A Clinical Comparison of Visual Field Testing With a New Automated Perimeter, the Humphrey Field Analyzer, and the Goldmann Perimeter

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Abstract: Automated threshold static perimetry with the Humphrey field analyzer and kinetic and suprathreshold static perimetry with the Goldmann perimeter were performed on 171 eyes: 69 with glaucoma or ocular hypertension, 69 with "neurologic" disorders, and 33 normal. The two fields were similar or differed only slightly in 78% of eyes overall and in 88% when both fields appeared reliable. In general, defects were slightly more extensive using the Humphrey than the Goldmann perimeter. In 21% of the eyes with glaucoma or ocular hypertension, defects were found with the Humphrey perimeter that were not present with the Goldmann perimeter. Patient fixation was more difficult to maintain on the Humphrey than Goldmann perimeter. Poor fixation accounted for 9% of the automated fields being inadequate whereas only 2% of the manual fields were inadequate. The results indicate that the Humphrey Field Analyzer is capable of reliably detecting and quantitating visual field defects. [Key words: automated perimetry, glaucoma, perimetry, visual field defects.] Ophthalmology 92:77–82, 1985

A number of different automated perimeters have been marketed with the goal of providing a standardized, accurate assessment of the visual field with less technical expertise required of the operator than is required with a Goldmann perimeter.[1] Automated suprathreshold static perimetry (eg. Fieldmaster) is most useful as a visual field screener whereas threshold static perimetry (eg. Octopus) provides quantification of visual field defects that is as good if not better than manual visual field testing using a Goldmann perimeter.[2–5]

We have had the opportunity to test a recently developed automated perimeter, the Humphrey Field Analyzer. This instrument has the capability of performing both suprathreshold static perimetry as a screening test and threshold static perimetry for quantification of visual field defects. This report is concerned with the latter. We performed visual field evaluations using both the Humphrey perimeter and Goldmann perimeter on 13 normal subjects and 103 patients with visual field defects of neurologic or glaucomatous origin in order to assess the reliability of this new instrument.

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The authors have no proprietary interest in the Humphrey Field Analyzer, or in Humphrey Instruments, or its parent company.

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DESCRIPTION

The Humphrey Field Analyzer consists of a white hemisphere of radius 33 cm with a uniform background illumination of 31.5 apostilbs. A projection device presents the stimulus at points in the visual field specified by the program selected. Ten screening programs and nine quantifying threshold programs are available. Stimulus size can be varied from 0.25 to 64 mm^2; 4 mm^2 is the recommended size (equivalent to Goldmann perimeter size III target). The stimulus may be presented in white, red, blue, or green. A near correction appropriate for age is used.

Fixation is not directly monitored by the perimeter but is indirectly assessed through the blind spot. The patient's blind spot is initially localized, and during the testing procedure approximately 10% of the stimuli are presented in the blind spot. The number of times the patient responds to seeing this light is recorded. An additional assessment of the patient's reliability is obtained by the perimeter's periodically producing just the sound associated with the light stimulus without actually presenting the light (called false positive if patient responds) and periodically presenting a stimulus in an area the patient can see (called false negative if patient fails to respond). The technician also can monitor fixation through a telescope centered on the patient's eye similar to the Goldmann perimeter.

We have primarily used the central 30-2 test pattern. This program determines the threshold at 76 points having 6° of separation within the central 30° of the visual field. At the onset of the program, the threshold of four "primary" points—one in each quadrant 10° from fixation—is measured. An initial stimulus is presented at an intensity which is expected to be suprathreshold. The intensity is then reduced in four decibel decrements in subsequent presentations until the patient cannot perceive it. The stimulus is then increased in two decibel increments until seen again, and this value is recorded as the patient's threshold at that point. The thresholds of the four "primary" points are used as starting points to determine the threshold of neighboring secondary points which are in turn used as the starting point for their neighboring points and so forth. When a value varies from the expected threshold by more than four decibels, it is remeasured. If a follow-up test is later done, the values from the initial test may be used as the starting point for the threshold determinations.

After completion of the test, values in decibel units at each point tested may be printed out. A gray tone picture of the visual field contours or a profile of a meridional cut through a portion of the visual field may also be constructed (Figs 1, 2).

MATERIALS AND METHODS

The records of 116 consecutive patients on whom visual field examinations were performed with both the Humphrey and Goldmann perimeters were retrospectively reviewed. The patients were grouped according to diagnosis: 63 had glaucoma or ocular hypertension, 40 had "neurologic" disorders, and 13 were normal. The average age of the patients was 50.5 years (range, 14–88).

