Visual field constriction as a cause of blindness or visual impairment

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Reported are the results of a study of onchocerciasis in communities mesoendemic for savanna onchocerciasis in Kaduna State, northern Nigeria. The study involved 6831 individuals aged ⩾5 years who underwent an extensive screening examination for visual function including Friedmann field analysis. A total of 185 (2.7%) were bilaterally blind by acuity and an additional 28 (0.4%) were blind by visual field constriction. Also 118 (1.7%) individuals were visually impaired by acuity criteria. No criteria for visual impairment by field constriction have been established, and we therefore investigated three potential criteria. As a result, a further 60 (0.9%) individuals were identified with significant visual impairment due to field loss by the various definitions. Small islands of remaining peripheral field occurred in 50 individuals, while 40 individuals had marked reduction of binocular visual field below the horizontal meridian. Concentric visual field constriction to <20° was found in seven individuals.

The WHO definition of blindness currently includes visual field damage criteria for blindness but not for visual impairment. Visual field loss is recognized as a major disability. We hope that these findings stimulate international discussion leading to the development of satisfactory definitions for visual impairment by visual field constriction.

Introduction

In 1973 a WHO Study Group on the prevention of blindness proposed five categories of visual impairment that have since been widely adopted, permitting direct comparison of blindness and visual impairment rates from various studies in different populations (Table 1) (*1*).

Visual field loss is recognized as a major disability. Severe visual constriction despite preserved central vision constitutes one of the internationally agreed categories of blindness (*1*). It has been recommended that in areas where onchocerciasis is present visual field testing be included in the basic eye examination (*2*). Nevertheless, almost all reports on the prevalence of blindness have omitted field constriction, even in onchocercal areas, because such data are difficult to validate and their collection is very time consuming.

In this article we report the effect of measuring field constriction in addition to visual acuity on estimates of blindness and visual impairment rates in mesoendemic onchocercal communities in the guinea savanna of Kaduna State, northern Nigeria.

Table 1: **WHO categories of blindness and visual impairment**

		In the better eye:		
	WHO category	Visual acuity		Visual field constriction
Visual impairment	1	<6/18		—
	2	<6/60		—
Blindness	3	<3/60	or	<10°
	4	<1/60	or	<5°
	5	NPL[a]		—

[a] NPL = no perception of light.

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Methods

Population characteristics

As part of a large randomized, controlled trial to investigate the impact on onchocerciasis of annual mass chemotherapy with ivermectin, 34 communities in Kaduna State, northern Nigeria were selected for detailed ophthalmic screening (the criterion for selecting communities was that the prevalence of *Onchocerca volvulus* positive skin-snips in those aged ≥20 years be ≥30%). The prevalence of positive skin-snips was 71% in all the communities studied and lay in the range 39–93%. The community microfilarial load (CMFL) in those aged ≥20 years in the 34 study communities was 3.23 microfilariae per mg of skin and ranged from 0.95 to 9.96. The vast majority of the households in the study communities live by subsistence farming with few cash crops grown. The habitat is guinea savanna and the vectors are *Simulium damnosum s.s.* and *S. sirbanum* (*3*).

Screening methods

After the free and informed consent of the participants had been obtained, an extensive ophthalmic screening examination was performed at a central location in each community by six trained ophthalmic nurses. This basic eye examination included the tests outlined below.

Visual acuity. Visual acuities were tested using single optotype E charts at 6 m in ambient outdoor light. The scale of the trial dictated that all non-essential tests be omitted to permit completion before the rains made work impossible. The following levels of acuity were recorded: 6/9, 6/18, 6/36, 6/60, 3/60, perception of light (PL) and no perception of light (NPL). Acuities of <6/9 were checked with a pinhole device and the result recorded separately.

Visual fields. Peripheral field defects were assessed using the simultaneous counting fingers test. The paracentral visual field was also assessed by confrontation using a 6-mm white target. Paracentral perception of red and red desaturation was assessed using the red-dot card test (*4*). If a defect was detected by any of these or other basic tests, a Friedmann analysis of the paracentral field was performed.

Methodology of tests

- Simultaneous counting fingers test in peripheral field

Eyes with visual acuities of hand movements or less were not tested. The nurse sat facing the patient at 1 m distance. Patients were placed so that any directional lighting source was behind them. The test was performed uniocularly, each eye being tested in turn. The nurse made two fists, palms towards the patient, and held them in their upper outer nasal and temporal visual fields. While ensuring that central fixation was maintained, the nurse presented the subject with one or two fingers from each fist for half a second and then asked how many fingers the subject had seen. In this way all four quadrants were tested. Any defect detected was recorded and the other eye was tested.

- 6-mm White target paracentral confrontation test

Central fixation was ensured by asking the patient to look directly at the examiner's eye. The target used for this test was a 6-mm white pin-head painted black on the reverse side so that the target could easily be made to appear and disappear by rotation. The central 15° of visual field was tested paying special attention to the area just nasal to central fixation in each eye.

