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ORIGINAL RESEARCH

Evaluation of the relationship between quality of vision and visual function in Japanese glaucoma patients

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Purpose: To evaluate the correlation between quality of vision (QOV) and visual function in glaucoma patients.

Patients and methods: The relationship between QOV and visual function was investigated in 200 Japanese glaucoma patients. QOV was assessed using the Japanese version of the 25-item National Eye Institute Visual Function Questionnaire. The better eye and the worse eye were defined based on the mean deviation (MD) value of the Humphrey Field Analyzer program 30-2. A single linear regression analysis was applied to assess the relationship.

Results: The lowest subscale score was observed in general health followed by general vision and driving. Visual acuity and the central 10° MD value in the better eye and the central 30° MD value in the worse eye were highly correlated with QOV. Threshold MD values at which patients began to have lower QOV ranged from −2 to −12 dB in the better eye and from −7 to −16 dB in the worse eye.

Conclusion: Loss of visual function in both the better and the worse eye is significantly correlated to QOV. QOV of glaucoma patients begins to decrease in the early stages of visual field defects.

Keywords: glaucoma, 25-item National Eye Institute Visual Function Questionnaire, visual field, visual acuity, quality of vision

Introduction

Glaucoma is the third leading cause of blindness worldwide followed by cataract and trachoma. It is responsible for the loss of vision in 5.2 million people[1] (ie, 15% of the total cases of blindness) and is also a primary cause of visual impairment even in advanced countries. In Japan, glaucoma is the main cause of visual disability in 307,000 people. The Tajimi Study,[2] a population-based epidemiological survey in Tajimi in central Japan in 2001, revealed that 5% of people over 40 years of age were affected by glaucoma. As long as the treatment of glaucoma is able only to decelerate the disease and is not able to recover visual functionality, it is critical that patients are treated before their quality of life (QOL) deteriorates.

Conventional clinical assessments of visual function, such as visual acuity and visual field tests, do not fully reflect the impact of visual disabilities on daily life. An objective estimation of an individual's QOL is not simple, because QOL is affected by many factors, including lifestyle, occupation, gender, and age. However, the recently developed scoring system for QOL, which is based on the 25-item National Eye Institute Visual Function Questionnaire (NEI VFQ-25), has been successfully applied to quantitatively evaluate the vision-specific QOL (quality of vision [QOV]) of

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patients with different eye diseases.[3,4] The NEI VFQ-25 has been translated and is used around the world.[5–8] The NEI VFQ-25 has proved its validity and reliability for assessing QOV among patients with diabetic retinopathy,[10] retinitis pigmentosa,[11] age-related macular degeneration,[12] and glaucoma.[13,14] In the current study, we used the Japanese version of the NEI VFQ-25[9] to analyze the relationship between the loss of visual function and QOV in glaucoma patients. The Japanese version of the NEI VFQ-25 has also been proved to have both reliability and validity in glaucoma patients.[9] In this study, we focused on the impact of glaucoma on the patient's QOV. Furthermore, we investigated the mean deviation (MD) threshold at which glaucoma patients begin to have difficulty with their vision.

Patients and methods

Study population

We evaluated 200 consecutive Japanese patients (103 men and 97 women) with glaucoma during follow-up visits at Niigata University Medical and Dental Hospital in Japan or its facilities. Glaucoma subtypes were determined by clinical examination including intraocular pressure, slit lamp examination, and gonioscopic examination. Of these 200 patients, 91 presented with normal tension glaucoma, 74 with primary open-angle glaucoma, 12 with secondary glaucoma, eight with developmental glaucoma, eight with primary angle-closure glaucoma, and seven with overlapping types of glaucoma. All patients clinically diagnosed with glaucoma had met one of the following criteria: i) reproducible visual field defects using program 30-2 of the Humphrey® Field Analyzer (HFA; Carl Zeiss, Dublin, CA, USA); or ii) glaucomatous excavation of the optic nerve head. Patients with underlying pathological ocular conditions were excluded; these conditions included apparent senile cataract (eg, greater than grade 2 in Emery–Little classification or posterior subcapsular cataract) and cerebral conditions that could cause visual field loss. Patients who underwent intraocular surgery within the last 6 months were also excluded from the study.

