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ORIGINAL RESEARCH

Comparison of Presbyopia Between Glaucoma Patients Using Prostaglandin F Receptor Agonists and Fixed Combination Therapy

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Objective: The purpose of this study was to compare the near add power among glaucoma patients using prostaglandin F (FP) receptor agonists and fixed combination therapies and controls.

Methods: Participants were aged from 40 to 69 years and phakic with visual acuity of 20/25 or better, and included 2200 controls, 784 patients using FP receptor agonist for primary open-angle glaucoma (FP), and 412 patients using fixed combination (Combi). Each group was further divided into three groups based on age: those aged 40 to 49 years (40s), those aged 50 to 59 years (50s), and those aged 60 to 69 years (60s), and the near add power at 30 cm and various ophthalmic factors were compared.

Results: The mean near add power for the control, FP, and Fixed combination groups were 1.21±0.66, 1.88±0.75 and 2.04±0.81 for those in their 40s, 2.16±0.59, 2.48±0.55 and 2.70±0.53 for those in their 50s, and 2.74±0.38, 2.89±0.35 and 2.97±0.17 for those in their 60s, respectively. Significant differences were found between all pairs of groups in all age groups ($P<0.05$, *t*-test). The odds ratios for near add power reaching 3.00 D were 4.8 (95% CI, 4.0–5.7) for glaucoma, 2.5 (2.1–3.0) for FP, and 6.0 (4.7–7.9) for the Fixed combination group, all of which were significant.

Conclusion: The mean near add power of the Fixed combination group was higher than that of the control and FP groups for the same ages, indicating a faster progression of presbyopia.

Keywords: presbyopia, glaucoma, near add power, prostaglandin F (FP) receptor agonist, fixed combination accommodation

Introduction

Glaucoma is an optic neuropathy, often due to elevated intraocular pressure (IOP). Managing IOP is essential in treating glaucoma, and eyedrops are a common first-line treatment.[1] Fixed combination eyedrops, which contain two active ingredients, are particularly useful for patients requiring multiple medications to control their IOP. Patients can use fewer eyedrops, simplifying their treatment regimen, and they have been widely used for better adherence, minimal side effects, and efficacy.[2,3] Commonly used fixed combinations include prostaglandin F (FP) receptor agonists and beta blockers, and fixed combination latanoprost/timolol was first introduced in 2010. FP receptor agonists increase the outflow of aqueous humor, while beta blockers reduce its production. Patients may experience side effects from each of these active agents; as glaucoma requires lifelong care and gradually progresses, careful consideration of the efficacy and side effects of treatment is crucial for vision restoration and preservation.

Presbyopia is an age-related deterioration of focusing ability that begins early in life and two thirds of accommodative ability dioptrically lost by age 34[4] and 50% of forward muscle movement is lost by age 30.[5,6] Presbyopia decreases quality of life and induces a significant economic burden as reported by several investigators.[7,8] The demand for near vision[9] and the number of people suffering from presbyopia is rapidly increasing[10,11] in a digitalized and super-aging society.

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Both glaucoma and presbyopia are typical age-related ocular disorders, and their prevalence rapidly increases from around the age of 40 years, these conditions becoming serious health problems when productivity for these people is high. The pathophysiologies of these disorders are associated with the ciliary body and surrounding tissues, which are responsible for aqueous production, outflow, and ciliary muscle mobility that manipulate lens thickness and the kinetics of accommodation.[12,13] The ciliary muscle plays an important role in the regulation of aqueous humor outflow, which is essential for maintaining IOP. When the ciliary muscle contracts, it pulls on the scleral spur, which in turn opens the trabecular meshwork. This action facilitates the outflow of aqueous humor through Schlemm's canal into the episcleral veins. Relaxation of the ciliary muscle increases the spaces between the muscle fibers, allowing aqueous humor to flow through the uveoscleral pathway. This route involves the aqueous humor passing through the ciliary muscle and exiting through the suprachoroidal space. With aging, the efficiency of aqueous humor outflow can decrease due to the increased stiffness of ciliary muscle insertion[12,13] leading to higher IOP and an increased risk of glaucoma. FP receptor agonists contract the ciliary muscle[14] and EP receptor agonists relax it[15] to achieve pressure reduction, for example. Previous experimental and clinical studies have suggested that glaucoma medication may be associated with presbyopia,[12–17] and recent clinical studies indicated that near add power increased earlier in glaucoma patients than in non-glaucoma individuals.[18–20] However, the effects of beta blockers on presbyopia have not been fully clarified in clinical settings although weak effects were suggested from experimental and clinical studies.[21–23]

