Severity and Stability of Glaucoma

Patient Perception Compared With Objective Measurement

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Objective: To elucidate the relationship between the subjective assessment in patients with glaucoma of (1) the severity of their visual loss, and (2) any deterioration in their visual function and their objective visual fields as measured by computed perimetry.

Design: First, patients completed a questionnaire relating to perceived visual disability and underwent binocular visual field testing. Second, a separate group of patients answered a question about perceived visual deterioration: their monocular visual field tests were analyzed retrospectively by pointwise linear regression to establish stability or deterioration.

Setting: The Glaucoma Service of a specialist eye hospital, which is a tertiary referral center and serves the local community.

Subjects: One hundred twenty-three patients with glaucoma including 62 for the severity arm of the study and 61 for the progression arm.

Main Outcome Measures: Questionnaire responses, Esterman binocular disability score, and objective visual field deterioration.

Results: Questions strongly associated with Esterman binocular disability scores related to bumping into things, problems with stairs, and finding things that have been dropped. There was a strong association between perceived visual deterioration and measured bilateral visual field deterioration ($P<.01$).

Conclusions: There is a strong association between some types of perceived visual disability and the severity of binocular field loss. A patient who notices gradual visual deterioration is twice as likely to have bilateral visual field deterioration as not. The findings in this sample of patients with mild-to-moderate glaucoma challenge the belief that glaucoma is an insidious process in which the symptoms do not appear until the end stage of the disease.


At present, glaucoma is the third most common cause of blindness in the world. Based on evidence of increasing access to cataract surgery and increasing success in prevention and treatment of nutritive and infectious cause of blindness, glaucoma has been projected to become the most common cause of blindness in the year 2000. It is estimated that approximately 5.2 million people are bilaterally blind from glaucoma: this represents 15% of the total burden of world blindness. There are approximately 250,000 known individuals with glaucoma in the United Kingdom, and it is likely that an equal number of cases are undiagnosed. With the shift toward an older population, the medical, social, and economic burdens imposed by glaucoma will increase.

Two of the most important facets of the disease status of patients with glaucoma are the extent of established optic nerve damage and the rate of progression of this damage. The combination of these static and dynamic components has a critical bearing on the patient’s present and future visual function and on the clinical management used. This study was designed to investigate the relationship between objective measurements and subjective patient perception of these 2 components.

Visual field damage

Visual field damage in glaucoma is conventionally measured using automated perimetry. Monocular testing is used to tailor therapy to each eye. However, the patient’s visual disability through field damage is better assessed using binocular testing: binocular visual field tests are routinely used to measure whether a patient’s visual field is legally adequate for driving. The most widely used strategies for testing and scoring the binocular visual field are based on the system devised by Esterman, which was originally used with monocular fields and was then

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PATIENTS AND METHODS

SEVERITY OF VISUAL FIELD DAMAGE

To compare severity of visual field damage with perceived visual disability, patients consecutively attending the Glaucoma Service at Moorfields Eye Hospital, London, England, for visual field testing were studied. All patients gave informed consent for the study; there were no refusals to participate. Visual acuity in each eye was required to be better than 20/40 and eligible patients had no significant ocular pathological conditions apart from primary open-angle glaucoma. Sixty-two patients met these inclusion criteria. One of the investigators (D.P.) administered a brief binary forced-choice questionnaire to each patient. The questionnaire consisted of the following 10 questions related to visual disability derived from those validated in previous published research in this area.6

1. Do you ever notice that parts of your field of vision are missing?
2. Have you noticed any deterioration in your sight over the last few years?
3. Do you ever have trouble following a line of print or finding the next line when reading?
4. Do you notice variation in color intensity?
5. Do you bump into things sometimes?
6. Do you trip on things or have difficulty with stairs?
7. Have you had to give up activities because of your sight?
8. Do you have difficulty finding things that you have dropped?
9. Are you troubled by glare or dazzled on sunny days or in bright lighting?
10. Do you have particular difficulty seeing after moving from a light to a dark room?