Questionnaire

We asked each patient to complete a self-assessment of their QOV with the Japanese version of the NEI VFQ-25 (a total of 38 questions with 25 items and 13 options), which addresses aspects of visual ability with 12 subscales. These subtypes include the general health, general vision, ocular pain, near vision, distance vision, social function, mental health, role limitations, dependency, driving, color vision, and peripheral vision of the patient. Each subscale is a single-item question with five possible answers ranging from grade 1 to 5 or 6. Each subscale grade was then converted to a possible score ranging from 0 to 100, with a higher score indicating better QOV. A composite score, which was the mean score of all the subscales except for general health, was also calculated.

Evaluating visual function

Data on visual function were obtained from bilateral eyes. The best-corrected visual acuity was evaluated at baseline and at follow-up. Data that were collected at the same time as this study or within 6 months were used. Decimal units of visual acuity were converted to the mean visual acuity of the logarithm of the minimum angle of resolution ($\log_{10}$MAR). The central visual field was tested using either full-threshold or sita-standard HFA programs 30-2 and 10-2. Scores (dB) of MD and foveal threshold were used to assess the severity of visual field loss. The determination of both the better eye and the worse eye was based on the value of MD from HFA program 30-2.

Data analysis

A single linear regression analysis was applied to assess the relationship between visual function and scores on the NEI VFQ-25 questionnaire. Twelve subscale scores and the composite score from the NEI VFQ-25 were used as independent variables for comparison with the dependent variables of visual acuity, MD scores from programs 30-2 and 10-2, and foveal threshold.

The patients were divided into two groups: one group included patients aged younger than 60 years and the other group aged 60 or older than 60 years. A nonparametric analysis (Mann–Whitney *U* test) was used to decide which age group had a better QOV.

Table 1 Ophthalmological data for the glaucoma patients

	Better eye (±SD)	Worse eye (±SD)
$\log_{10}$MAR BCVA	–0.03 ± 0.13 (–0.07 to 0.39)	0.12 ± 0.62 (–0.07 to LS)
Foveal threshold (dB)	33.93 ± 3.50 (24 to 43)	31.59 ± 7.43 (0 to 38)
HFA 30-2 MD (dB)	–8.33 ± 8.36 (3.74 to –28.68)	–14.17 ± 8.52 (1.05 to –30.96)
HFA 10-2 MD (dB)	–10.41 ± 9.10 (1.8 to –31.62)	–16.49 ± 9.17 (–0.30 to –32.98)

Abbreviations: BCVA, best-corrected visual acuity; HFA, Humphrey Field Analyzer; $\log_{10}$MAR, logarithm of the minimum angle of resolution; LS, light sense; MD, mean deviation; SD, standard deviation.