The aim of this study was to compare the near add power and ocular parameters between glaucoma patients treated with FP receptor agonists and fixed combination therapies across different age groups. Additionally, we sought to identify which parameters significantly affect near add power using regression analysis. This study focused on detecting presbyopia progression by analyzing participants aged between 40 and 69 years, an age range when the amplitude of accommodation is roughly linear, and most individuals begin to experience focusing difficulties, start using reading glasses, and near add power becomes stable.[24,25]

Methods

Study Design, Patient Recruitment, and Institutional Review Board Approval

This study was a hospital-based, cross-sectional analysis involving outpatient participants consecutively enrolled from Otake Eye Clinic in Kanagawa, Japan, between December 2018 and March 2024. The study received approval from the institutional review boards and ethics committees of the Kanagawa Medical Association (approval granted on 12 November 2018, under permission number krec2059006), adhering to the principles of the Declaration of Helsinki. Informed consent was waived as the Kanagawa Medical Association's institutional review boards and ethics committees approved an opt-out consent process for this study. Additionally, the Institutional Review Board and Ethics Committee of Keio University School of Medicine approved this study (approval date, 31 May 2024; approval number 20241019) to permit authorship for authors (KN, AH, and MA) affiliated with the Keio University School of Medicine. The protocol was registered with the UMIN Clinical Trials Registry (UMIN000051891) on 15 August 2023.

Inclusion and Exclusion Criteria

We recruited consecutive patients aged 40 to 69 years with bilateral phakic eyes and a best-corrected visual acuity of 20/25 or better in both eyes. Patients who had near add power measured were selected and classified into three groups: glaucoma patients using FP receptor agonists (FP group), glaucoma patients using fixed combination therapy (Fixed combination group), and a control group. Exclusion criteria included a history of corneal or intraocular surgeries, including ocular laser treatment and refractive or cataract surgeries, and moderate-severe cataract (≥ Grade 2 nuclear cataract based on the WHO cataract grading system)[26] since nuclear sclerosis may affect near add power.[27] The FP, Combi, and control groups were further divided into three age groups: the 40s group (aged 40 to 49 years), the 50s group (aged 50 to 59 years), and the 60s group (aged 60 to 69 years).

Ophthalmological Examinations and Diagnosis of Glaucoma

All participants underwent a comprehensive ophthalmologic evaluation, including best-corrected visual acuity, slit lamp examination, IOP measurement, fundus examination, and standard automated perimetry using the Humphrey Visual Field Analyzer Swedish Interactive Threshold Algorithm–Standard 24–2 program (Carl Zeiss Meditec, Dublin, CA, USA).[28] Patients with cataracts or other non-glaucomatous ocular conditions that could cause visual field defects were excluded following a basic eye exam. Glaucoma was diagnosed when at least two reliable visual field tests confirmed glaucomatous visual field defects consistent with glaucomatous optic disc changes. Patients with secondary glaucoma were excluded. Consequently, patients with primary open-angle glaucoma treated with eyedrops for more than six months were enrolled. Topical glaucoma medications used included FP receptor agonists: 0.005% latanoprost, 0.0015% tafluprost, 0.004% travoprost, and 0.03% bimatoprost; and fixed combinations of FP receptor agonist/beta blocker: 0.5% timolol and 2% carteolol. Eighty percent of the fixed combination users were previously prescribed an FP receptor agonist. The evaluation of control participants involved measuring best-corrected visual acuity, slit-lamp biomicroscopy, funduscopy, IOP measurements, optical coherence tomography, or Humphrey Field Analyzer. Corneal vital staining and fluorescein tear break-up time were assessed according to previously described procedures.[29] The prescribed eyedrops for dry eye treatment included 0.1% hyaluronate, 3% diquafosol, and 2% rebamipide. Binocular near add power was determined by a blinded examiner using a Bankoku near-acuity chart (Handaya Inc., Tokyo, Japan) at a distance of 30 cm. After establishing the patient's distance refractive correction, the minimum additional power required for near acuity $\geq$ 20/25 was measured in increments of 0.25 or 0.50 D and recorded as the near add power.