 Patients then underwent a binocular visual field test with a perimeter (Humphrey Field Analyzer, model 630; Humphrey Instruments Inc) using the 120-point Esterman strategy program. The Esterman disability score represents the proportion of points missed during the test. Thus, as the Esterman disability score increases, disability increases. The strength of association between responses to the questionnaire and Esterman disability scores was investigated using stepwise multiple regression and correlation analysis. In these analyses, an attempt was made to ascertain which of the questions are good predictors of the Esterman disability score. However, it was also possible to regard each of the questions as a possible outcome of the Esterman disability score, since poor binocular visual field may lead to problems with the performance of visual tasks. For this reason, the data were also analyzed using logistic regression: in this analysis, the Esterman disability score was regarded as the dependent variable and each question as a separate dependent variable.

adapted for use with binocular fields.7 Test points are more closely spaced in areas of the field considered more functionally important (Figure 1). This gives additional weight to these areas when the Esterman disability score (the proportion of points missed) is calculated. In a study6 of patients with severe glaucomatous visual field loss, a moderate association was found between some questions about visual disability and the degree of binocular visual field damage as measured by the Esterman disability score. The modest ability of the questions as predictors of the Esterman disability score was ascribed to denial of visual disability and the use of adaptive strategies. One of the aims of the present study was to examine the strength of association between subjective patient perception of visual disability (using questions similar to those used by previous workers6 to enable comparison) and objective measurements of functional vision (Esterman disability score).

RATE OF VISUAL FIELD DETERIORATION

Sixty-one consecutive untreated patients attending the normal-tension glaucoma clinic at Moorfields Eye Hospital were studied. All patients gave informed consent for the study; there were no refusals to participate. Untreated patients were chosen because we believed it was important to analyze the natural history of glaucomatous visual damage and the concomitant perception of that damage in the absence of the potentially confounding effects of therapy. Patients were untreated if no evidence of progressive disease using global indices could be detected in the presence of open-angle glaucoma with normal intraocular pressure. Subsequent detection of progressive disease using pointwise analysis, combined with the demonstration that a 25% to 30% lowering of intraocular pressure reduces the rate of deterioration,31,32 led to treatment being recommended. Patients had no significant ocular pathologic findings apart from normal-tension glaucoma. All patients underwent a series of at least 5 visual field tests in each eye during 16 months. The maximum number of visual field tests performed during follow-up was 23 and the maximum length of follow-up was 9.6 years.

Patients were asked the single question, “Have you noticed any deterioration in your sight over the last few years?” and were allowed a choice of yes or no. The results of the series of visual field tests for each eye were then assessed for progression or stability using PROGRESSOR. Patients were unaware of the results of the PROGRESSOR analysis at the time that the question was asked. A field series was regarded as progressing if PROGRESSOR identified at least 1 test location with a rate of decay of 1 dB per year or worse associated with \( P < 0.01 \) for a 2-tailed \( t \)-test of the slope against 0 (ie, the null hypothesis of no deterioration). The slope criterion of 1 dB per year represents a rate of sensitivity loss approximately 10 times greater than the normal age-related decline.33 Edge points are known to be more subject to fluctuation,33 so a stricter slope criterion of 2 dB per year (also \( P < 0.01 \)) was introduced for them. These slope criteria, in combination with a less stringent slope significance criterion of \( P < 0.10 \), have been demonstrated to compare closely with the analyses (Statpac 2 Glaucoma Change Probability; Humphrey Instruments, Inc) used in other studies.26,30 The association between measured monocular or binocular visual field deterioration and subjective perception of deterioration was examined with the \( \chi^2 \) statistic.

STATISTICAL ANALYSIS

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS Inc, Chicago, Ill) for Windows (version 6.0; Microsoft Corporation, Redmond, Wash).
RATE OF VISUAL FIELD DETERIORATION

Although the rate at which the visual field deteriorates is one of the defining factors of the severity of glaucoma, there is no clear consensus on the criteria by which deterioration should be measured.\(^9\)\(^{-}\)\(^{15}\) The use of clinical judgment alone has been found to be unreliable, even when performed by experienced observers,\(^16\) so a variety of statistical techniques have been applied to estimate change in glaucomatous visual fields.