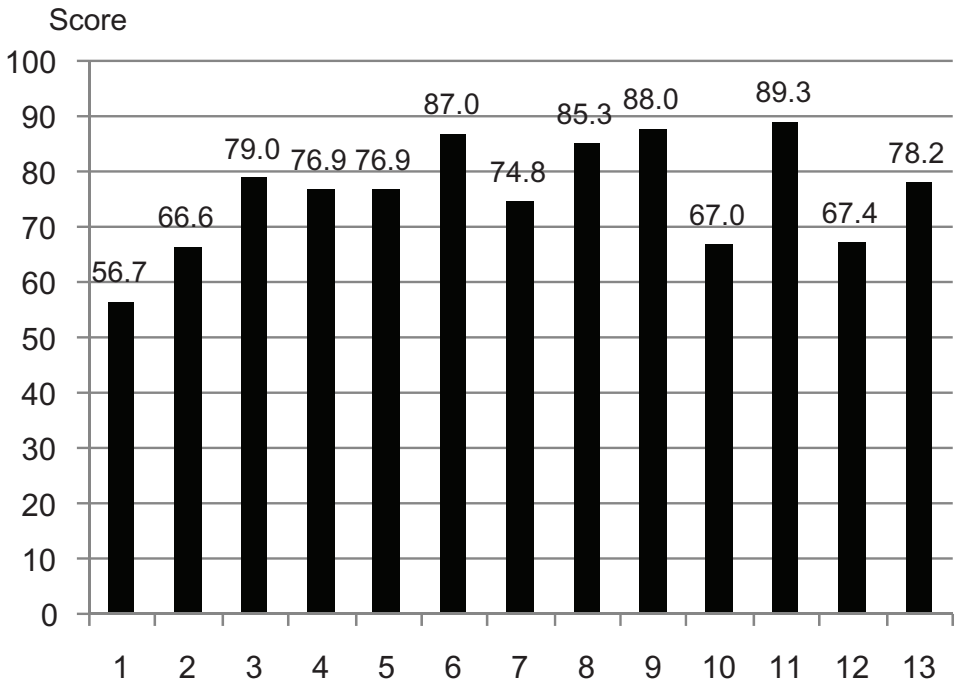
We defined subscale scores less than 59 as "low", in order to determine the MD threshold value of which glaucoma patients begin to feel difficulties in their day-to-day activities. For this analysis, we divided patients into a higher score group (higher than 60) and a lower score group (less than 59) for each subscales. A nonparametric analysis (Chi-square test) was used to evaluate this data.

P values less than 0.001 were considered significant. Correlations were denoted as "good" when the correlation coefficient was between 0.4 and 0.6, "moderate" when between 0.2 and 0.39, and "poor" when less than 0.2. All statistical analyses were carried out using statistical analysis software SPSS® Version 14 for Windows® (SPSS, Chicago, IL, USA).

Results

The mean best-corrected visual acuities, foveal threshold, MD scores from program 30-2, and MD scores from program 10-2 for the better and worse eyes are shown in Table 1. The average scores for the 12 subscales and the composite are shown in Figure 1. In summary, general health (56.68 ± 15.37) scored the lowest of all of the variables, followed by general vision (66.55 ± 16.37), driving (66.98 ± 25.75), and peripheral vision (67.38 ± 23.67).

Higher correlations were found between QOV and visual functions for vision-specific subscales, whereas no significant correlations were observed for universal subscales, including general health and ocular pain. Loss of visual function, including visual acuity and visual field,



1: General health
2: General vision
3: Ocular pain
4: Near vision
5: Distance vision
6: Social function
7: Mental health
8: Role limitations
9: Dependency
10: Driving
11: Color vision
12: Peripheral vision
13: Composite

Figure 1 Average subscale scores for glaucoma patients on a Japanese version of the 25-item National Eye Institute Visual Function Questionnaire.

Table 2 *P* values and correlation coefficients for single linear regression analysis of the association between visual function and visual disability indices in the better eye

