Ophthalmologica 1993;207:82–89

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Analytical and Statistical Survey of Early Stages of Open-Angle Glaucoma with Low Luminance Visual Field

Key Words
Bjerrum's scotoma
Early glaucoma
Ophthalmic monitor
Pericaecal scotoma
Seidel scotoma
Static perimetry
Rönne's step

Abstract
The purpose of this study was to show the early visual field signs in glaucoma using the 'Moniteur Ophtalmologique' at a background mesopic luminance of 0.3 apostilbs. Forty-five patients were selected, and 68 eyes with suspected early glaucoma were examined. Among the defects which were studied, we noticed a predominance of what we called pericaecal scotoma (PCS) and levelling. These two first signs appear as an alarm signal. To detect the early visual field signs of open-angle glaucoma developing, this study recommends the use of a background mesopic luminance of 0.3 apostilbs and observation for two uncommon visual field signs: PCS in evolution around the blind spot and a slight decrease in central mesopic sensitivity called levelling.

Introduction

The purpose of this study was to show the early visual field signs of onsetting open-angle glaucoma using the ophthalmic monitor at a background mesopic luminance of 0.3 apostilbs.

The ophthalmic monitor allows an automated static perimetry as well as a kinetic one.

Patients and Methods

Patient Selection

In the 45 patients selected for this study, 68 eyes suspected of early glaucoma were examined. The selection criteria were as follows:

- visual acuity range from 16/20 to 20/20;
- an open angle in all cases;
- cup/disc less than 7–8/10;
- age between 25 and 78 years;
- IOP less than 20 mm Hg; and
- patients with 1 eye with glaucoma and the other showing no obvious sign thereof.

Received:
September 20, 1992
Accepted:
January 4, 1993

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0030–3755/93/
2072–0082 $2.75/0

Material

The visual field study is performed with the ophthalmic monitor using a lower mesopic luminance of 0.3 apostilbs. The ophthalmic monitor [1] is an automated perimeter which allows both static and kinetic measurements. It comprises a hemispheric screen (33-cm radius, identical to the Goldmann cupola) and two halogen sources with an alternating filter for each: one for the mesopic background illumination and the other for the stimulus projection. This is all connected to a computer which displays different visual field examination programs.

The procedure we use is called 'meso 95', with which the tests are displayed at a supraliminary level of 4 dB.

Method

After connection to the main, the instrument automatically calibrates the mesopic light. The program we used corresponds to 95 points on 30° displayed in a circle around the fixation point. After the patients eyes were dark adapted during 15 min, they were placed in front of the cupola at 33 cm from the fixation point.

Several tests were performed, and they are carried out as follows:

(1) A first series of 4 points at high illumination (1,000 apostilbs) are gradually presented.

(2) This same series of 4 points is displayed at the same frequency (1.10 s), but the patient is asked to answer using a bell so that we can evaluate the delay in answering and accordingly adapt the display between two tests.

(3) Other points are displayed to check the position of the blind spot and the correct positioning of the patient's head and to control the patient's fixation and response during the examination.

The basic level, which is calculated with a computer, is the level of light that has to be applied to the different tested points from the supraliminary level so that the slightest relative defects can be observed: if the level of light is too low, no point can be seen, if it is too high, the defect cannot be detected. Consequently, we have statistically calculated a basic level between these two extreme values according to the age of the patient and his pathology so that the luminance of each point should follow the sensitivity of the visual field.

Thus, when performing perimetry, the ophthalmologist modifies the basic level according to the supraliminary level which remains constant and has been defined by the manufacturer.

This basic level will be increased or decreased so that the display level detects the slightest defect. To obtain a better evaluation, we stimulate 5 central points at 2.5° from the fixation point; the monitor then displays the correction. Factors modifying the basic level are age, media opacifications, pupillary size and refraction.

After we gather the information on peripheral kinetic measurements, static measurements of 95 points on 30° are performed. The size of the test is identical to test No. 3 with the Goldmann perimeter.

At the end of the examination, a laser printer gives the results in terms of defects and sensitivity. All the examinations of this survey were performed by the same technician.

