Use of a central 10° field and size V stimulus to evaluate and monitor small central islands of vision in end stage glaucoma

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Abstract

In a retrospective review of 24 clinically stable eyes with small central islands of vision due to end stage glaucoma the combined use of a central 10° program and size V stimulus (10-2 with V) measured visual function undetected on a central 30° field tested with both the standard size III and non-standard size V stimuli. Furthermore, the mean sensitivity of the 10-2 with V remained stable on serial field testing (mean 3.9 examinations) on long term follow-up (mean 22.2 months). This study suggests that in end stage glaucoma the size V target is the stimulus of choice and a central 10° field may be the program of choice of evaluating and monitoring small central islands of vision.

Most routine automated threshold perimetry is performed with a central 30° program and size III stimulus (4 mm²). With these standard test parameters, central fields may be non-measurable or have minimal thresholds in conditions with severe field loss. Under these circumstances the usefulness of field testing for long term monitoring is severely limited. Using the larger No. 5 stimulus (64 mm²), Wilensky and co-workers¹ measured visual function in areas considered absolute scotomas with the standard sized stimulus. Use of the larger sized stimulus may yield enough additional information to warrant future field monitoring with the No. 5 stimulus for all subsequent examinations.¹

In end stage glaucoma a small island of tunnel vision and a temporal island are all that remain of the central field. When the central island is evaluated with a standard 30° field, the 16 test loci within 13° of fixation are the major locations of measured visual function. In the absence of measurable field between 15° and 30° it would seem more practical to monitor a small central island of vision with a central 10° program. To my knowledge there have been no investigations of a central 10° program in end stage glaucoma. This study examines retrospectively the usefulness of combining a central 10° program and size V stimulus (10-2 with V) in evaluating and monitoring small central islands of vision in end stage glaucoma.

Materials and methods

Central static threshold visual fields of all patients in my glaucoma referral practice with end stage glaucoma damage were reviewed retrospectively to identify those in which the 10-2 with V program was performed and followed up

for at least one year. An eye classified as end stage glaucoma had a cup-to-disc ratio greater than or equal to 0.9 and a central island of vision less than 13° on a central 30° field tested with the standard size III stimulus (30-2 with III).

To avoid potentially confounding variables I excluded eyes with a visual acuity less than 20/40, clinically unstable intraocular pressure, and consistently unreliable visual fields. Clinically unstable intraocular pressures were defined by any single intraocular pressure greater than 21 mmHg or a mean intraocular pressure greater than 17 mmHg during the follow-up period. These intraocular pressure criteria were selected to be strict enough to ensure that the glaucoma was adequately controlled with a high degree of probability, yet flexible enough to allow for an isolated increase of intraocular pressure into a borderline range which was subsequently controlled with additional treatment. Unreliable visual fields were defined by fixation losses or false positive errors greater than 25%. False negative errors were not used in defining reliability because of the low number of catch trials in the presence of severe visual field loss.

All central static threshold visual fields were performed on the Humphrey Field Analyser Model 620, an automated, computer-driven projection perimeter. All eyes were tested with the 10-2 with V program as well as the standard 30-2 with III and non-standard 30-2 with V programs.²⁻⁴ The central 10-2 program tests 68 points, equally spaced 2° apart and offset from the horizontal and vertical meridians by 1°. The central 30-2 program tests 76 points, equally spaced 6° apart and offset from the horizontal and vertical meridians by 3°. All first visual fields were performed with a 'full' threshold strategy and all subsequent examinations with a 'full from prior' threshold strategy, the patient's most recent test results being used as a starting point for re-examination. All eyes had serial field testing with 10-2 with V program alone or in combination with either the 30-2 with III or 30-2 with V programs. While the field analyser was updated with software revisions as they became available, all visual fields were analysed by Statpac Plus. The software compares the patient's measured threshold values with an age related normal database in programs using the standard size III stimulus, a feature incorporated into Statpac, and to mathematically derived 'normal' values based on a slope equation in programs using the non-standard size V stimulus.

The 'first' fields of all eyes performed with each program were examined for the mean deviation (30-2 with III) or mean sensitivity

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(30-2 with V and 10-2 with V), the percentage of loci with measureable thresholds within 13° of fixation, and the number of quadrants with no detectable threshold – that is, 0 dB, at 4.2° from fixation per quadrant. The parameters of 13° and 4.2° were selected so as to include the loci at the four diagonal positions 9° ($9^\circ \times 1.414 = 12.7^\circ$ eccentricity) and 3° ($3^\circ \times 1.414 = 4.2^\circ$ eccentricity) from the horizontal and vertical meridians. A subgroup of 50% of eyes with the lowest mean deviations on the 30-2 with III program were also compared with respect to their mean sensitivities on 30-2 with V and 10-2 with V programs. The value mean deviation used with the size III stimulus reflects the average deviation of sensitivity from a normal population of the same age, while the value mean sensitivity used with the size V stimulus does not take age or a normal population into account.