The "glaucoma" group consisted of 57 eyes of 53 patients with glaucoma and 12 eyes of 10 patients with ocular hypertension. In most patients in this group, both visual field examinations were performed on just the right eye because of the length of the testing procedure.

The neurologic group consisted of patients with nonglaucomatous optic nerve disorders (22 patients) or lesions of the optic chiasm (9 patients) or retro-chiasmal visual system (9 patients). All patients underwent testing with both the Goldmann and Humphrey perimeters in each eye. In 11 of the patients with optic nerve disorders the fellow eye appeared normal. These eyes are included in the normal group below.

The normal group consisted of 22 eyes of 13 normal subjects who had no ocular pathology other than a refractive error and of the 11 normal eyes from the patients with unilateral optic neuropathy.

Thus the glaucoma group consisted of 69 eyes, the neurologic group of 69 eyes, and the normal group of 33 eyes.

The visual field examinations on each patient were performed by any one of our four highly skilled perimetrists. Testing with the Goldmann perimeter preceded that with the Humphrey perimeter in almost all patients. Both tests were always performed on the same day usually after a short rest period.

The central 30-2 test pattern of the Humphrey perimeter was used for all patients employing a white 4 mm^2 target. A near correction was used when appropriate.

The testing strategy using the Goldmann perimeter differed slightly among the three groups. In the "glaucoma" group, a target which could be seen 25° from fixation on the temporal side was used to kinetically plot a central isopter. This target was then statically presented at 76 points within the central 15° of the visual field. A second isopter was then plotted using a target which could be seen at 85° from fixation temporally. A near correction was used for the central isopter but was removed for plotting the peripheral one. Any field defects that were identified were then further defined in terms of depth and extent with additional isopters. The testing procedure followed in the "neurologic" and "normal" groups was similar except that standard isopters (I_{1e}, I_{2e}, I_{4e}) were kinetically plotted with additional isopters plotted as indicated. As in the "glaucoma" group the central 15° of the visual field were tested in a suprathreshold fashion.

For each eye the two visual fields were assessed and then compared by one of us (RWB). A field on the Goldmann perimeter was considered unreliable if the blind spot could not be plotted or if the perimetrist assessed the patient's fixation to be too poor to plot an adequate field. A field on the Humphrey perimeter was considered unreliable if the blind spot was not plotted,