	Log_{10}MAR BCVA	HFA 30-2		HFA 10-2
		Fovea (dB)	MD (dB)	MD (dB)
General health	0.029 (0.155)	0.014 (0.177)	0.002 (0.216)	0.193 (0.120)
General vision	<0.001 (0.297)	<0.001 (0.298)	<0.001 (0.467)[a]	<0.001 (0.556)[a]
Ocular pain	0.055 (0.134)	0.076 (0.128)	0.049 (0.141)	0.371 (0.082)
Near vision	<0.001 (0.380)	<0.001 (0.395)	<0.001 (0.465)[a]	<0.001 (0.541)[a]
Distance vision	<0.001 (0.372)	<0.001 (0.424)[a]	<0.001 (0.474)[a]	<0.001 (0.540)[a]
Social function	0.003 (0.210)	<0.001 (0.331)	<0.001 (0.371)	<0.001 (0.478)[a]
Mental health	<0.001 (0.269)	<0.001 (0.315)	<0.001 (0.497)[a]	<0.001 (0.543)[a]
Role limitations	<0.001 (0.373)	<0.001 (0.410)[a]	<0.001 (0.460)[a]	<0.001 (0.508)[a]
Dependency	<0.001 (0.274)	<0.001 (0.348)	<0.001 (0.420)[a]	<0.001 (0.494)[a]
Driving	<0.001 (0.391)	0.001 (0.379)	<0.001 (0.473)[a]	<0.001 (0.525)[a]
Color vision	0.020 (0.168)	<0.001 (0.252)	<0.001 (0.323)	<0.001 (0.336)
Peripheral vision	0.008 (0.191)	<0.001 (0.200)	<0.001 (0.437)[a]	<0.001 (0.437)[a]
Composite	<0.001 (0.354)	<0.001 (0.393)	<0.001 (0.528)[a]	<0.001 (0.581)[a]

Note: [a]Correlation coefficients of ≥0.4.
Abbreviations: BCVA, best-corrected visual acuity; HFA, Humphrey Field Analyzer; Log_{10}MAR, logarithm of the minimum angle of resolution; MD, mean deviation.

in both eyes was significantly correlated with decreased general vision, near vision, distant vision, mental health, role limitations, dependency, driving, and composite scores. Correlation coefficients in eight subscales and the composite were higher in the worse eye than in the better eye. Visual field was the only variable that was significantly correlated with social function, color vision, and peripheral vision. Neither visual acuity nor visual field was significantly correlated with general health and ocular pain (Tables 2 and 3). The results of the correlation coefficients for the single linear regression analysis between HFA program 30-2 and 10-2 were slightly greater in program 10-2, but they were similar overall. The visual field impairment measured by the HFA program 30-2 was highly correlated with the composite score for both better and worse eyes (Figures 2 and 3). A scatter plot of composite scores showed a monotonic trend. As the MD worsened, the subscale scores decreased along with it.

The relationship between age and average subscale scores revealed that younger patients (<60 years old) generally had better QOV. Scores were higher in younger patients for all subscales except for general vision and the composite

Table 3 *P* values and correlation coefficients for single linear regression analysis of visual function and visual disability indices in the worse eye

	Log_{10}MAR BCVA	HFA 30-2		HFA 10-2
		Fovea (dB)	MD (dB)	MD (dB)
General health	0.303 (0.073)	0.366 (0.066)	<0.001 (0.249)	0.005 (0.255)
General vision	<0.001 (0.274)	<0.001 (0.348)	<0.001 (0.464)[a]	<0.001 (0.530)[a]
Ocular pain	0.994 (0.001)	0.230 (0.087)	0.043 (0.146)	0.230 (0.110)
Near vision	<0.001 (0.288)	<0.001 (0.320)	<0.001 (0.442)[a]	<0.001 (0.488)[a]
Distance vision	<0.001 (0.401)[a]	<0.001 (0.372)	<0.001 (0.506)[a]	<0.001 (0.519)[a]
Social function	<0.001 (0.251)	<0.001 (0.282)	<0.001 (0.379)	<0.001 (0.361)
Mental health	0.001 (0.308)	<0.001 (0.344)	<0.001 (0.522)[a]	<0.001 (0.530)[a]
Role limitations	<0.001 (0.243)	<0.001 (0.265)	<0.001 (0.408)[a]	<0.001 (0.430)[a]
Dependency	<0.001 (0.278)	<0.001 (0.304)	<0.001 (0.431)[a]	<0.001 (0.494)[a]
Driving	0.007 (0.391)	<0.001 (0.379)	<0.001 (0.473)[a]	<0.001 (0.426)[a]
Color vision	<0.001 (0.198)	0.006 (0.200)	<0.001 (0.343)	<0.001 (0.363)
Peripheral vision	<0.001 (0.207)	0.001 (0.239)	<0.001 (0.442)[a]	<0.001 (0.370)
Composite	<0.001 (0.311)	<0.001 (0.366)	<0.001 (0.540)[a]	<0.001 (0.541)[a]