Moreover, the first 30-2 with V examination for each eye was evaluated for the presence of test loci with measurable thresholds in Bjerrum's region between 15° and 25°. For serial visual field examinations the number of fields performed and length of follow-up with each program were determined. The mean deviation of the 30-2 with III program and the mean sensitivity of the 30-2 with V and 10-2 with V programs were the indices used to determine stability or change on serial examination.

The means were compared by a correlated-samples *t* test. Frequencies were compared by McNemar's test. A repeated-measures analysis of variance was performed on the mean sensitivity of serial 10-2 with V fields, the mean deviation of serial 30-2 with III fields, and the mean sensitivity of serial 30-2 with V fields. The actual calculations were made with the App-Stat software package for the Apple IIe computer.⁵ The standard two-tailed 0.05 significance level was used.

Results

Twenty-four eyes in 18 patients fulfilled the study criteria. The mean length of follow-up for visual fields performed with the 10-2 with V program was 22.2 months (SD 4.9 months). The mean intraocular pressure of all eyes during the follow-up period was 15.0 mmHg (SD 1.4 mmHg). The mean age of the patients was 73.5 years (SD 9.5 years).

Table 1 shows the 'first' field data for the mean deviation of the 30-2 with III program and the mean sensitivity of the 30-2 with V and 10-2 with V programs. The mean sensitivity for the 10-2 with V program was significantly greater than for the 30-2 with V program for all 24 eyes ($p < 0.001$) and for 50% of eyes with the lowest mean deviation on 30-2 with III ($p < 0.001$). Coincidentally, this subgroup also had the 12 lowest mean sensitivities on the 30-2 with V. Fig 1 is an example of the numeric threshold and grey-tone printouts from the three field programs of an eye in this subgroup.

Table 2 shows the percentage of measurable loci within 13° and the number of eyes with absolute loss at 4.2° from fixation per quadrant on the first fields of all three programs. The percentage of loci with measureable thresholds

Table 1 Mean deviation (30-2 with III) and mean sensitivity (30-2 with V and 10-2 with V) of first fields (in dB)

	All eyes (n=24)		50% of eyes (n=12)*	
	Mean	SD	Mean	SD
30-2 with III	-25.79	3.15	-28.27	1.39
30-2 with V	6.60	6.32	1.50	1.95
10-2 with V	15.58†	7.27	12.33†	8.28

*Eyes with lowest mean deviations on 30-2 with III.

† $p < 0.001$ compared with 30-2 with V.

within 13° was significantly greater for the 10-2 with V compared with both the 30-2 with V ($p < 0.001$) and 30-2 with III ($p < 0.001$) and for the 30-2 with V compared to the 30-2 with III ($p < 0.001$). The number of eyes with detectable thresholds at 4.2° from fixation was significantly greater with both the 30-2 with V program ($p = 0.003$) and 10-2 with V program ($p < 0.001$) as compared with the 30-2 with III program. However, there was no significant difference between the 30-2 with V and 10-2 with V programs. Further, on the central 30° program 10 of 24 eyes had measureable thresholds in Bjerrum's region from 15° to 25° by the size V stimulus in at least one quadrant. These same areas were considered absolute scotomas with the standard sized III stimulus.

Table 3 shows the number of eyes tested, number of serial visual fields, and length of follow-up for each field program. Of the 24 eyes followed up serially with the 10-2 with V, eight were simultaneously followed up with the 30-2 with III, and 11 other, different, eyes were simultaneously followed up with the 30-2 with V. There was no significant difference on serial field testing of the mean sensitivity of the 10-2 with V and 30-2 with V programs and the mean deviation of the 30-2 with III program during their respective follow-up periods. Fig 2 shows the grey-tone printouts of six serial fields using the 10-2 with V program on the eye in Fig 1.

Discussion

In end stage glaucoma the central visual field is a tiny island of vision in a sea of darkness. With automated threshold perimetry these central fields may be unmeasurable or have minimal thresholds by the standard test parameters, namely, a 30° field and size III stimulus. To my knowledge this study is the first investigation examining the combined use of a central 10° program and size V stimulus to evaluate and monitor small central islands of vision in end stage glaucoma. In a retrospective review of 24 clinically stable eyes with end stage glaucoma the 10-2 with V program measured visual function undetected with the 30-2 with III program. Furthermore, the mean sensitivity of the 10-2 with V program remained statistically unchanged on serial testing over a mean of 22 months. These findings suggest that the 10-2 with V program provides additional field information to evaluate the integrity of small central islands of vision and possibly to monitor their stability in the long term.