Optical Coherence Tomography

Optical coherence tomography (RS-3000, Nidek, Aichi, Japan) was used to measure the thickness of the macular retinal nerve fiber layer (RNFL), ganglion cell layer + inner plexiform layer, macular RNFL + ganglion cell layer + inner plexiform layer (GCC) from the maps derived from macular cube scans of a fovea-centered 6×6 mm area. For peripapillary RNFL imaging, raster scanning over a 6×6 mm area centered on the optic disc center was conducted at a scan density of 512 A-scans (horizontal) × 128 B-scans (vertical). Peripapillary RNFL measurements were obtained using a 3.45-mm diameter circle that was automatically centered around the optic disc.

Statistical Analysis

Patient demographics and ophthalmological parameters are presented as the mean ± standard deviation for continuous variables and as percentages for categorical variables. *t* tests and chi-squared tests were used to compare these demographics at the same age group, as appropriate. Subgroups with each type of eyedrop were also compared. To explore possible ophthalmic parameters that were associated with near add power, we performed univariate regression analysis. Consequently, we selected age, sex, spherical equivalent, astigmatism, IOP, mean deviation, cup/disc ratio, GCC and RNFL thickness, presence of glaucoma, short tear break-up time, and use of dry eye medication as explained variables. We then estimated the odds ratios (ORs) and 95% confidence intervals for the presence of advanced presbyopia (characterized by a cutoff point of near add power 3.00 D) in relation to each selected ophthalmic parameter, using logistic regression models. Kaplan-Meier survival analysis was used to compare the age of reaching a near add power of 3.00 D between the three groups and results were analyzed with the Log rank test. Given that the decline of accommodation amplitude starts at birth, a near add power of 3.00 D was set as the endpoint when presbyopia may become stable.[4–6,24,25] If presbyopia progressed more rapidly, the survival rate decreased earlier. This method has been repeatedly used previously.[18–20] All analyses were performed using StatFlex (Atech, Osaka, Japan), with a P-value < 0.05 considered to indicate a significant difference.

Results

Patient demographics and baseline characteristics are shown in Table 1. Mean spherical equivalent was −4.57±3.76D (−16.00-+9.00D). Between the FP and Fixed combination groups, there was no difference in mean age or mean deviation, but there was significant difference in astigmatism, near add power, IOP, cup/disc ratio, and GCC thickness. Significant differences were found in near add power between all pairs of age groups and between all pairs of study

Table 1 Patient Demographics and Baseline Characteristics

Age Group	40s			50s			60s		
Study Group	**Cntr**	**FP**	**Combi**	**Cntr**	**FP**	**Combi**	**Cntr**	**FP**	**Combi**
Number (% men)	600 (29.3**)	118 (58.5)	120 (74.2*)	1000 (27.2)	387 (44.8)	195 (40.2)	600 (28.3*)	337 (46.9)	137 (37.4)
Mean age, y	45.5 (2.5)	46.0 (2.5)	45.5 (1.8)	54.3 (2.7)	54.4 (2.7)	54.2 (2.8)	64.4 (1.8)	64.7 (2.8)	64.9 (3.8)
SE, D	−3.24** (3.24)	−5.38 (3.24)	−5.44 (3.37)	−3.24** (3.60)	−4.41 (3.65)	−6.39** (4.14)	−1.66** (2.87)	−3.67 (3.46)	−2.79 * (3.52)
Astigmatism, D	0.54 (0.89)	0.76 (0.86)	0.51** (0.65)	0.59 (0.86)	0.84 (1.00)	0.49 ** (0.59)	0.74 (0.83)	0.97 (0.79)	0.67** (0.69)
Anisometropia, D	0.53 (0.66)	0.60 (0.92)	0.49 (0.58)	0.57** (0.76)	0.78 (1.18)	0.40** (0.51)	0.60** (0.98)	0.96 (1.16)	0.74 (1.09)
Near add power, D	1.21** (0.66)	1.88 (0.65)	2.04* (0.81)	2.16** (0.59)	2.48 (0.61)	2.70** (0.53)	2.74** (0.38)	2.89 (0.25)	2.97** (0.17)
Near add power ≥ 3.0 D, %	1.8**	39.7	26.7*	14.2**	39.7	55.6**	60.3**	80.4	93.2**
Glaucoma-related clinical features									
IOP, mmHg[†]	16.1 (3.2)	15.6 (3.4)	13.8** (2.5)	16.1** (3.6)	14.6 (3.0)	14.3* (2.9)	15.4** (3.3)	14.0 (3.1)	14.1 (3.5)
MD, dB[†]	−2.3** (3.3)	−7.9 (5.4)	−6.7 (5.3)	−2.6** (3.6)	−7.4 (6.7)	−7.2 (7.0)	−3.3** (4.5)	−8.1 (5.6)	−7.8 (8.0)
C/D ratio, %[†]	62** (15)	79 (12)	75* (10)	62** (14)	75 (13)	76 (13)	63** (15)	78 (10)	79 (14)
GCC, μm[§]	87.9** (11.6)	74.4 (9.0)	71.3** (8.0)	86.7** (11.3)	75.0 (12.0)	68.5** (9.7)	86.0** (10.8)	72.3 (9.5)	70.5** (11.4)
RNFL, μm[§]	118.2** (21.5)	89.4 (12.9)	86.2 (10.7)	112.2** (19.8)	89.9 (20.4)	88.2 (13.4)	114.5** (20.1)	87.1 (21.4)	93.2* (33.9)
Dry eye-related clinical features									
BUT, s	3.3 (2.3)	3.2 (2.2)	3.4 (2.3)	3.3 (2.3)	3.2 (2.2)	3.4 (1.8)	3.1* (2.2)	3.5 (2.2)	4.4** (3.0)
Short BUT, %	46.8**	78.6	72.9	44.8	74.7	74.8	44.9**	69.4	57.0*
SPK, %	32.0	38.4	33.3	27.6	28.2	25.5	21.7	23.3	35.4*
Use of dry eye medication, %	10.1*	16.2	51.4**	19.4	22.2	27.8	13.5	15.9	13.3