- The red-dot card test for paracentral red field loss

This card was designed for use at 33 cm from the patients' eyes. It consists of a central fixation hole and four 1-cm diameter circular areas which lie 1.5 cm above and below the horizontal meridian at 12° from fixation. These circular areas can be turned red by sliding the holds at the side of the test card. In addition there are "dummy holes" in the card so that the patient does not know where the red is likely to appear. A central hole for the examiner's eye means central fixation can be assured throughout the test. Both non-visualization and desaturation of the targets were recorded with this test. Eyes with vision ≤6/60 were not tested.

Optic disc. The nurses assessed the optic disc for pallor and a vertical cup/disc ratio in excess of 0.5 using a direct ophthalmoscope without dilation.

Referral

If a defect was detected by any of the above tests the individual was referred to one of the two ophthalmologists (*IEM*, *OEB*). If the individual concerned was bilaterally blind, the ophthalmologist recorded the putative cause. If the patient was not bilaterally blind and the ophthalmologist was satisfied that a defect was present, the individual concerned underwent a full ophthalmic examination, including Friedmann field analysis.

Friedmann fields. The Friedmann mark I field analyser was used since it is physically robust. The macular threshold of each eye was determined and the test performed at 0.4 units brighter than this threshold. If spots were not seen, the test was repeated at an intensity 0.4 units brighter again. If spots were still not seen, the test was re-performed at zero level (maximum brightness). Results were recorded on standard forms.

Sensitivity. A computer-generated, age-weighted, random sample of 455 individuals was identified. Of these, 388 also completed Friedmann field analysis as part of the examination by the ophthalmologists to test the sensitivity of our screening measures.

Table 2: **Type of blindness, acuity definition or visual field constriction, by cause, among the study population**

Diagnosis	No. of eyes blind: By acuity	By fields
Onchocerciasis	165 (91)[a]	16 (9)[a]
Optic atrophy	26 (59)	18 (41)
Glaucoma	44 (94)	3 (6)
Cataract	26 (100)	0 (0)
Other causes	127 (99)	1 (1)
Total	388 (91)	38 (9)

[a] Figures in parentheses are percentages of the total in each diagnostic category.

Results

A total of 6831 persons underwent the screening examination, 185 (2.7%) of whom were bilaterally blind by acuity (<3/60 in the better eye). An additional 28 people (0.4%) had visual field constriction to <10° in their better eye upon Friedmann field analysis. The causes and distribution of blindness have been reported previously (*5*). In this article we report a detailed analysis of the results for those individuals visually impaired by virtue of visual field constriction.

Of the 28 people classified as blind as a result of visual field constriction, 10 were blind by field constriction in both eyes, while 18 were blind by field constriction in one eye and by decreased acuity in the other. Thus, among the bilaterally blind, 38 eyes (9%) were blind as a result of field constriction. Of these eyes, seven had acuities of ≥6/9, nine of 6/18, nine of 6/36, six of 6/60, and seven of 3/60. Thus 42% of these eyes had unimpaired central acuity according to WHO standards.

As might be expected, the causes of blindness in those eyes "blind by fields" are almost all related to optic nerve pathology. Among the bilaterally blind almost half of all the eyes blind by field constriction were so because of optic atrophy in the absence of other associated ocular pathology. The absolute number of eyes blind by field constriction due to this cause was not much less than the number blind by acuity (Table 2). The eye recorded blind by fields under "other causes" in Table 2 had marked inflammatory disease.

Inclusion of individuals blind by fields increases from 70 to 82 the number of those who were bilaterally blind with a bilateral diagnoses of onchocerciasis, an increase of 17%. It also increases those with bilateral optic atropy of unknown etiology by 90% (from 10 to 19); and those with a bilateral diagnosis of glaucoma from 16 to 19 (19% increase).

Visual impairment

In addition to the 213 (185 + 28) bilaterally blind individuals, 118 persons (1.7%) were visually impaired (acuity <6/18 in the better eye), the main causes of which were onchocerciasis, cataract, trachoma, and glaucoma. The current definition of visual impairment is based solely on acuity and does not include a criterion for field constriction. The impact of various definitions of visual impairment by field constriction on the numbers of those visually impaired in the study population is shown below.

Concentric field constriction criteria. Since the current blindness definition is based on field constriction to <10°, we identified those individuals who had visual field constriction in their better eye. One individual was blind by acuity in the left eye and had field constriction to <15° in the other eye. A further six individuals (i.e. 7 in total) had constriction of their visual fields to <20° in their better eye.