Note: [a]Correlation coefficients of ≥0.4.
Abbreviations: BCVA, best-corrected visual acuity; HFA, Humphrey Field Analyzer; Log_{10}MAR, logarithm of the minimum angle of resolution; MD, mean deviation.

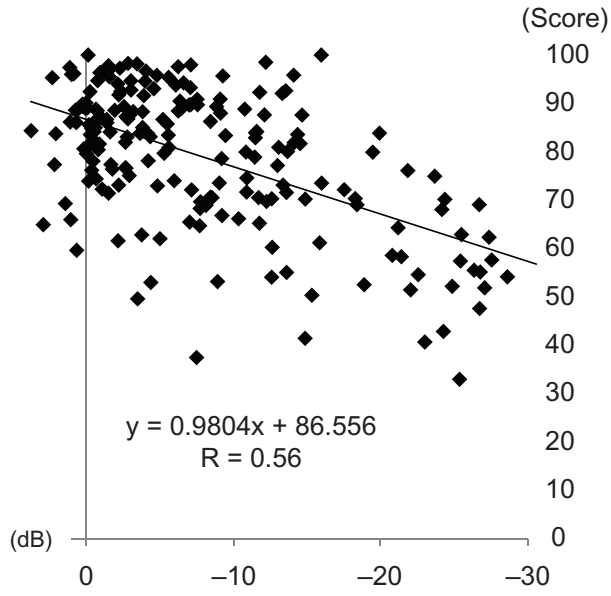


Figure 2 Composite 25-item National Eye Institute Visual Function Questionnaire scores in the better eye (y-axis) are correlated with mean deviation scores from Humphrey Field Analyzer program 30-2 (x-axis).

(Figure 4). A significant difference between younger and older patients was observed in social function and color vision. There was not a significant difference in either visual acuity or MD scores between the younger age group and older one (Table 4).

The threshold MD scores at which the patients began to feel some difficulty with QOV were determined for all 12 subscales, as well as for the composite score. The threshold ranged from –2 dB to –12 dB for the better eye and from –7 dB to –16 dB for the worse eye. Three subscales in both the better eye and the worse eye, including general health, ocular pain and color vision, showed no significant threshold when MD value decreased to as low as –25dB (Table 5).