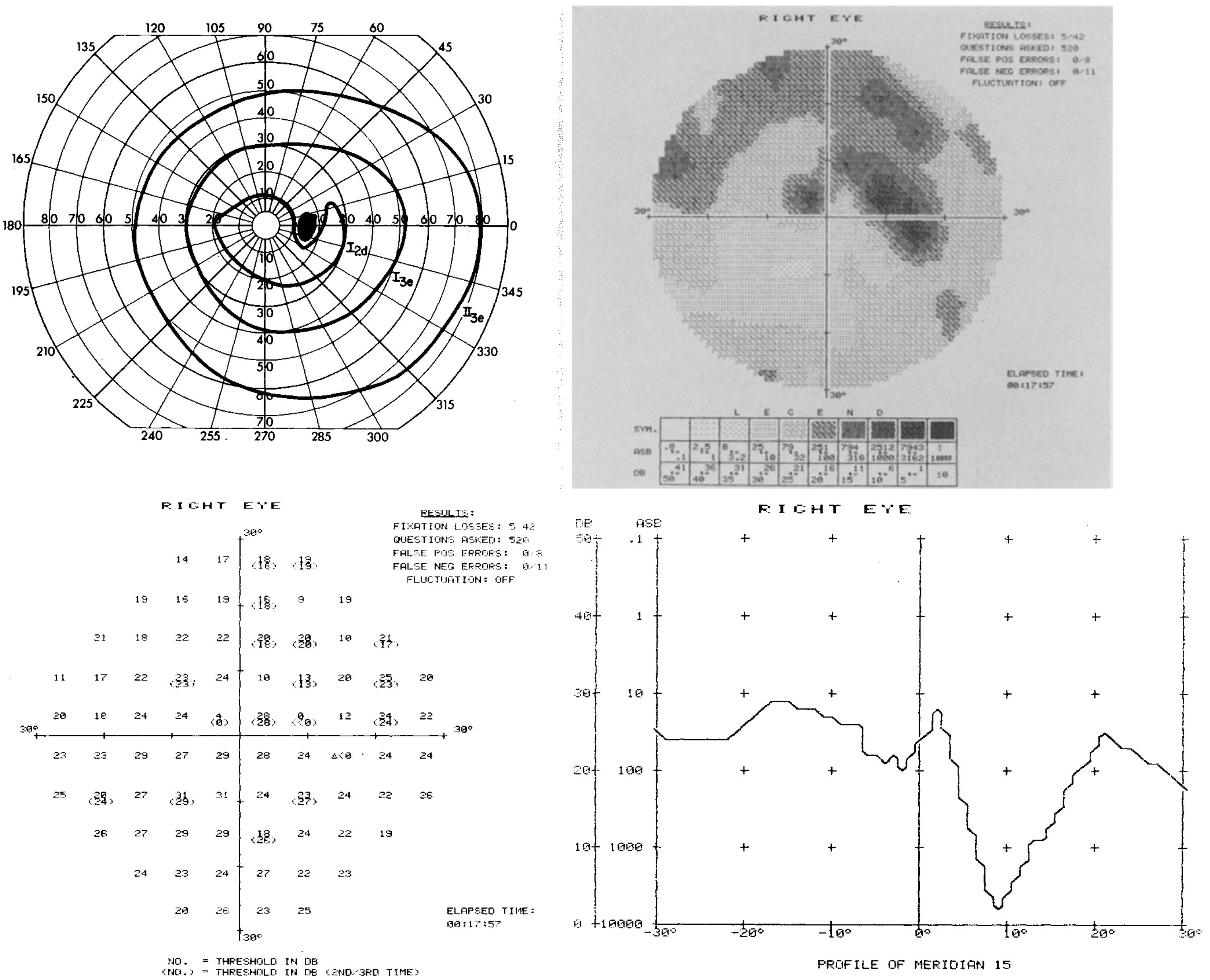

Fig 1. *Top left,* visual field performed on a Goldmann perimeter in a patient with glaucoma. *Top right,* gray-tone picture of the visual field in the same patient performed on the Humphrey Field Analyzer. Note that the visual field defect appears denser with the Humphrey than with the Goldmann perimeter. *Bottom left,* printout of the decibel values for the visual field at each point tested. *Lower right,* construction of the profile of the visual field along the 15° meridian.

or if visual loss was so extensive that virtually no field at all was plottable with the 4 mm^2 test stimulus. We did not consider fixation losses, "false positives," or "false negatives," (see earlier description) in this determination because of a lack of specific guidelines. However, almost all patients in whom the blind spot was properly plotted had a low number of fixation losses. Since the two testing methods differed so greatly we were unable to quantitatively compare the fields. Instead we made an independent subjective assessment of the extent and depth of any visual field defects on the plot from the Goldmann perimeter and the graytone printout from the Humphrey perimeter. We then compared the two fields and classified them into one of nine categories: (1) both fields with very similar defects, (2) both fields similar but with slightly more extensive defects on the Humphrey perimeter, (3) both fields similar but with slightly more extensive defects on the Goldmann perimeter, (4) both fields normal, (5) Goldmann perimeter field normal; Humphrey perimeter field abnormal, (6) Humphrey perimeter field normal; Goldmann perimeter field abnormal, (7) Goldmann perimeter field reliable; Humphrey perimeter field unreliable, (8) Humphrey perimeter field reliable; Goldmann perimeter field unreliable, and (9) both fields unreliable.

RESULTS

The distribution of the results of the visual field comparisons in this classification is demonstrated in Table 1 for pathologic eyes and Table 2 for normal eyes. Overall, the two fields were similar or differed only