Interpretation

The characteristics of the visual field alteration have been defined firstly taking into consideration the corrected basic level and also from the decrease or loss of sensitivty (1) of the central zone that we have called levelling, (2) around the blind spot called the pericaecal scotoma (PCS) and (3) is from the standard defects of glaucoma, i.e. Bjerrum's scotoma, Seidel's scotoma and Rönne's step. Apart from these defects, a few other notches have also been detected.

The surface we observed in this study is limited in static perimetry to the 30° parallel, and a kinetic control was performed on the 60° parallel.

Regarding the PCS, we did not use the standard terminology of enlargement of the blind spot usually given to the scotoma of the pericaecal area: it seems improper as this enlargement should include a global loss of sensitivity identical to the one noticed in blind spot exploration. Indeed, it is only a relative loss at the blind spot periphery corresponding to the anatomic peripapillary area which seems to play an important role, as some authors have stressed [2, 3]. But around the blind spot, an infraliminal spot shows a slight decrease in sensitivity, which disappears with a supraliminal test.

The macula area levelling is a flattening or a local decrease of the central sensitivity because of the mesopic situation which allows an easier detection of the slightest central defect, thanks to the isosensitivity (already used by Friedman in his instrument).

Seidel's scotoma is characterised by a pear-shaped aspect, of which the thinnest part is often directed upwards; but differentiating between PCS and Seidel's scotoma is often difficult when this scotoma is not of the classical form.

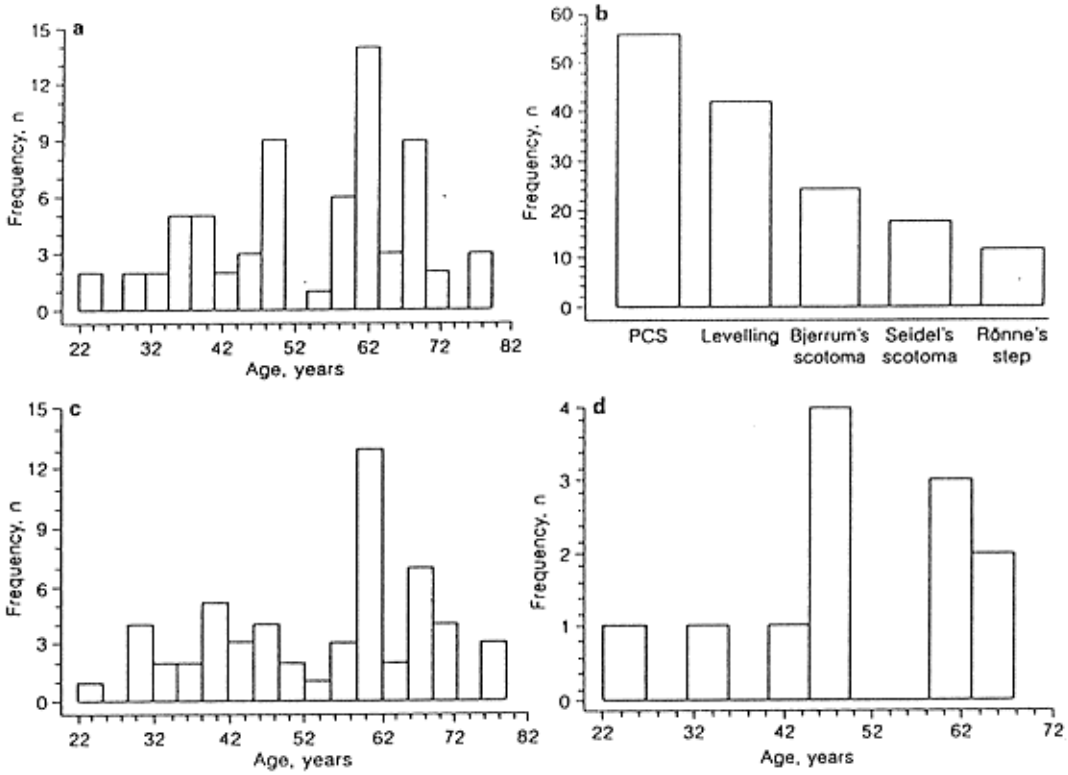

Fig. 1. Distributions of patients according to age (a) and single signs in early glaucoma (b). Also shown are age distributions of patients with (c) and without (d) PCS.

Results

Distribution of Patients According to Age

The highest frequency is between 62 and 64 years with secondary peaks at 34 and 52 years (fig. 1a).