Small island(s) of remaining vision. Concentric visual field constriction is not the only possible definition of visual impairment by virtue of visual field loss. A small island of peripheral field may be of no functional use to an individual who has, in reality, a severe visual incapacity due to field loss. However, under the present definitions it may prevent such persons being classified as visually impaired or blind if their central acuity is still good. To assess the numbers of individuals who might be included in this category, we investigated various numbers of Friedmann spots seen on or outside 10° in either eye (Table 3).

There was no particular pattern as to which quadrant of the visual field on or beyond 10° had remaining islands of vision. More than one quadrant was involved in 43 (86%) and more than two quad-

Table 3: **Effect of general visual field loss criteria on the numbers of visually impaired (VI) in communities mesoendemic for onchocerciasis, northern Nigeria**

No. of Friedmann spots seen at ≥10°	No. of individuals	Cumulative increase in VI population
1 (3)[a]	4	4; *3*[b]
2 (6)	4	8; *7*
4 (13)	4	12; *10*
6 (19)	10	22; *19*
8 (25)	13	35; *30*
10 (31)	15	50; *42*

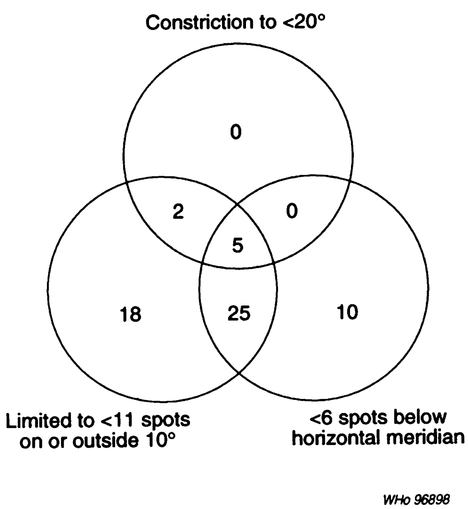
[a] Figures in parentheses are % of the total spots seen at 10°.
[b] Figures in italics are percentages.

rants in 35 (70%) of the individuals with up to ten spots seen on or beyond 10°.

Inferior hemifield loss on or beyond 10°. By far the most useful part of the visual field for everyday tasks is the inferior hemifield; the data were therefore analysed to determine the number of individuals with major loss in this field. Four individuals had no visual field below the horizontal meridian and a further 36 individuals saw fewer than six Friedmann spots below this meridian when the findings for the right and left eyes were combined.

Are the individuals identified by these various definitions the same people? A total of 60 individuals were identified with significant visual impairment due to field loss by the various definitions. The distribution of these individuals, by criteria, is shown in Fig. 1.

Fig. 1. **Venn diagram for individuals classified as visually impaired according to different criteria of visual field loss.**



Causes of visual impairment. For those visually impaired by acuity, cataract was the cause in the largest number of eyes (69 (29%)), followed by onchocerciasis (49 eyes), trachoma (33 eyes) and optic atrophy of unknown etiology (23 eyes). Table 4 shows the effect that inclusion of those severely handicapped by visual field constriction in their better eye would have on some relevant diagnostic groupings.

How did the screening methods employed fare in identifying those with marked visual field loss? If criteria for visual impairment caused by visual field constriction are to be developed, a rapid, efficient method of identifying those impaired individuals in the field is clearly desirable. Table 5 shows the sensitivities and specificities for the three visual field screening tests used to identify those with visual impairment, by either loss of acuity or loss of visual field.

From these results it is clear that, overall, visual acuity has the highest sensitivity and specificity. The visual field tests, however, perform remarkably well, particularly the counting fingers test, and they supplement the sensitivity of the visual acuity test for the blind while not markedly compromising the specificity. The sensitivity and specificity for each field test combined with acuity testing were similar although only those for the combination counting fingers and acuity tests are given.

Sensitivity of the screening process. No individuals were identified in the random sample (n = 455) with visual impairment who had not been already identified by the screening process.

Table 4: **Causes of visual impairment, by criteria[a]**

Diagnosis	No. of VI[b] eyes, by acuity	Number of VI[b] eyes, by fields, using all criteria
Onchocerciasis	49	74 (151)[c]
Optic atrophy	23	31 (135)
Glaucoma	6	8 (133)
Cataract	69	0 (0)
Other	89	7 (4)
Total	236	120 (51)

[a] Acuity definition or visual field constriction.
[b] VI = visually impaired.
[c] Figures in parentheses are the % increase.

Table 5: **Sensitivity and specificity of failing simple visual field screening methods in both eyes for identifying the visually impaired, using the Friedmann analyser as the gold standard**

	Visual impairment: Blind, VI + VI by fields[a]	
Screening method	% Sensitivity	% Specificity
Visual acuity (VI criteria)	74	100
Counting fingers field	72	97
6-mm target to confrontation	65	98
Red-dot test		
Defect only	63	99
Defect or desaturation	66	96
Visual acuity and count-fingers field tests combined	90	97

[a] VI = visually impaired.