Notes: Data are presented as mean and standard deviation in parentheses unless specified otherwise. [†]worse eye. [§]mean of both eyes. *$P < 0.05$, **$P < 0.01$, vs FP; unpaired *t* test with Bonferroni correction or chi-squared test.

Abbreviations: Cntr, control; FP, FP receptor agonist user; Combi, fixed combination user; SE, spherical equivalent; IOP, intraocular pressure; MD, mean deviation; GCC, ganglion cell complex thickness; RNFL, peripapillary retinal nerve fiber layer thickness; BUT, tear break-up time; SPK, superficial punctate keratitis.

groups ($P < 0.05$, *t* test; Figure 1). The age of initiation of glaucoma medication and the duration of medication in the 40s groups were 42.1 ± 5.3 years and 4.2 ± 4.7 years for the FP group and 40.4 ± 3.2 and 5.1 ± 2.8 for the Fixed combination group, respectively (both $P < 0.01$). Twenty-three patients (19.2%) in their 40s in the Fixed combination group were prescribed with a fixed combination therapy as a first medication. A Kaplan-Meier survival plot showing the age at which individuals reached the near add power endpoint of +3.0 D demonstrated that the earliest was the Fixed combination group, then the FP group, and then controls ($P < 0.01$, Log rank test; Figure 2).

The comparison of mean near add power between groups based on particular FP receptor agonists and the corresponding fixed combination therapies showed that near add power was different between the latanoprost and latanoprost/timolol groups (Table 2). Regression analysis indicated near add power was significantly associated with age, sex, spherical equivalent, astigmatism, IOP, mean deviation, cup/disc ratio, GCC and RNFL thickness, presence of glaucoma, short tear break-up time, and use of dry eye medication (Table 3). The ORs for near add power reaching 3.0 D were significant for the same parameters as the regression analysis (Table 4). Specifically, the OR was 4.8 (95% confidence interval, 4.0–5.7) for glaucoma, 2.5 (2.1–3.0) for FP drug use, and 6.0 (4.7–7.9) for fixed combination drug use (Table 4).

