BLUE VERSUS WHITE STIMULI IN OCULAR HYPERTENSION WITH THE FRIEDMANN MARK 1 VISUAL FIELD ANALYSER

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SUMMARY

Fifty eyes of fifty patients with ocular hypertension had their visual fields tested on a Friedmann Mark 1 field analyser whilst wearing a Wratten 47B blue filter in a spectacle frame. All had normal visual fields to a white stimulus. Use of a scoring system with the blue field identified 11 patients (22%) with ocular hypertension as abnormal. The scores from this subgroup were indistinguishable from a group of subjects with early glaucomatous field loss, whilst the remaining scores were similar to normal subjects. These two subgroups of ocular hypertensive patients were similar in age and intraocular pressure. The use of a blue filter in front of the eye may offer a simple test to identify a subgroup of patients with ocular hypertension who are at increased risk of developing field loss.

Ocular hypertension (OH) is a frequently seen condition in clinical practice. It is characterised by a raised intraocular pressure (IOP) but without an associated field defect. Longitudinal studies suggest that approximately 10% of patients with OH will later develop field loss,[1,2] although reports of conversion to glaucoma range from 3%[3] to nearly 36%[4]

A major clinical challenge is to identify the subgroup of ocular hypertensives who will later develop field defects. This is of some importance because recent work has suggested that topical treatment can decrease the incidence of glaucomatous damage.[5]

The use of a blue filter with Friedmann visual field screening has been previously reported to increase the size and depth of field defects in glaucoma.[6] However, later work employing a suprathreshold technique suggested that a blue stimulus was less practical and less sensitive than a white stimulus[7] Both of these studies used the inbuilt filter in a Friedmann Mark 2 Visual Field Analyser. We have found that the use of a blue filter mounted in a spectacle frame with the Friedmann Mark 1 provided good discrimination between normal and glaucomatous patients, when used in conjunction with a scoring system based on target groups.[8]

This report discusses its use in ocular hypertensive subjects, and its advantages over a white stimulus.

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METHODS

Patients were recruited from ophthalmic outpatient clinics at two hospitals. To be eligible for this study, unaided visual acuity had to be 6/18 or better, with a best corrected acuity of at least 6/9. Known diabetics were excluded, as were patients on miotic drops. All patients gave verbal consent after the nature and purpose of this investigation had been explained to them.

Two groups of patients were identified: normal subjects, i.e. an IOP <21 mmHg with normal optic discs and healthy fundi and ocular hypertensives with an IOP >21 mmHg without field defects on standard Friedmann testing or pathological disc changes on biomicroscopy with either a fundal contact lens or a Volk 90 dioptre lens. There were no media opacities on clinical examination.

For all patients, IOPs were recorded using a standard Goldmann applanation tonometer. The diagnostic IOPs (i.e. those recorded before treatment was commenced) were used in the statistical analysis.

Two visual fields were recorded for each patient, using the Friedmann Mark 1 Visual Field Analyser. The background illumination of this machine is in the mesopic range. The protocol is described in detail elsewhere.[8] Briefly, subjects were tested without spectacle correction and the threshold to a white stimulus was determined. This was defined as the filter setting when two of the four targets 2.5 degrees from fixation were seen in two of the three attempts allowed. This value was then reduced by 0.4 log units to give the working value. The field to a white stimulus was then measured at the working value. Any points that were missed after three attempts at this level were re-

tested with the neutral density filter being reduced in steps of 0.2 log units, until the targets were seen, or the limits of the machine were reached.

The second visual field was recorded with the subject wearing a spectacle frame containing a Wratten 47B blue filter with an occluder in front of the fellow eye. This filter gives a peak transmission at 440 nanometres. The same sequence as above was employed, although the test was started using the working value already determined for the white target.

A scoring system was used with the blue field, termed the selective blue field (SBF). The highest filter setting for each target setting (groups of 2 to 4 targets) was defined as the threshold for that particular group. One point was then given for each 0.2 log unit reduction from this derived 'setting threshold' for the remaining points in the group, to give the SBF score (see example in Figure 1). A similar scoring system was also used with the white field.

Statistical analysis was performed with the unpaired t-test on normally distributed data. Non-parametric tests were employed with the white and SBF scores, which were not distributed in a normal fashion. Results are given as mean (SD) unless otherwise noted. If both eyes were eligible for inclusion, only one was randomly selected for statistical analysis.