Discussion

To our knowledge these are the first data describing the effect of measuring visual field constriction on estimates of the prevalence of blindness obtained from large-scale studies in onchocercal communities. A total of 13% of those blind by WHO criteria would have been missed had only the acuity criterion been used. This underlines the importance of including visual field constriction criteria, particularly in communities with substantial optic nerve pathology.

Although the current WHO definition of blindness includes criteria for both decreased acuity and visual field constriction, the definition of visual impairment comprises solely a criterion of decreased acuity. At least 60 individuals in our study population had severe functional disability caused by visual field loss and would not have been identified as visually impaired by current criteria. This represents a 50% increase in the number of visually impaired in the study community.

Visual field loss is therefore an important source of visual impairment in the study community; however, the challenge is to determine a useful definition of visual impairment as a result of field loss. Although it would be logical to create a criterion for visual field constriction in the same manner as for blindness, our data show that this would not accurately identify those with significant field loss. Even if the criterion were extended to <20°, only a further seven individuals would be identified as visually impaired. Similarly a clear cut-off of "no visual field below the horizontal meridian" would only identify a further four individuals.

The other criteria presented here are Friedmann-analyser dependent, clearly not satisfactory for a single, universally applicable definition. The most useful approach seems to be one that identifies individuals with major field loss below the horizontal meridian on or beyond 10°. Among our study population this identified an additional 40 individuals with severe visual impairment. However, the term "major" needs to be defined (perhaps using less than "one clock hour" of inferior visual field in either eye). Even if this definition were adopted it would still leave a further 20 individuals in our study population with severe visual impairment unclassified.

Routine testing of visual fields in mass population screening trials is time consuming and often thought not to be a practical proposition. We hope that the data presented here may stimulate application of simple methods to identify vulnerable persons with potentially progressive deficits at a stage when their further deterioration may be prevented, and hence that the socioeconomic effects may be minimized or alleviated. Since visual impairment is a characteristic of an individual, it may be more appropriate to use a binocular test.

It is hoped that these findings will lead to international discussion on the need for satisfactory definitions and eventual agreement on standards for "visual impairment as a result of visual field loss" and "visual impairment as a result of field loss and reduction of central acuity".

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Résumé

La perte de champ visuel comme cause de cécité ou de déficience visuelle

Dans une étude de l'onchocercose dans des communautés de mésoendémicité pour l'onchocercose de savane, menée dans l'Etat de Kaduna, dans le nord du Nigéria, 6831 individus âgés de cinq ans au moins ont été soumis à des examens approfondis

de dépistage des anomalies de la fonction visuelle, notamment au moyen de l'analyse de champ de Friedmann. Au total 185 personnes (2,7%) souffraient de cécité bilatérale par défaut d'acuité et 28 autres (0,4%) de cécité par rétrécissement du champ visuel. Par ailleurs, 118 personnes (1,7%) souffraient de déficience visuelle définie selon les critères d'acuité. Il n'existe pas de critères de la déficience visuelle par rétrécissement du champ, aussi avons-nous envisagé trois critères possibles. C'est ainsi que 60 autres personnes (0,9%) ont été recensées comme souffrant de déficience visuelle importante due à une perte de champ visuel selon les diverses définitions. des îlots de vision périphérique subsistante (c'est-à-dire moins de 11 points de Friedmann vus à ≥10° dans le meilleur oeil) étaient présents chez 50 individus. Quarante autres personnes présentaient une réduction sensible du champ visuel binoculaire au-dessous du méridien horizontal (c'est-à-dire) moins de 6 points de Friedmann vus au-dessous du méridien horizontal à la fois dans l'oeil droit et l'oeil gauche). Un rétrécissement concentrique du champ visuel à moins de 20° dans le meilleur oeil a été constaté chez sept personnes. Certaines personnes répondaient à plusieurs définitions; cinq aux trois définitions; deux aux définitions du rétrécissement et des îlots et 25 aux définitions des îlots et de la moitié du champ visuel inférieur. Les causes prédominantes de cette perte de champ visuel étaient l'onchocercose (62%), l'atrophie optique d'étiologie inconnue (26%) et le glaucome (7%). Ces résultats correspondent à une augmentation de 151% du nombre de personnes déclarées souffrir de déficience visuelle en raison de l'onchocercose; à une augmentation de 135% pour l'atrophie optique et une augmentation de 133% pour le glaucome.

La définition OMS de la cécité comprend à l'heure actuelle des critères de détérioration du champ visuel pour la cécité mais non pour la déficience visuelle. La perte de champ visuel est reconnue comme une incapacité majeure. Il est à souhaiter que ces résultats encouragent le débat au niveau international et débouchent sur la mise au point de définitions satisfaisantes de la déficience visuelle par rétrécissement du champ visuel.

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