnosis of glaucoma (POAG vs. other)	−.064	(−.224, .096)	0.43
Number of medications (1 vs. ≥ 2)	−.134	(−.312, .045)	0.14
Years of having glaucoma (per year)	.001	(−.015, .016)	0.93
Disease severity (mild/moderate vs. severe)	.088	(.004, .171)	0.04

MPR = Medication Possession Ratio; CI=confidence interval; POAG= Primary Open-Angle Glaucoma

*Adherence was measured using MPR as a continuous variable

Model R^2 = .079