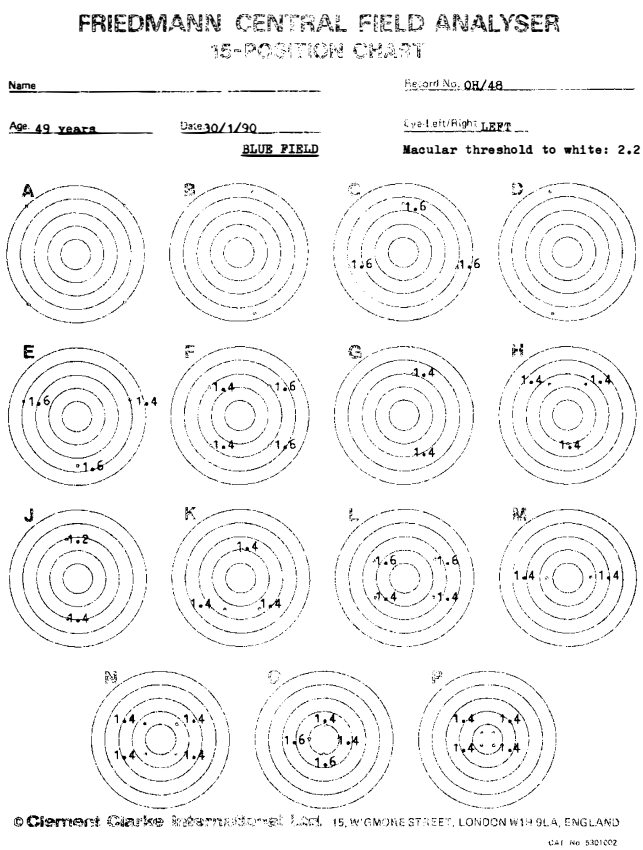
RESULTS

One hundred patients were studied, 50 normal subjects and 50 ocular hypertensives. Their mean ages were 59.1 (10.4) and 62.0 (11.7) years respectively, which were not significantly different. The mean IOP and white and SBF scores for both groups are shown in Table I. The frequency distributions of the white and SBF scores are displayed in Figures 2 and 3.

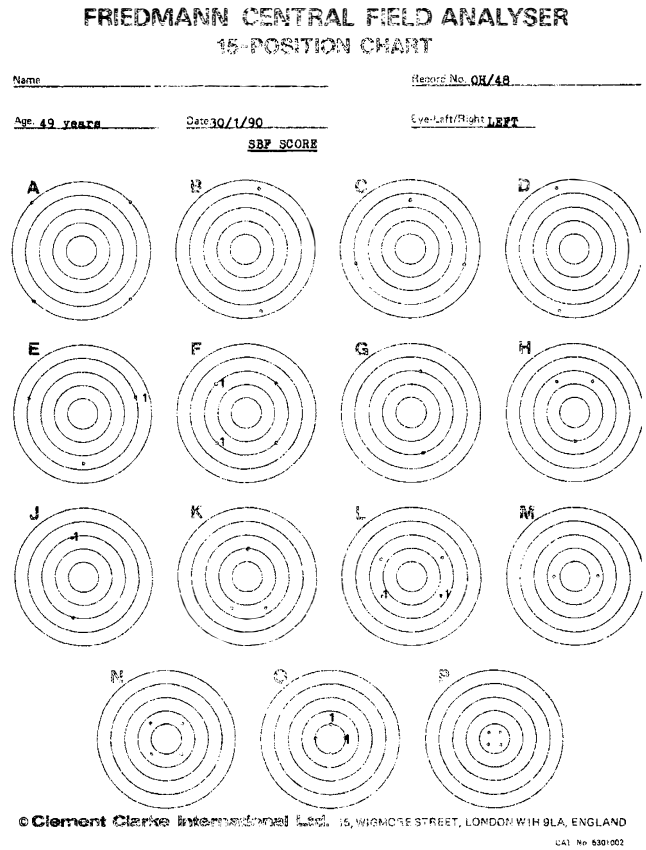
The mean IOP of the normal subjects was, as expected, lower than the OH group ($p<0.0001$). There was no difference in white field score between the normal and ocular hypertensive groups, by definition. The SBF score for normal subjects was significantly lower than the OH group ($p>0.02$).

There was no difference in macular thresholds between the two groups, and so the operating range of the machine was the same for all. This was not affected by the blue filter, because it was used at the working value calculated for the white stimulus. Thirty-six normals and 37 ocular hypertensives had both eyes tested. Paired analysis between right and left eyes (right eyes being tested first throughout) showed no differences in white and SBF scores.