Main Signs of Early Glaucoma

Individual Signs. Fifty-six of 68 eyes (82.4%) presented PCS and 42 of 68 eyes (61.8%) presented levelling (fig. 1b). This levelling can be a simple decrease of sensitivity from 2 to 5 dB on the central points.

A paracentral extension, most often directed upward, was noticed, resulting in a shift of fixation to obtain a higher central sensitivity and leading to displacement of the blind spot in the same direction (fig. 3b). The other defects (fig. 1b) show a very quick frequency decrease: 24 eyes with Bjerrum's scotoma, 17 eyes with Seidel's scotoma (25%) and 12 eyes with the Rönne step (17.6%).

Associated Signs. The number of cases with the following combinations of signs were found: PCS + levelling, n = 33 (fig. 2a); PCS + Bjerrum, n = 20 (fig. 3a); PCS + Seidel,

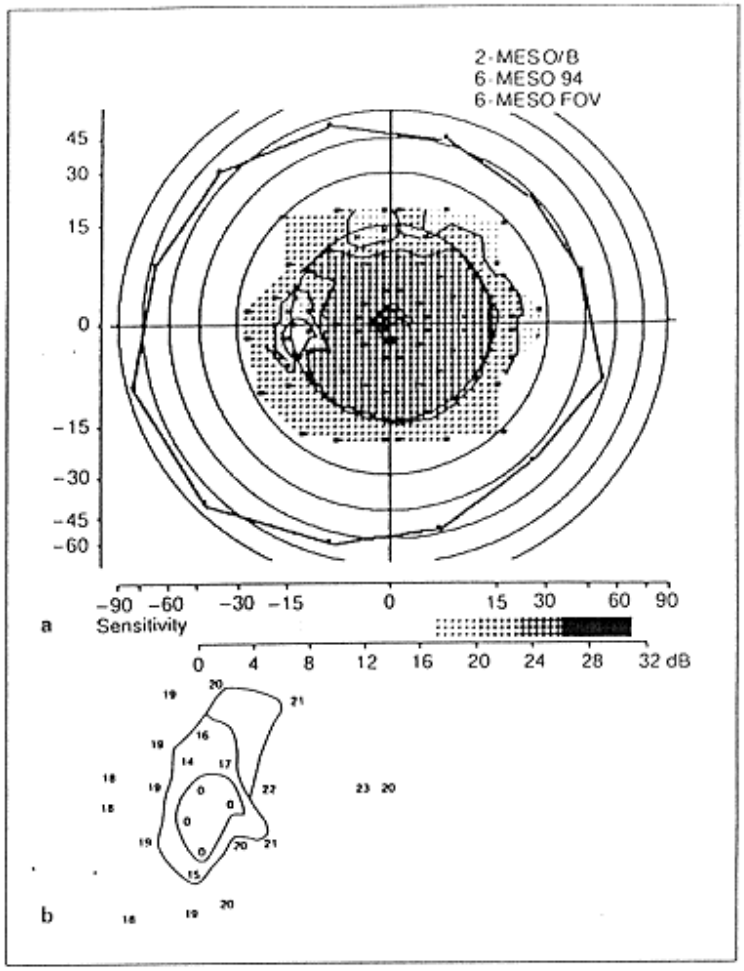

Fig. 2. a PCS + levelling + Bjerrum. b Example of PCS. Centre: blind spot sensitivity = 0; pericentre: PCS sensitivity = 16-14-17.

n = 9 (fig. 3b); PCS + Rönne's step, n = 9 (fig. 3c); Bjerrum + levelling, n = 18; levelling + Seidel, n = 12 (fig. 3d); levelling + Ronne's step, n = 7 (fig. 3d); Bjerrum + Seidel, n = 4, and Bjerrum + Rönne's step, n = 2.

Twenty-one cases of three-variable combinations were also found: PCS + levelling + Bjerrum, n = 15 (fig. 2a); and PCS + levelling + Seidel, n = 6.