Methods based on estimates of change in summary measures of the field, such as regression analysis of the mean defect value,\(^17\) mean deviation,\(^17\) other global measures,\(^13\) measurement of whole-field and quadrant sensitivity losses,\(^18\) and trend and regression analysis of various estimates of the sensitivity of the whole field or parts of it,\(^10\)\(^{,}\)\(^{21}\) largely or completely ignore the detailed spatial information contained within computed visual field tests and are insensitive to early localized change.\(^22\)

Furthermore, different regions of the visual field may deteriorate at different rates.\(^10\)\(^{,}\)\(^{21}\)\(^{,}\)\(^{23}\) The analysis of summary measures, whether based on the whole field or clusters of points within it, have been found to be inadequate at detecting glaucomatous change.\(^24\)\(^{,}\)\(^{25}\)

We used a pointwise linear regression (PROGRESSOR; OBF Laboratories, Malmesbury, England)\(^56\) that analyzes visual field deterioration using pointwise linear regression of sensitivity on time. This technique has been used for several years to investigate glaucomatous visual field change\(^27\)\(^,\)\(^{28}\) and has recently been reexamined.\(^13\) PROGRESSOR produces a cumulative graphical output. The pointwise linear model has been demonstrated to provide a valid framework for detecting and forecasting glaucomatous loss\(^29\) and has been found to compare favorably with other pointwise methods of analysis (Statpac 2 Glaucoma Change Probability; Humphrey Instruments Inc, San Leandro, Calif).\(^30\)

This study investigates the relationship between perceived visual field deterioration (assessed by questionnaire) and objectively measured field deterioration (using PROGRESSOR).

RESULTS

SEVERITY OF VISUAL FIELD DAMAGE

Esterman binocular disability scores ranged from 0 to 91.7. The mean (SD) was 12.85 (18.12) and the median was 7.08. The distribution of Esterman binocular disability scores is shown in Figure 2.

Stepwise multiple regression identified 3 questions as predictors of the Esterman binocular disability scores: question 5, question 6, and question 8. The adjusted $R^2$ resulting from the analysis was 0.34.

For comparison with previous studies,\(^8\) a correlation coefficient value of 0.4 or greater indicated a noteworthy association between the question concerned and the Esterman binocular disability score. Questions satisfying this criterion were the same as those identified by the multiple regression analysis (questions 5, 6, and 8) with the addition of question 4.

Logistic regression identified the same questions as correlation analysis (questions 4, 5, 6, and 8). It also identified question 1, question 3, and question 10. These results are summarized in the Table.

RATE OF VISUAL FIELD DETERIORATION

Of the 61 patients questioned, 29 reported a subjective perception of gradual deterioration of vision and 32 reported no such perception. Of the 29 patients reporting visual deterioration, 22 had field deterioration in at least 1 eye as shown by the results of PROGRESSOR: 16 of these patients had deterioration in both eyes. Of the 32 patients reporting no perceived deterioration in vision, 19 were found in the results of PROGRESSOR to have field deterioration in at least 1 eye and 5 had field dete-
### Questions Associated With Esterman Disability Score

<table>
<thead>
<tr>
<th>Question</th>
<th>Multiple Regression</th>
<th>Correlation</th>
<th>Logistic Regression</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Do you ever notice that parts of your field of vision are missing?</td>
<td>...</td>
<td>...</td>
<td>.01</td>
</tr>
<tr>
<td>3. Do you ever have trouble following a line of print or finding the next line when reading?</td>
<td>...</td>
<td>...</td>
<td>.01</td>
</tr>
<tr>
<td>4. Do you notice variation in color intensity?</td>
<td>...</td>
<td>.41</td>
<td>.009</td>
</tr>
<tr>
<td>5. Do you bump into things sometimes?</td>
<td>2.10</td>
<td>0.51</td>
<td>.002†</td>
</tr>
<tr>
<td>6. Do you trip on things or have difficulty with stairs?</td>
<td>2.02</td>
<td>0.51</td>
<td>.002†</td>
</tr>
<tr>
<td>8. Do you have difficulty finding things that you have dropped?</td>
<td>1.93</td>
<td>0.35</td>
<td>.001†</td>
</tr>
<tr>
<td>10. Do you have particular difficulty seeing after moving from a light to a dark room?</td>
<td>...</td>
<td>...</td>
<td>.01</td>
</tr>
</tbody>
</table>

*Ellipses indicate not applicable.
†These questions are significant at the 5% level after Bonferroni correction for multiple comparisons.