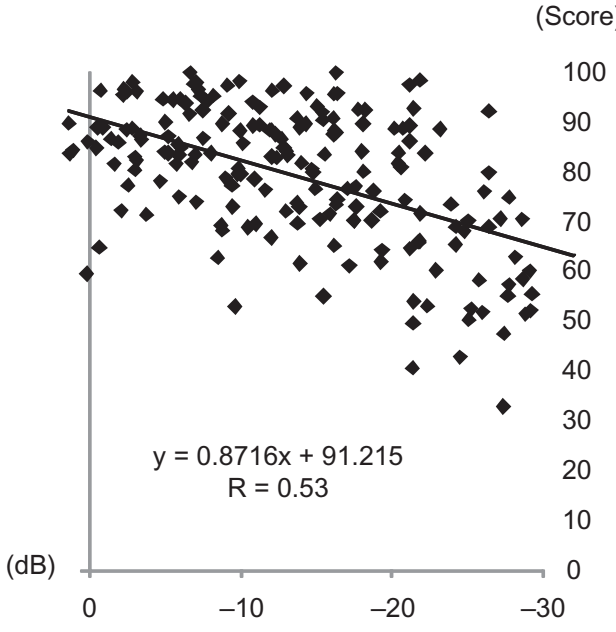
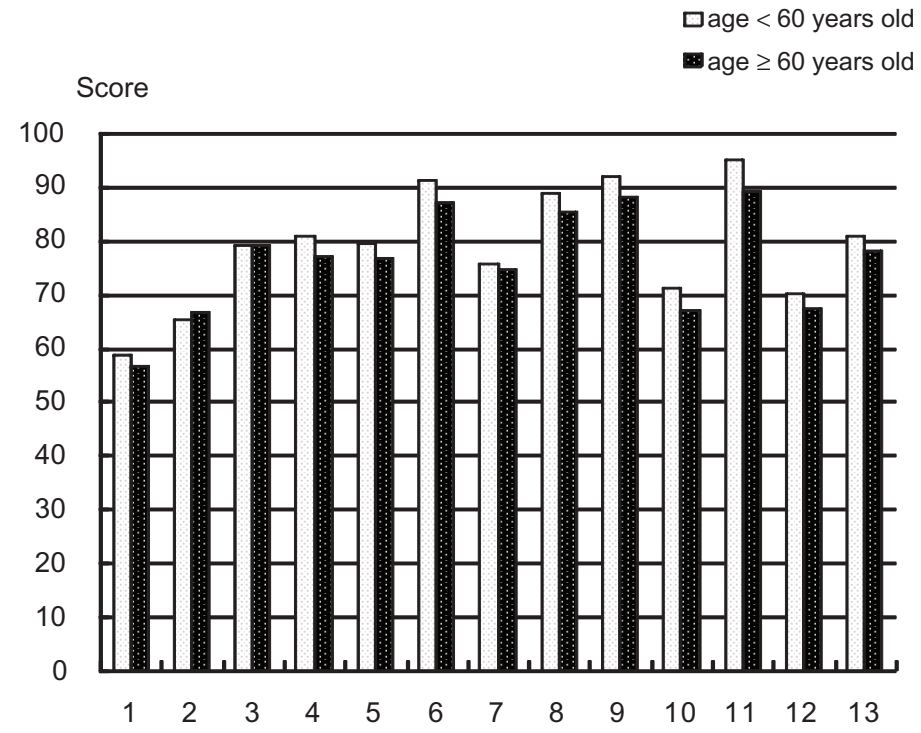


Figure 3 Composite 25-item National Eye Institute Visual Function Questionnaire scores in the worse eye (y-axis) are correlated with mean deviation scores from Humphrey Field Analyzer program 30-2 (x-axis).

Discussion

In this study, we used the NEI VFQ-25 to evaluate QOV in glaucoma patients. Most of the subscale scores and the composite score were significantly associated with the deterioration of visual acuity and the visual field. Among the 12 subscales and the composite, the lowest scores were observed in general health, followed by general vision, driving, and peripheral field. These results are consistent with previous studies of QOV in glaucoma patients.[15–17] When patients were divided into two groups based on age, the lowest scores were still observed in general health in both the young and old groups of patients. This preliminary result may reflect the substantial psychological burden experienced by glaucoma patients.

Glaucoma patients are said to have difficulties with driving,[13] and driving received the third worst score in our study. Our results of MD value thresholds showed that many patients begin to have lower scores of NEI VFQ-25 in early stages of visual field defects. One report concluded that glaucoma patients who have less than a –4.0 dB MD value in the worse eye are more likely to fail to see a pedestrian than those with a better visual field.[18] Furthermore, glare and dark adaptation were significantly associated with more severe visual field loss in glaucoma patients.[19] The ability to see at low luminance levels is required for night driving; therefore, glaucoma patients who have reduced contrast sensitivity[20] will likely be distracted. Because peripheral vision, in addition to central vision, is required for driving, lower scores in that variable may be responsible for the low scores in driving. Haymes et al investigated on-road performance in glaucoma patients with a slight to moderate visual field defect.[18] They concluded that the worse-eye MD was the most correlated factor with driving among other visual functions, including visual acuity, contrast sensitivity, visual field, and binocular visual field. However, we did not find a similar difference between the better eye and worse eye in the central 30° visual field in driving in this study. MD threshold scores in the better and worse eyes indicate that driving performance may begin to deteriorate in the early stages of visual field defect.