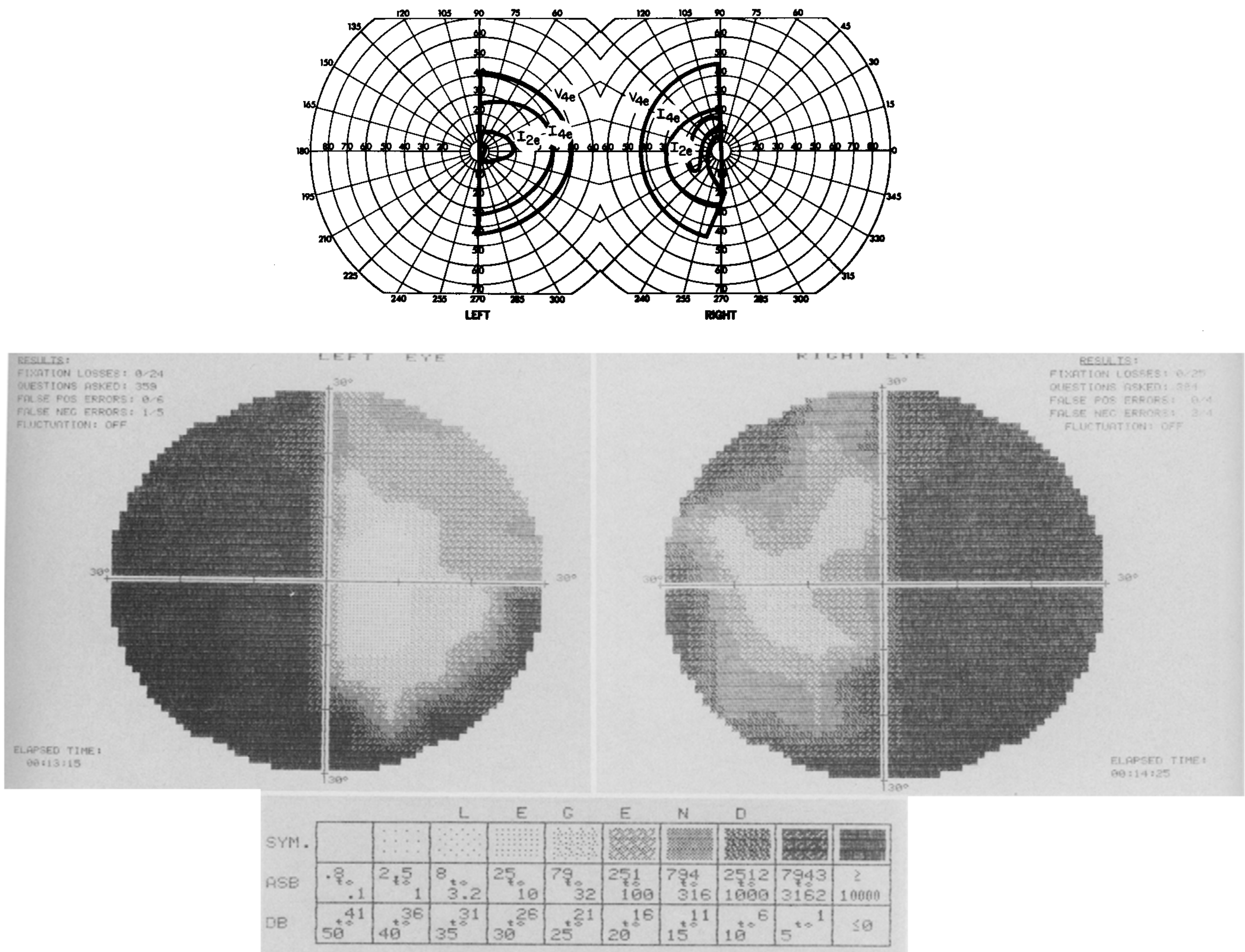

Fig 2. *Top,* visual field performed on a Goldmann perimeter in a patient with a chiasmal lesion. *Bottom,* Humphrey perimeter field in the same patient.

slightly in 78% of eyes. When both fields appeared reliable, they were similar in 88%.

In the neurologic group the two fields were similar or differed only slightly in all eyes in which both fields were reliable (87% of the group).

In the glaucoma group, both fields appeared reliable in 90% of eyes. In 77% of these the two fields were similar or differed only slightly. In an additional 21%, defects were found on the Humphrey perimeter that were not present on the Goldmann perimeter. In one case, a defect on the Goldmann perimeter was not present on the Humphrey.

In the normal eye group, no eye had defects on both manual and automated perimetry, but three eyes were minimally abnormal on the Humphrey perimeter and one on the Goldmann. There did not appear to be any pathologic explanation in these cases although two of the three with abnormal fields on the Humphrey perimeter had experienced optic neuritis in the fellow eye.

In 19 eyes (11%) the field on the Humphrey perimeter was inadequate. In three cases this was due to visual loss being so severe that virtually no field at all was plottable on the Humphrey while a V_{4e} isopter was plotted on the Goldmann perimeter. In the other 16 eyes, there was poor fixation and in each case the blind spot was not adequately plotted. Seven of the 16 were in the glaucoma group, six in the neurologic group and three in the normal group. In 12 of the 16, the field on the Goldmann perimeter appeared reliable (based on the blind spot being plotted and the technician's assessment of the patient's fixation and responses) while in four it did not. Patients with poor fixation averaged 52 years old (not significantly different from the total group). Reduced central vision was an impairment to fixation in only five cases.