However, the 10-2 with V program may not

Figure 1 The numeric threshold and grey-tone printouts from the first 30-2 with III (left), 30-2 with V (middle), and 10-2 with V (right) of an eye with a small central island of vision due to end stage glaucoma.

be the optimal parameters for all eyes with end stage glaucoma. As with the 10-2 with V program, the 30-2 with V program measured visual function within 13° and at 4.2° from fixation undetected with the 30-2 with III program. In addition, in 42% of eyes the 30-2 with V program measured visual function between 15° and 25° in at least one quadrant.

These data support the findings of Wilensky and co-workers,¹ who first demonstrated that the size V stimulus measured visual function in areas considered absolute scotomas with the standard size III stimulus. However, the mean sensitivity of the 10-2 with V was 235% greater than the 30-2 with V for all eyes and 822% greater for the 50% of eyes with the least measurable fields. Within the central 13° the 2° spacing of test loci on the 10-2 with V program appears to provide additional field information not seen with 6° spacing on the

30-2 with V program. These findings suggest that in end stage glaucoma the size V target is the stimulus of choice and the 10° field may be more appropriate than the 30° field for evaluating and monitoring small central islands of vision which have minimal or non-existent thresholds in Bjerrum's region.

The psychophysical effects of varying target size in the visual field have been previously examined.⁶⁻⁸ It has been well established that spatial summation is larger in the peripheral retina, at low luminance levels, and for large stimuli.⁶ Owing to spatial summation a large stimulus is more easily seen than a smaller stimulus of the same luminance.⁶ Most automated perimeters use a standard 4 mm² stimulus size, equivalent to the Goldmann size III, because it creates the greatest dynamic range of differential light sensitivity in the visual field.^{6,9} The smaller size I stimulus at maximum intensity is not strong enough to quantify the depth of defects, and the size V stimulus is larger than some of the scotomas one may wish to detect.¹⁰ In end stage glaucoma with small central islands of visual field, spatial summation due to the larger size V stimulus allows measurement of significant visual function undetected by the standard size III stimulus. In this population use of the size V stimulus appears to have practical advantages over the standard size III stimulus in measuring and following serial fields over time.

The 50% of eyes with the least measurable fields had non-existent or virtually non-existent thresholds when the 30-2 with III and 30-2 with V programs were used. The severity of field loss in this subgroup, as seen in the example of Fig 1, precludes a meaningful prospective evaluation with standard testing parameters. Eyes with less severe field loss would have to be used in a prospective comparison of the 10-2 with V and 30-2 with III programs. Furthermore, a prospective study should control the frequency and number of visual fields. This would eliminate the possibility of self selection by patients and provide a more meaningful comparison of the serial fields. A prospective

Table 2 Measurable loci within 13° and absence of detectable thresholds at 4.2° from fixation on the first field of the 30-2 with III, 30-2 with V, and 10-2 with V programs (n=24 eyes)

Visual field program	Percentage of loci with thresholds >0 dB within 13°		Number of eyes with no detectable threshold at 4.2° from fixation per quadrant			
	Mean	SD	1 quad	2 quads	3 quads	4 quads
30-2, III	37.8	21.2	18	15	9	3
30-2, V	58.9†	25.4	7†	3	2	1
10-2, V	87.5‡§	25.0	5‡	2	1	0

*The 30-2 with III and 30-2 with V have 16 test loci and the 10-2 with V program has 68 test loci within 13 degrees from fixation.

†p<0.01 compared to 30-2 with III.

‡p<0.001 compared to 30-2 with III.

§p<0.001 compared to 30-2 with V.

Table 3 Number of eyes tested, number of serial visual fields, and length of follow-up with each program

Visual field program	Number of eyes	Number of serial visual fields		Length of follow-up (in months)	
		Mean	SD	Mean	SD
10-2 with V	24	3.9	1.6	22.2	4.9
30-2 with V	11	4.8	1.3	20.6	8.9
30-2 with III	8	5.8	2.3	26.0	8.1

Figure 2 The grey-tone printouts of six serial fields performed over 2½ years using the 10-2 with V program on the eye in Fig 1. On linear regression analysis, the mean sensitivity slope, $+1.1$ ($SD\ 3.8$) dB/year, was not significant, $p \geq 5\%$.

study should also consider monitoring the temporal peripheral island of vision, which is often quite large and prominent in end stage glaucoma. Evaluation of these temporal islands of vision would require peripheral field testing with the 30/60-2 program, an effort which was not undertaken in the current study.

For central threshold perimetry in end stage glaucoma retaining a small central island of vision I recommend that eyes with a mean deviation greater than -20 dB using a 30° field with size III stimulus should have additional 30° field testing using a size V stimulus. Furthermore, eyes with a mean deviation greater than -25 dB using a 30° field with the size III stimulus should have additional field testing using a 10° program with the size V stimulus. As the use of non-standard parameters in automated threshold perimetry becomes more commonplace, a normal reference population database will become necessary to facilitate the development of statistical parameters other than mean sensitivity. This effort would further enhance our

ability to evaluate and monitor severe visual field loss.

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