1: General health
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5: Distance vision
6: Social function*
7: Mental health
8: Role limitations
9: Dependency
10: Driving
11: Color vision*
12: Peripheral vision
13: Composite

Figure 4 Average subscale scores for young and old glaucoma patients.
Note: *$P < 0.001$.

Aging is one of the many factors that affect QOV, although the impact of a patient's age on QOV is controversial. In this study, we divided patients into two groups at the age of 60 years. Because the retirement age is 60 years in general in Japan, we divided the group at the age of 60 years in order to differentiate people who are actively at work and those who are not. Magacho et al[21] reported that younger patients have better QOV, whereas Asano et al[16] found that older patients had better QOV. Our results were similar to those of Magacho et al,[21] that the younger patient group had a better QOV in the composite and all subscales except for general vision. Although the MD scores of HFA program 30-2 did not reveal a difference between the two groups, the older patient group tended to have worse visual acuity in the better eye. This may suggest that the age-related deterioration of visual acuity, such as senile cataracts, is a potential cause of decreased NEI VFQ-25 scores. There was not a significant difference between the QOV of older patients and younger patients; significant differences were observed only for social function and color vision scores. When comparing older and younger patients in terms of QOV, these results suggest that younger people may adapt better to the deterioration of visual function. Patients' lifestyles, residence, clinical course, and social functions might also be factors that affect people's QOV.

Although it is essential to evaluate each eye when determining the severity of the glaucoma, it is more

Table 4 Visual function data in young and old glaucoma patients

	Aged <60 years Mean ± SD	Aged ≥60 years Mean ± SD	*P* value
Age	48.52 ± 8.00	69.45 ± 5.77	<0.001
Better eye			
BCVA	−0.04 ± 0.15	−0.02 ± 0.11	0.021
MD of HFA 30-2	−8.23 ± 8.14	−8.21 ± 8.80	0.827
Worse eye			
BCVA	0.26 ± 0.91	0.03 ± 0.30	0.965
MD of HFA 30-2	−14.26 ± 8.56	−14.22 ± 8.52	0.888

Abbreviations: BCVA, best-corrected visual acuity; HFA, Humphrey Field Analyzer; MD, mean deviation; SD, standard deviation.

appropriate to investigate QOV using binocular visual function in order to assess patients' QOV more naturally. The Esterman binocular visual field test was developed for evaluating the total field and is able to provide a more appropriate visual field score without using a difficult formula.[22,23] However, the Esterman test does not assess binocular summation,[24] and the relationship between the Esterman visual field test and the NEI VFQ-25 ($r = 0.44$; VFQ overall) is reported to be lower than that of the combination of two monocular fields ($r = 0.48$) or MD in the worse eye ($r = 0.49$).[25,26] Several studies have compared the better eye and the worse eye in order to explore which eye contributes more to QOV in glaucoma patients. Gutierrez et al[27] used the Advanced Glaucoma Intervention Study (AGIS) score to calculate the visual field and concluded that more visual field defects in the better eye were associated with VFQ-25 than in the worse eye. A relationship between the VFQ-25 and AGIS scores was also well documented in a study by Jampel et al, which did not reveal a difference between the better eye and the worse eye.[26] Some factors, including the scoring program of the visual field, the number of VFQ-25 items used, and the data collection methods, may have led to differences between the statistical results. Our results showed that the score of the VFQ-25 correlated the most with the MD of HFA program 30-2 in the worse eye but was not much different from the score of the better eye. In contrast, visual acuity and the MD of HFA program 10-2 correlated higher in the better eye than in the worse eye, which has also been reported by other investigators.[27] The significance of the visual function of each eye varies between studies. For example, some studies demonstrate significant correlations between the better eye and QOV,[28,29] whereas others show better correlations in the worse eye.[30,31] The significance of the better eye and the worse eye has not been fully understood, and further studies may be needed to reach a conclusion. In our study, the better eye was more important in terms of visual acuity and the central 10° visual field, whereas the worse eye was more important in the central 30° visual field. From this result, we presumed that the central vision-related QOL depends on the better eye, whereas the more peripheral vision-related QOL may depend on the worse eye.