The average test on the Humphrey perimeter was 14.5 minutes per eye. Normals averaged 14.2, glaucoma 14.9, and neurologic 14.3 minutes. We did not accurately time all the visual fields on the Goldmann perimeter but the normal and neurologic visual fields seemed to take slightly less time and the glaucoma ones more than with the Humphrey instrument. Patients in general felt

Table 1. Comparison of Humphrey and Goldmann Perimeters by Diagnosis

	Total Group	Glaucoma	Ocular Hypertension	Nonglaucomatous Optic Neuropathy	Chiasmal Lesion	Retrochiasmal Lesion
No. of Eyes	138	57	12	33	18	18
Very Similar Defects	70	25	0	17	15	13
Similar; Humphrey more extensive	28	15	0	6	3	4
Similar; Goldmann more extensive	4	2	0	1	0	1
Both normal	6	0	6	0	0	0
Goldmann normal; Humphrey abnormal	13	7	6	0	0	0
Humphrey normal; Goldmann abnormal	1	1	0	0	0	0
Humphrey unreliable; Goldmann reliable	12	5	0	7	0	0
Humphrey reliable Goldmann unreliable	0	0	0	0	0	0
Both unreliable	4	2	0	2	0	0

that the field on the Humphrey perimeter was more tiring and difficult to perform than the one on the Goldmann.

DISCUSSION

We found the test strategy we used on the Humphrey field analyzer to be reliable in the identification and quantification of both glaucomatous and neurologic defects in the visual field when compared to our standard technique on the Goldmann perimeter. Since the two techniques assess the visual field so differently, we did not attempt to define false positives or false negatives with either instrument. In the vast majority of cases in which fixation was adequate, defects found on the Goldmann perimeter were similar on the Humphrey perimeter. In general, however, defects appeared slightly more extensive on the Humphrey than Goldmann. This was particularly true with early glaucoma or ocular hypertension in which defects found on the Humphrey perimeter were often not present on the Goldmann. This is likely related to threshold static perimetry being more sensitive than kinetic perimetry combined with suprathreshold static testing[6,7] rather than a high false positive rate with the Humphrey perimeter.

Patient fixation was more difficult to maintain on the Humphrey than the Goldmann perimeter. Poor fixation accounted for 9% of the automated fields being inadequate whereas only 2% of the manual fields were inadequate. Our testing procedure of performing the field on the Goldmann perimeter prior to the one on the Humphrey perimeter in almost all patients may have contributed to this, but both the patients and our technicians felt that fixation was easier to maintain with the manual rather than the automated perimeter. Similar difficulty has been reported with the Octopus and other automated perimeters.[4,8] Performing accurate perimetry on a patient with poor fixation is truly an art and our results would indicate that in such cases a reliable field can better be obtained by an experienced technician using manual perimetry rather than automated. Without a highly skilled technician, however, perimetry performed on the Goldmann instrument may well have been as poor as on the Humphrey in the patients with poor fixation.

Testing with the 4 mm^2 size stimulus on the Humphrey instrument was generally satisfactory. In 10 eyes, however, visual loss was so extensive that a 64 mm^2

Table 2. Comparison of Humphrey and Goldmann Perimeters in Normal Eyes

	Total Group	Normal Subjects	Normal Fellow Eyes*
No. of Eyes	33	22	11
Both normal	26	17	9
Both abnormal	0	0	0
Goldmann normal; Humphrey Abnormal	3	1	2
Humphrey normal; Goldmann Abnormal	1	1	0
Humphrey unreliable	3	3	0
Goldmann unreliable	0	0	0

* Normal eyes of patients with unilateral optic neuropathy.

stimulus would likely have provided more useful information. We felt it would be too taxing on the patient to repeat the entire test with a larger stimulus on the same day. If a patient is known from previous testing to have extensive visual field loss, however, it would be advisable to use a 64 mm^2 stimulus for the initial field.

The results obtained with the Humphrey perimeter indicate a high degree of reliability in detecting and quantitating visual field defects. For the general ophthalmologist, visual field testing with the Humphrey instrument would seem to be much preferable to that with a Goldmann perimeter performed by a marginally trained technician. Trobe et al have demonstrated that community based perimetrists generally perform visual field testing on a Goldmann perimeter poorly.[9] With a reliable automated perimeter, a standardized visual field strategy is followed each time and the variable of technician error is essentially eliminated. We cannot answer the question as to whether the Humphrey perimeter is better than the Goldmann perimeter operated by a highly skilled technician. The detection rate of visual field defects was greater with automated than manual perimetry, but for the patient with poor fixation the manual technique did much better. There is thus likely a role for both automated threshold and manual kinetic perimetry.

The Octopus which performs automated threshold static perimetry similar to the Humphrey instrument has been demonstrated to be highly reliable in the detection and definition of visual field defects.[2–5] The results of our preliminary study suggest that the Humphrey perimeter is likely to prove to be of comparable value. A prospective study randomizing the order in which the two fields are performed and altering the test strategy used on the Goldmann perimeter to allow a more objective comparison to the automated threshold field will be necessary to further evaluate this instrument.

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