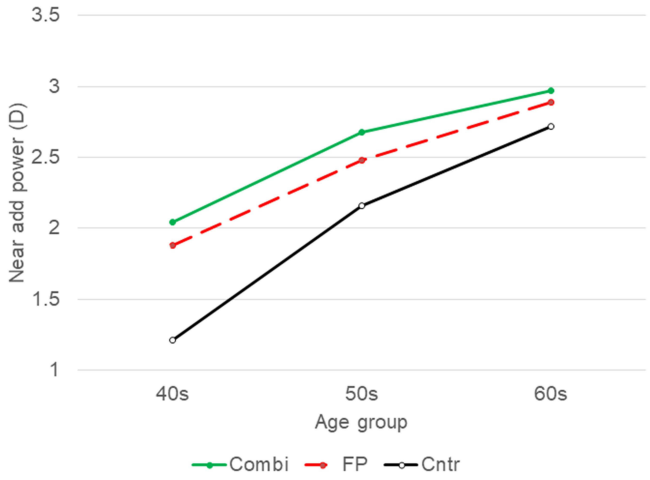

Figure 1 Mean near add power of study groups. There were significant differences in near add power between all pairs of age groups and between all pairs of study groups ($P < 0.05$, *t* test). Cntr, control group; FP, prostaglandin F receptor agonist group; Combi, fixed combination therapy group.

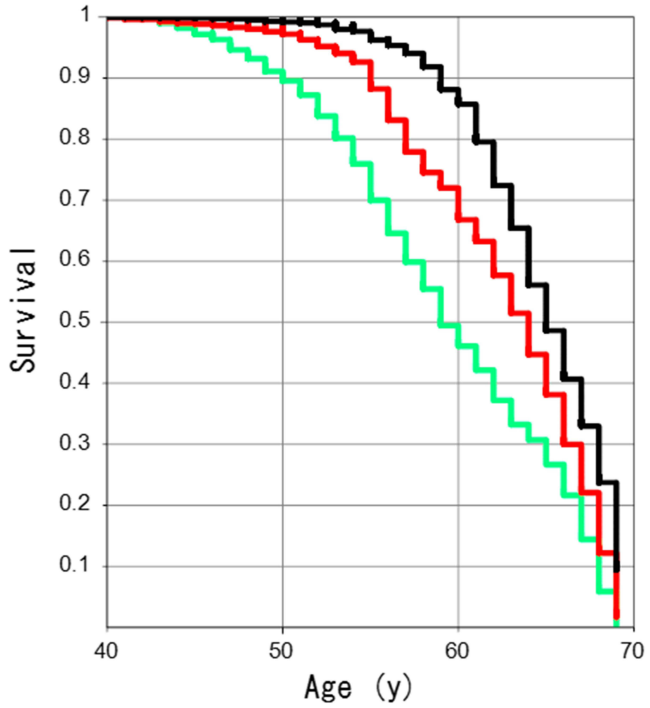

Figure 2 Kaplan-Meier survival plot showing the age at which individuals in the control group (black line), glaucoma patients using prostaglandin F (FP) receptor agonists (red line), and glaucoma patients using fixed combination therapies (green) reached the near add power endpoint of +3.0 D. There were significant differences between all pairs of groups ($P < 0.01$, Log rank test).

Discussion

This study demonstrated that near add power was significantly greater among fixed combination users than FP receptor agonist users across the age groups examined. The comparison between the control and FP group was consistent with previous investigations[18–20] showing that the progression of presbyopia was earlier in glaucoma patients.

The duration of glaucoma was associated with near add power in addition to age, although that was not the case for those receiving monotherapy, indicating that the severity of glaucoma may be associated with visual function and ciliary muscle function.[19,20] Glaucoma patients in the Fixed combination group started medication earlier than those in the FP group, and also had a longer duration of glaucoma medication. Collectively, patients in the Fixed combination group

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Table 2 Comparison Between Prostaglandin F (FP) Receptor Agonists and Corresponding Fixed Combination Including All Age Groups