Table 5 MD threshold scores from HFA program 30-2 of which the number of the patients becomes significantly higher to have lower subscale scores. The definition of the lower subscale score was determined as lower than 59

	Better eye		Worse eye	
	MD (dB)	*P* value	MD (dB)	*P* value
General health	−25	0.569	−25	0.038
General vision	−4[a]	<0.001[a]	−12[a]	<0.001[a]
Ocular pain	−25	0.186	−25	0.751
Near vision	−6[a]	<0.001[a]	−12[a]	<0.001[a]
Distance vision	−2[a]	<0.001[a]	−7[a]	<0.001[a]
Social function	−4[a]	<0.001[a]	−15[a]	<0.001[a]
Mental health	−25	0.507	−8[a]	<0.001[a]
Role limitations	−12[a]	<0.001[a]	−15[a]	<0.001[a]
Dependency	−12[a]	<0.001[a]	−16[a]	<0.001[a]
Driving	−6[a]	<0.001[a]	−8[a]	<0.001[a]
Color vision	−25	0.117	−25	0.089
Peripheral vision	−4[a]	<0.001[a]	−8[a]	<0.001[a]
Composite	−3[a]	<0.001[a]	−12[a]	<0.001[a]

Note: [a]*P* value < 0.001.
Abbreviations: HFA, Humphrey Field Analyzer; MD, mean deviation.

To the best of our knowledge, this report is the first to provide a threshold MD value that describes when patients begin to feel a decrease in their QOV due to glaucoma. We found that the thresholds ranged from −2 dB to −12 dB in the better eye and from −7 dB to −16 dB in the worse eye, which supports previous reports that vision-specific QOV begins to decline with mild visual field defects and that composite scores begin to decrease when patients have HFA program 30-2 MD values less than −5 dB.[16] The HFA program 30-2 is the most commonly used clinical assessment tool; thus, the significant correlation between HFA program 30-2 and QOV should generate reliable and useful ideas for further treatment. Our threshold data include specific MD values for each eye. Although we defined scores below 59 as low, the conclusions drawn by other studies may vary based on how the low scores are defined. It may be premature to conclude that the threshold data indicate when further treatment should be initiated. However, our data provide evidence that patients feel some visual disturbances in the early stages of glaucoma.

In conclusion, the current study suggests that impaired visual function in both eyes of patients with glaucoma is well correlated with impaired subscale scores on the NEI VFQ-25. Although aging is likely to reduce subscale scores, different lifestyles and social functions may also affect the patient. Thus, subscale scores should be assessed in the context of each individual patient. As long as visual acuity is well preserved until the late stages of glaucoma, it is essential to evaluate the appropriate relationship between glaucomatous visual field defects and QOV before impairment of vision is completed. Assessing QOV in glaucoma patients at early stages of the disease is critical for determining when further treatment should be given in order to maintain good QOV. The QOV of glaucoma patients begins to decrease at the early stages of visual field loss, which are easily detectable using the NEI VFQ-25. These findings showed that estimating QOV of glaucoma patients with the NEI VFQ-25 is effective and properly reflects impaired visual function. The results will be able to offer clinicians in providing good understanding of patients' QOV and benefit patients in most clinical settings in order to ensure treatment strategy at an appropriate timing.

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Disclosure

The authors report no conflicts of interest in this work.

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