As mentioned previously, the present study was partly inspired by work carried out by Mills and Drance in 1986. They selected 42 patients with severe visual loss due to glaucoma and examined the association between questionnaire responses and Esterman disability scores. Although the methods used in the present study and those of Mills and Drance are similar, the aims and patient selection criteria of the studies are different: Mills and Drance selected patients on the basis of severe visual loss (in 20 of the 42 patients, glaucoma was not the primary reason for impaired vision), whereas the present study concentrated on patients with good visual acuity in whom glaucoma was the primary reason for visual loss. Given these differences, it is interesting that 3 of the 5 questions that Mills and Drance found to have a correlation coefficient of greater than 0.4 were also identified as such in the present study: these were questions related to color intensity (question 4), bumping into things (question 5), and tripping (question 6). Mills and Drance described 4 questions as important according to both stepwise regression and correlation analysis:

- Do you have trouble following a line of print or finding the next line?
- Do you bump into things?
- Have you had to give up any activities because of your vision?
- Do you notice any variation in color richness from time to time?

The present study found that 3 questions were consistently identified as strongly associated with Esterman disability scores by stepwise regression, correlation analysis, and logistic regression:

- Do you bump into things sometimes?
- Do you trip on things or have difficulty with stairs?
- Do you have difficulty finding things that you have dropped?

These findings suggest that trouble following print and having to give up activities are a feature of the severe visual disability more prevalent in the patient group studied by Mills and Drance, whereas bumping into things is related to the level of visual disability for patients with glaucoma with mild-to-moderate visual field damage as well as those whose vision is more severely impaired. The question about tripping was excluded from the multiple regression analysis in the study by Mills and Drance because it was found to be closely related to the question about bumping into things. This was not the case in the present study, perhaps because the addition of the phrase “or have difficulty with stairs” was sufficient to differentiate it from the question about bumping into things. The question “Do you have difficulty finding things that you have dropped?”—which the present study found to have an important association with binocular visual disability—was derived from the question “Do you have trouble locating things?”—which Mills and Drance did not find to be associated with the Esterman disability score. This difference may be a result of the difference between the patient groups in the 2 studies or it may be because the former question is related to a specific visual task: patients may find it easier to remember difficulty, or the lack of it, in this area. The fact that the 3 questions identified by this study as strongly associated with the Esterman disability score all relate to visual tasks primarily involving the inferior visual field may reflect the fact that the Esterman test grid is biased toward the inferior visual field.

Although the 3 questions (questions 5, 6, and 8) mentioned earlier were found to have a strong association with Esterman disability score by all 3 methods of analysis (stepwise regression, correlation analysis, and logistic regression) the adjusted $R^2$ of the multiple regression analysis is 0.34: the questions only explain 34% of the variance of...
the Esterman disability score, so they are not viable as predictors of it. (Mills and Drance found an adjusted R² of 48% for their explanatory questions.)

The findings of an association between visual field deterioration in both eyes and the subjective perception of visual deterioration, but no association between visual field deterioration in at least 1 eye and subjective deterioration, suggests that a stable visual field in 1 eye tends to mask the perception of deterioration in the other. It is unlikely that the degree of initial visual field damage is a confounding variable for the perception of visual deterioration: if this were the case, question 2 of the questionnaire would have been associated with the Esterman binocular disability score. It is noteworthy that, of the 21 patients with measured binocular deterioration, 5 were unaware of any visual deterioration. This is reflected in the poor performance of perceived deterioration as a marker of objective binocular deterioration (sensitivity, 76.2%; specificity, 67.3%) and the modest likelihood ratio: a patient reporting visual deterioration was 2.34 times more likely to have objective binocular deterioration than not.

Patients’ knowledge of their diagnosis and information contained about the status of their eye health during previous visits would be likely to influence their answers to questions relating to visual function. For this reason the findings of our study cannot be generalized to patients with newly diagnosed or undiagnosed glaucoma.

Previous studies have demonstrated moderate correlation between the perceived visual disability and visual field damage as measured by automated perimetry in severe glaucoma and moderate or severe glaucoma. Taken together, the results of this study suggest that, in mild-to-moderate glaucoma, both the existing severity of visual field damage in glaucoma and its rate of deterioration are associated with corresponding subjective perceptions of visual disability and deterioration. This challenge the belief that glaucoma is an insidious process in which the symptoms do not appear until the end stage of the disease. However, patient perception is a poor predictor of objective measurement of the visual field: the latter will remain paramount as means of measuring the visual consequences of the disease or of any therapy.

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The Institute of Ophthalmology retains the intellectual property rights to the PROGRESSOR software used in this study.

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REFERENCES