	Control	Latanoprost	Combi 1	Combi 2	Tafluprost	Combi 3	Travoprost	Combi 4	Bimatoprost†
Number of individuals	2200	596	130	167	92	41	53	74	43
Mean age, y	54.5 (8.1)	57.2 (7.2)	57.8 (6.9)	52.5 (8.0)**	59.6 (7.8)	53.7 (7.4)**	57.8 (5.5)	52.8 (7.9)**	58.2 (7.3)
% men	28.1	50.5	42.6	52.4	28.3	17.1	56.6	73.0	27.9**
Spherical equivalent, D	−2.74 (3.44)	−4.25 (3.57)	−4.37 (5.10)	−5.37 (3.81)**	−4.34 (4.53)	−5.60 (2.07)	−3.83 (2.42)	−6.13 (2.59)**	−4.39 (2.76)
Near add power, D	2.02 (0.85)	2.54 (0.60)	2.67 (0.56)*	2.48 (0.71)	2.66 (0.62)	2.74 (0.41)	2.73 (0.49)	2.54 (0.62)	2.65 (0.66)
IOP, mmHg†	15.9 (3.4)	14.6 (3.28)	14.7 (3.1)	13.7 (2.8)**	13.0 (1.8)	14.2 (3.3)	13.9 (3.7)	13.9 (3.2)	14.5 (2.6)
Mean deviation, dB†	−2.8 (3.9)	−8.0 (6.6)	−6.4 (4.8)*	−6.5 (5.9)	−6.6 (3.6)	−3.9 (3.0)**	−9.1 (5.6)	−11.8 (10.4)	−6.3 (4.3)
GCC, μm§	86.9 (11.4)	74.7 (10.5)	72.8 (10.0)	71.2 (8.1)**	70.5 (11.2)	60.7 (10.3)**	71.9 (10.5)	64.6 (10.3)**	69.8 (10.7)**
RNFL, μm§	114.7 (20.3)	90.0 (19.9)	96.7 (28.4)**	86.9 (14.0)	89.2 (20.9)	88.1 (11.4)	79.5 (23.9)	80.7 (17.5)	81.2 (14.6)**

Notes: Data are presented as mean and standard deviation in parentheses unless specified otherwise. *$P < 0.05$, **$P < 0.01$, vs corresponding FP receptor agonist. †Comparison with latanoprost. §mean of both eyes.

Abbreviations: Combi 1, latanoprost/timolol; Combi 2, latanoprost/carteolol; Combi 3, tafluprost/timolol; Combi 4, travoprost/timolol; IOP, intra-ocular pressure; GCC, ganglion cell complex thickness; RNFL, retinal nerve fiber layer thickness.

Table 3 Association Between Near Add Power and Ocular Parameters

	Beta	*P*-Value
Baseline characteristics and refractive status		
Age in years	0.70	< 0.01
Sex (men = 1)	0.05	< 0.01
Spherical equivalent	0.11	< 0.01
Astigmatism	0.03	< 0.01
Anisometropia	0.01	0.09
Glaucoma-related clinical features		
Intraocular pressure†	0.01	< 0.01
Mean deviation†	−0.09	< 0.01
Cup/disc ratio†	0.11	< 0.01
GCC thickness§	−0.21	< 0.01
Peripapillary RNFL thickness§	−0.20	< 0.01
Full macular thickness§	0.01	0.62
Glaucoma	0.23	< 0.01
Use of FP receptor agonist	0.16	< 0.01
Use of fixed combination	0.21	< 0.01
Dry eye-related clinical features		
Short tear break-up time†	0.05	< 0.01
Superficial punctate keratitis†	0.03	0.02
Use of dry eye medication	0.11	< 0.01

Notes: Standardized partial regression coefficient, adjusted for age and sex. †worse eye. §mean of both eyes.

Abbreviations: GCC, ganglion cell complex; RNFL, retinal nerve fiber layer; FP, prostaglandin F.

suffered from glaucoma for longer, and consequently the effects of the disease and medication on presbyopia would be longer for the same age group. In practice, it is reasonable that FP receptor agonists are the first-line medical therapy followed by other medications, fixed combination or concomitant therapy, for sufficient pressure reduction and minimal side effects.[1–3]

Table 4 Comparison of Odds Ratios (ORs) for Risk Factors of Near Add Power of 3.0 D

Risk Factors	OR	Upper Limit of 95% CI	Lower Limit of 95% CI
Baseline characteristics and refractive status			
Age	1.20**	1.19	1.22
Sex (men = 1)	1.44**	1.22	1.69
Spherical equivalent	1.26**	1.06	1.50
Astigmatism	1.00	1.00	1.01
Glaucoma-related clinical features			
Intraocular pressure†	0.96**	0.94	0.98
Mean deviation†	0.96**	0.94	0.97
Cup/disc ratio†	1.02**	1.01	1.02
GCC thickness§	0.95**	0.94	0.96
Peripapillary RNFL thickness§	0.97**	0.97	0.98
Glaucoma	4.79**	4.00	5.74
Use of FP receptor agonist	2.48**	2.06	3.00
Use of fixed combination	6.05**	4.66	7.87
Dry eye-related clinical features			
Short tear break-up time†	1.27**	1.06	1.52
Superficial punctate keratitis†	1.44	0.76	1.13
Use of dry eye medication	2.32**	1.72	3.14

Notes: **$P < 0.01$; adjusted for age and sex. †worse eye. §mean of both eyes.
Abbreviations: CI, confidence interval; GCC, ganglion cell complex; RNFL, retinal nerve fiber layer; FP, prostaglandin F.

