A Comparison of the Pattern- and Total Deviation–Based Glaucoma Change Probability Programs

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PURPOSE. To compare the rates of progression of visual field defects in glaucoma patients, by using the Glaucoma Change Probability program based on pattern deviation and total deviation probability maps.

METHODS. The incidence of progression of visual field loss among 67 eyes of 56 glaucoma patients with an average of 6 years of follow-up was estimated by applying the criteria set by the Early Manifest Glaucoma Treatment study, which uses the output from the Glaucoma Change Probability (GCP) program of the Humphrey Field Analyzer (San Leandro, CA) based on pattern deviation probability maps. This incidence estimate was compared with one obtained by applying the same criteria but using the GCP program based on total deviation probability maps.

RESULTS. The 6-year incidence of progression among patients with glaucoma was 23.2% and 35.7% using the GCP program based on pattern deviation and total deviation probability maps, respectively. Not all patients in whom visual field loss progressed according to pattern deviation also showed progression according to total deviation.

CONCLUSIONS. The GCP program based on pattern deviation probability maps appears to screen out patients in whom progression of visual field defects may be due to diffuse loss from cataract, but the pattern deviation maps may also be identifying other types of field loss not detected by the total deviation maps. (Invest Ophthalmol Vis Sci. 2000;41:1012–1016)

The ability to detect progression of visual field defects in patients with glaucoma is important for clinicians who treat patients and for researchers who conduct clinical trials of treatments for the disease. Several statistical methods for analyzing longitudinal visual field data have been proposed, but there is little agreement about which approaches best reflect true progression of the disease.1–14 A number of clinical trials of treatments for the disease. Several statistical methods for analyzing longitudinal visual field data have been proposed, but there is little agreement about which approaches best reflect true progression of the disease.1–14 A number of clinical trials are underway to test various treatments for glaucoma, and each uses a different analytic method for detecting visual field progression.15–19 The problem with evaluating these methods is that there is no gold standard against which to validate them. In addition, glaucoma patients in this age group often have media opacities that progress, making it difficult to separate visual field changes due to glaucoma from those due to cataract.

The printout of the Humphrey Field Analyzer (San Leandro, CA) for an individual visual field test result displays a total deviation and a pattern deviation probability map.20 The total deviation map gives the differences between the threshold values observed on the test- and age-specific normal threshold values at each location in the field. The pattern deviation map takes the difference between each observed threshold and the average threshold across the entire field and displays the difference between these values and age-specific normal threshold differences at each location. The rationale for this approach is that the pattern deviation values remove the diffuse field loss due to cataract and make the localized patterns observed after its removal more likely to be due to glaucoma than cataract. Such an outcome has been observed after cataract surgery when mean deviation values improved but corrected pattern standard deviations worsened.21

The Glaucoma Change Probability (GCP) program (Humphrey) compares the average of results of two baseline full-threshold visual field tests against the current test on a point-by-point basis. In the commercial version, this comparison is based on comparing total deviation probability maps.20 In the Early Manifest Glaucoma Treatment trial, output from the GCP program of the Humphrey Field Analyzer was used to classify progression of visual field defects.19,22 In that trial, the GCP program was used based on data from the pattern deviation probability maps. The reason for using these rather than the total deviation maps is that the pattern deviation approach reduces the likelihood of identifying changes due to cataract progression in the absence of visual field changes due to glaucoma. The evidence for this comes from a study of patients with glaucoma in which the visual fields tested before and after cataract surgery were compared using the GCP program.23 The differences between fields before and after cataract surgery were much greater when using total rather than pattern deviation maps.

In this study, we applied both types of GCP programs to a common set of annual visual fields of patients with glaucoma observed for an average of 6 years to estimate and compare the
incidence of progression using the two methods. The idea was to see whether the incidence of progression using the pattern deviation maps would be lower than if the total deviation maps were used, whether incident cases based on the pattern deviation maps would be a subset of those from the total deviation maps, and whether one or the other agreed more closely with a clinical assessment of visual field progression in these patients.

**METHODS**

The Glaucoma Screening Study was a longitudinal study at the Wilmer Eye Institute, sponsored by the National Eye Institute, to identify early risk factors for the development of glaucomatous field loss in patients with ocular hypertension. Primary open-angle glaucoma was diagnosed during a comprehensive examination by one of four study ophthalmologists. All patients with glaucoma had intraocular pressure higher than 21 mm Hg on at least two occasions before treatment. Visual field testing was performed annually using Program 30-2 of the Humphrey Field Analyzer. This is a full-threshold test of the central 30° field using a stimulus of size III and was administered by trained technicians according to the study protocol for testing. Patients included in this study were those in whom glaucoma had been diagnosed and who had at least 5 years of follow-up (at least six visual field tests), whose visual acuity was 20/100 or better, and whose first two field test results in the study were outside normal limits on the Glaucoma Hemifield Test. Only 0.6% of fields had false-positive response rates of 50% or more, 2.2% had false-negative responses of 50% or more, and 3.8% had fixation losses of 50% or more. Fields were not excluded on the basis of reliability criteria, because only a small fraction of fields were grossly unreliable and because there was no a priori reason to think that the comparison of the two methods would be differentially affected by reliability.

The clinical assessment of visual field progression was performed by two fellowship-trained glaucoma specialists who reviewed the sequence of visual fields for each patient. The clinicians were provided with individual printouts from the Humphrey programs but were not given the GCP printouts or any other clinical information. Each sequence of fields was classified as “definite progression,” “possible progression,” “stable-improved,” or “too unreliable to assess.” Each clinician independently assigned the sequences to one of the categories. Differences between the two clinicians were adjudicated, and one clinical assessment of progression was produced from this adjudication. To compare the clinical assessment with the statistical methods, eyes were classified as having incident progression if both clinicians agreed that there had been “definite progression.”