An upper limit of normal (ULN) of 19.7 was calculated from the SBF scores of normal subjects, in order to give a specificity of 96% Applying this cut-off value to the OH group produces a low OH subgroup of 39 subjects and a high OH subgroup of 11 subjects. The number of ocular hypertensives who fall in the high OH subgroup is unlikely to have arisen by chance (chi squared with Yates'



(a)



(b)

Fig. 1. *(a) Visual field of left eye with the blue filter. (b) Same field, with SBF scores (see text for details). The SBF score in this example is 8.*

Table I. Mean (SD) intra-ocular pressure (IOP) and white and selective blue field (SBF) scores

	Normal	OH	Significance
IOP*	16.0 (2.9)	27.1 (5.0)	$p<0.0001$
White field score	0.5 (1.5)	0.5 (1.0)	NS
SBF score	7.5 (6.2)	12.7 (10.4)	$p<0.02$

* In mmHg

correction, $p<0.02$). Their IOPs and white field and SBF scores are detailed in Table II. The mean age of these two subgroups was similar (61.4 (12.0) years and 64.2 (10.5) years respectively, as were their IOPs.

The white field scores show no difference between the low OH and normal groups, whilst the high OH subgroup is just different from both normals and the low OH subgroup ($p<0.05$). There is no difference in SBF score between normals and the low OH group. However, the SBF scores of the high OH and normal subjects are significantly different ($p<0.0001$).

DISCUSSION

In order to perform statistical analysis on visual field data, a scoring system is required. Our system, giving one point for each 0.2 log unit reduction from the working value, is very similar to that used by Henson and co-workers (9,10). Although it gives a better indication of the depth of the defect, our system includes no attempt to weight the scoring system for clusters of missed points. Despite this, our system gives good discrimination between normal and early glaucoma subjects[8] for both white and blue fields. However, some of our early glaucoma subjects had an SBF score that was less than the calculated ULN. Differing mechanisms of damage have been suggested to occur in glaucoma, supported by a study comparing the blue colour mechanism in low and high tension glaucoma.[11] Sophisticated statistical analysis by Schulzer and colleagues has also demonstrated two distinct populations of glaucoma patients, one pressure sensitive and the other pressure independent.[12] This may be a reason why some of our glaucoma patients gave apparently normal results with the blue filter. A recent paper has shown that some glaucoma patients have preservation of normal colour vision, albeit from macular testing of colour contrast sensitivity.[13] The authors of this study suggest that there may be two patterns of colour vision damage in glaucoma, one diffuse and the other sparing the macula.

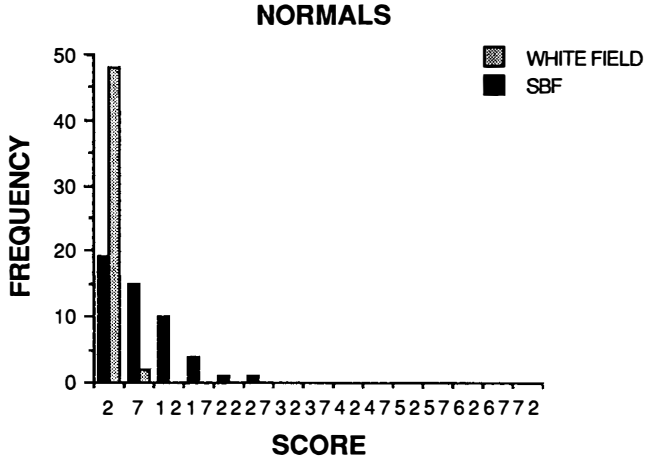


Fig. 2. *Frequency histogram of white and SBF scores for normal subjects.**

As would be expected in view of the initial classification of our patients, there was no difference in white field scores between normal and ocular hypertensive subjects. The statistically significant difference in white field scores that was found with the two subgroups of ocular hypertension represents a single missed point at 0.2 log units below the working value. Such missed points are very common in normals,[14] and therefore of no clinical relevance.

Wearing the blue filter reduces both the target and background illumination to the same extent. Thus the ratio of target to background, the Weber-Fechner relation,[15] remains constant. Logan and Anderson rejected the use of a blue stimulus over a white one, but kept the background illumination identical for both tests.[7]

Does our reduction in background illumination induce a dark adaptation factor? The lack of any asymmetry in the SBF scores in those patients who had both eyes tested indicates that any dark adaptation occurring during the test does not affect the results, providing our protocol is followed.

The advantage of the SBF score is that the use of a calculated ULN produces two subgroups from the original ocular hypertensive population, that was not possible with the IOP or the white field score. Clinical examination of the optic discs was also unhelpful in separating these two subgroups. However, recent work has emphasised the vital importance of the size of the optic disc when assessing the relevance of a particular cup-disc ratio.[16,17] The routine clinical examination of the optic discs in this study could not include the disc size factor.