The results of each fixed combination should be carefully interpreted since the near add power for each fixed combination group was greater than that for the cognate FP receptor agonists after adjusting for age given that near add power increases 0.14 D/year between the ages of 40 and 59 years.[8] For example, the age-adjusted near add power was larger in Combi 2, Combi 3, and Combi 4 groups than that for each corresponding FP receptor agonist group. Each of the fixed combinations and corresponding FP receptor agonists should be carefully compared since the fixed combination subgroups were heterogeneous in age, severity of glaucoma, and medical history, making it hard to fully adjust for these factors.

Considering the severity of glaucoma in the fixed combination group and the weak effects of beta blockers on presbyopia, the effects of fixed combination therapy on presbyopia is still debatable.[21–23] The pressure reduction mechanism in terms of site of action is different between FP receptor agonists and beta blockers, and beta blockers may have only a weak effect on the ciliary muscle. The pressure reduction effects of FP receptor agonists derive from ciliary muscle mobility and matrix metalloproteinase modulation, whereas beta blockers affect the neural control of aqueous humor production in the ciliary body that is not associated with accommodation. A larger glaucoma case series with single beta blocker users is warranted to clarify the effects of beta blockers on presbyopia. Nevertheless, the present study suggests that users of a fixed combination of FP receptor agonist/beta blocker experienced a faster progression of near add power than those using FP receptor agonist monotherapy, and this is of clinical significance.

It should be noted that glaucoma patients using fixed combination therapy may suffer from presbyopia more seriously than those using monotherapy, especially among younger patients. Additionally, beta blockers may be recommended for young glaucoma patients to avoid the worsening of near vision in their professional work.

There is another possibility in relation to glaucoma and presbyopia. Presbyopia reaches its end stage at about the time of onset of glaucoma. Presbyopia for the most part happens first. However, presbyopia may be involved in the development of glaucoma, and this study demonstrates that presbyopia is more pronounced in glaucoma patients, and may not be due solely to the glaucoma treatments. Studies from the Kaufman group[5,6,13] suggest that open-angle glaucoma may result from a pronounced progression of presbyopia, as glaucomatous eyes require higher near add

power. During accommodation, pressure and tension spikes occur on the optic nerve, which may become more pronounced with age and contribute to glaucoma development. Additionally, age-related changes—such as the stiffening of posterior tendons of the ciliary muscles and vitreous aggregates—could increase tension on the optic nerve, accelerating glaucoma onset.

This study has several limitations. There was no near add power data before glaucoma treatments in the glaucoma patients. Most of the patients in the Fixed combination group had a history of FP receptor agonist monotherapy and it was hard to adjust for severity and other factors between the fixed combination and FP groups. There are few cases with monotherapy with a beta blocker or carbonic anhydrase inhibitor. Glaucoma treated with fixed combination therapy is generally more severe than that treated with monotherapy. Consequently, it is difficult to adjust for GCC and RNFL, even after adjusting for age, the strongest factor contributing to near add power. Subgroups treated with fixed combination therapies were heterogenous since the status of glaucoma varied among patients that started with a fixed combination therapy. Consequently, a precise comparison was difficult and definitive conclusions could not be made. Since FP agonists are recommended as a first-line medical therapy,[1–3] beta blockers were used mostly in fixed combinations. Consequently, the number of patients treated with only beta blockers was too small for analysis, and we decided to compare FP agonists and fixed combinations containing beta blockers in this study.

In conclusion, the near add power of glaucoma patients treated with fixed combination FP receptor agonist/beta blocker was higher than that for controls and glaucoma patients treated with FP receptor agonist monotherapy among the same age groups, indicating a faster progression of presbyopia. The effects of FP receptor agonists on near add power have been confirmed, however, those of beta blockers remain elusive.

Data Sharing Statement

The data collected during the current study are available from the corresponding authors upon reasonable request.

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Disclosure

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