The classification system designed for the Early Manifest Glaucoma Treatment Study was used to identify incident progression of visual field defects. Progression was defined as a statistically significant deterioration \( P < 0.05 \) on the pattern deviation probability maps of the GCP printouts in at least three locations (not necessarily contiguous) with confirmation on two consecutive tests in the same locations. Improvement was defined as three locations that improved \( P < 0.05 \), and these improvements were confirmed on two further tests.

**RESULTS**

The study population has been described in detail elsewhere. Briefly, 67 eyes of 56 patients with glaucoma had two baseline visual fields that were outside normal limits on the Glaucoma Hemifield Test and had at least 5 years of follow-up field tests (median follow-up was 6.3 years). Forty-five percent of patients were African-American, and the average age at baseline was 62 ± 10 years. Ten percent underwent cataract surgery during this period, of whom 9% underwent combined cataract and glaucoma surgery. The average baseline vertical cup-to-disc ratio was 0.62. According to the classification of Hodapp et al., 28% of baseline fields had early, 30% had moderate, and 42% had severe defects. The average baseline mean deviation was \(-7.43 \text{ dB}\), and the average corrected pattern SD was 7.09 dB. Agreement between the two clinicians about progression of field loss was excellent, \( \kappa = 0.87 \) (95% confidence interval [CI], 0.63, 0.99), and adjudication was required for only 3 of the 67 eyes for classification as definite progression versus all other categories.

Based on clinical assessment, 20.9% of eyes and 23.2% of patients had progression of visual field loss during the 6 years of follow-up (Table 1). The incidence was the same using the GCP pattern deviation maps. However, the incidence was 32.8% of eyes and 35.7% of patients if total deviation maps were used (a 50% higher incidence than pattern deviation estimates). The rates of improvement of visual fields were similar for all three methods, with the total deviation map rates being slightly higher than clinical assessment or progression based on pattern deviation maps but not reaching statistical significance. There were nine eyes of nine patients in whom overall threshold values were too low at baseline to allow a comparison with subsequent fields using pattern deviation maps. If these patients were removed from the numerator and denominator, the inci-
Agreement between Clinical Assessment of Incidence of Progression of Visual Field Loss and Incidence Based on the GCP Pattern and Total Deviation Probability Maps

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DISCUSSION

The study by Bengtsson et al.23 showed that the change in pattern deviation maps between field tests performed before and after cataract surgery was much less than for total deviation maps. This suggests that the GCP program based on pattern deviation maps would be less affected by increasing media opacities than the one based on total deviation maps. However, this is the first time the two programs have been applied to a common longitudinal set of visual fields and the incidence of field loss progression compared. The incidence of progression using the pattern deviations maps was a third lower than the incidence based on total deviation maps. However, there were three patients who were identified as having progressive field defects on the pattern but not on the total deviation maps. Two of these patients had fields that produced unreliable results (one with abnormally high sensitivity). The third patient had reliable results in fields with three noncontiguous edge points that showed progression of field loss on pattern deviation maps but showed no progression on the total deviation maps. Because only one patient had unexplained disparate findings, our results support the notion that some progression detected
on the total deviation maps was due to progression of cataract rather than glaucoma.

Agreement between clinicians in this study was excellent when visual field sequences were classified into two categories alone. The agreement was moderate (κ 0.69) for classification into four categories. Unlike this study, Werner et al. found that agreement was better between statistical methods than between clinical observers. Agreement, as measured by κ statistics, ranged from 0.48 to 0.61 among three observers using two categories of classification, but it is difficult to compare results because agreement depends on the type and number of categories, the patient population, and the way in which agreement is measured.

It is difficult to know whether the pattern deviation maps screened out patients with increasing media opacification, because clinical documentation of cataract progression was not available for these patients. Because visual acuity was measured each time visual field testing was performed, a change in visual acuity was used as a proxy for media opacification. By visual acuity criteria, there was no evidence that those with a larger change in acuity were classified by the total deviation but not the pattern deviation method, as would be expected if the acuity changes reflected media opacification. There was modest agreement between clinical assessment of progression and the GCP. The agreement was slightly, but not significantly, higher using total deviation rather than pattern deviation maps. The clinicians had no information about cataract in these patients but had visual acuity and mean deviation data available to them, although these are poor proxies for true but more subtle media opacification.

In patients who had cataract surgery during follow-up, visual acuity improved only slightly, but this improvement did not correlate with improvement in visual fields as measured by the GCP based on either type of probability map. There was also no overlap in improvement in fields between clinical assessment and either of the two methods. It appears that the improvement was probably an artifact of the variability of visual field testing in this study.

An additional consideration in using pattern deviation maps for measuring progression is that the program could not assess 13% of eyes in which baseline threshold values were considered too low (or too high) to make an accurate assessment of change over time. Eight of nine of these eyes had baseline mean deviations that ranged from −17 to −23 dB. One eye had baseline thresholds that were too high (mean deviation of +3 and +2 dB). This may be a reasonable caution regarding assessment of progression and may help indicate to clinicians that a different testing strategy may be appropriate for these patients with more advanced disease. This caution is not provided with the current total deviation–based program.

In summary, the GCP program based on pattern deviation probability maps is likely to screen out some patients with increasing media opacities but with stable glaucoma. The program also identifies patients who have baseline thresholds that are low enough to make it difficult to assess further progression using the 30° full-threshold test. The program is not yet available commercially. Although the program appears promising, a study comparing the two methods using longitudinal data of adequate follow-up with well-documented media opacities and visual fields and perhaps simulation studies would be helpful in assessing whether pattern deviation maps are the preferred way to identify visual field defect progression in patients with glaucoma.

References