Yamazaki and colleagues reported a correlation between loss of blue sensitivity and the highest recorded IOP, although this was in glaucoma patients.[18] This finding might be expected to have some influence on the com-

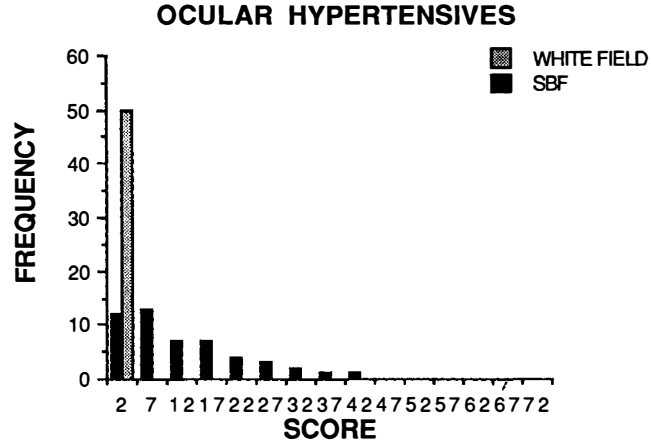


Fig. 3. *Frequency histogram of white and SBF scores for ocular hypertensive subjects.**
**Scores represent mid-points of groups of 5 scores e.g. 2 = 0.4, 7 = 5.9, etc.*

Table II. Mean (SD) intra-ocular pressure (IOP) and white and selective bue field (SBF) scores for the two subgroups of ocular hypertensives

	Low OH	High OH	Significance
IOP*	27.1 (4.9)	27.4 (5.8)	NS
White field score	0.3 (0.8)	1.2 (1.5)	$p<0.05$
SBF score	8.2 (5.7)	28.6 (6.5)	$p<0.0001$

* In mmHg

position of the two subgroups of ocular hypertensives. However, the lack of any significant difference in the mean IOPs of the two subgroups would suggest that in fact it played no part. Interestingly, we did not find a correlation between SBF score and IOP in either group.

The low OH subgroup produced by use of the SBF score with a calculated ULN have similar SBF scores to normal subjects, whereas the high OH subgroup are indistinguishable from the results that we have previously reported in an early glaucoma group.[8] The proportion of OH subjects with an abnormal SBF score changes only slightly (from 22% to 26%) when the specificity of the test is reduced from 96% to 90%. A recent study, using a blue stimulus on a yellow background, also found that 19% of ocular hypertensives had glaucomatous field defects that were not present to a white target.[19] However, Sample and Weinreb reported that almost 43% of ocular hypertensives fell more than two standard deviations below normal when measuring the threshold to a blue stimulus on a yellow background.[20] Contrast sensitivity has been shown to be abnormal (defined as greater than 2 SDs from age-matched normals) in 63% of subjects with OH,[21] and pattern electroretinography has also identified 63% of ocular hypertensives as being abnormal,[22] with results in that subgroup being similar to those obtained from patients with early glaucoma. All of these latter proportions are somewhat greater than the reported incidence of conversion to glaucoma in longitudinal studies of ocular hypertension.[1-4] However, recent work using peripheral colour contrast sensitivity[23] found that about 20% of the high risk OH group were abnormal when using their criteria for glaucomatous subjects.

The visual fields were tested without spectacle correction. This was to prevent artefacts arising from the overlap between the subject's own spectacle frame and that of the blue filter. This may be a source of error in our results. However, whilst induced refractive errors have indeed been shown to cause a depression in thresholds values, this occurs to a similar degree across the central 25°.[24] Thus this is unlikely to have a significant effect on the results. The mean ages of the normal and OH subjects were similar, so accommodation (or lack of it) would not be expected to produce the observed difference in SBF scores between these two groups. The same argument applies to the two subgroups of the OH group, who have similar ages to each other.

Marked loss of nerve fibres may occur before visual field defects are noted.[25] This loss preferentially affects the large diameter fibres,[26,27] and blue light information is processed by larger ganglion cells than in red or green.[28] Blue colour vision abnormalities have been reported in both glaucoma and some ocular hypertensives[29,30] and use of a blue stimulus on a yellow background has been shown to detect glaucoma-like field defects not present with a standard white stimulus in some patients.[19,31] Our simple protocol appears to detect early loss of visual function in a similar proportion of OH patients.

A recent study has found that topical timolol reduces the incidence of glaucomatous field loss in patients with moderate risk ocular hypertension, based on factors such as IOP and vertical cup-disc ratio.[5] Their patients had similar IOPs to those in our OH group and its subgroups. Another group of investigators has also demonstrated this effect,[32] although their study population had lower IOPs than our OH group.

Our simple adaptation to the Friedmann protocol may permit recognition of a subgroup of ocular hypertensives who will later develop glaucomatous field loss, and who should benefit from early treatment. However, longitudinal studies using automated threshold analysers are required to define the value of the use of the blue filter.

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Key words: Blue filter, Friedmann Mark I Visual Field Analyser, Glaucopma, Ocular hypertension, Visual fields.

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