PCS and Patient Age

The distribution of frequency versus the age of patients with PCS (fig. 1c) shows in the range from 54 to 72 years a peak at 62 years. For younger patients, the frequency ranges from 30 to 50 years show two peaks at 34 and 46 years. The frequency is very low around in the age range of 20–26 years. In the distribution of frequency versus the age of patients without pericaecal scotoma (fig. 1d): the frequency peak is situated between 45 and 49 years, but between 55 and 69 years the frequency peak is one third lower until 63 and is equal to the frequency peak of patients between 33 and 37 and 67 to 69 years. The comparison of the mean age of patients with and

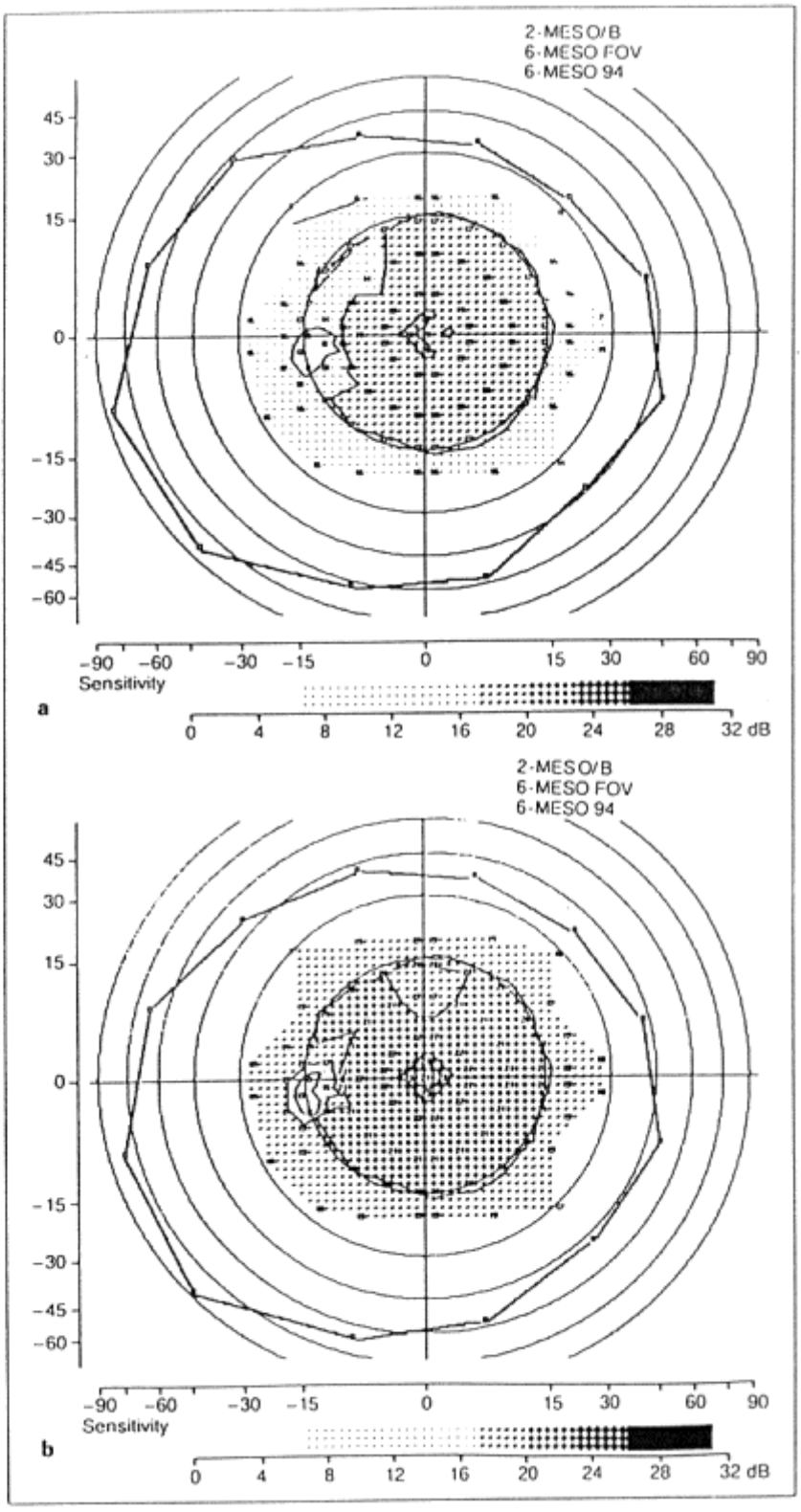

Fig. 3. **a** PCS + Bjerrum (n = 20). **b** PCS + Seidel (n = 9).

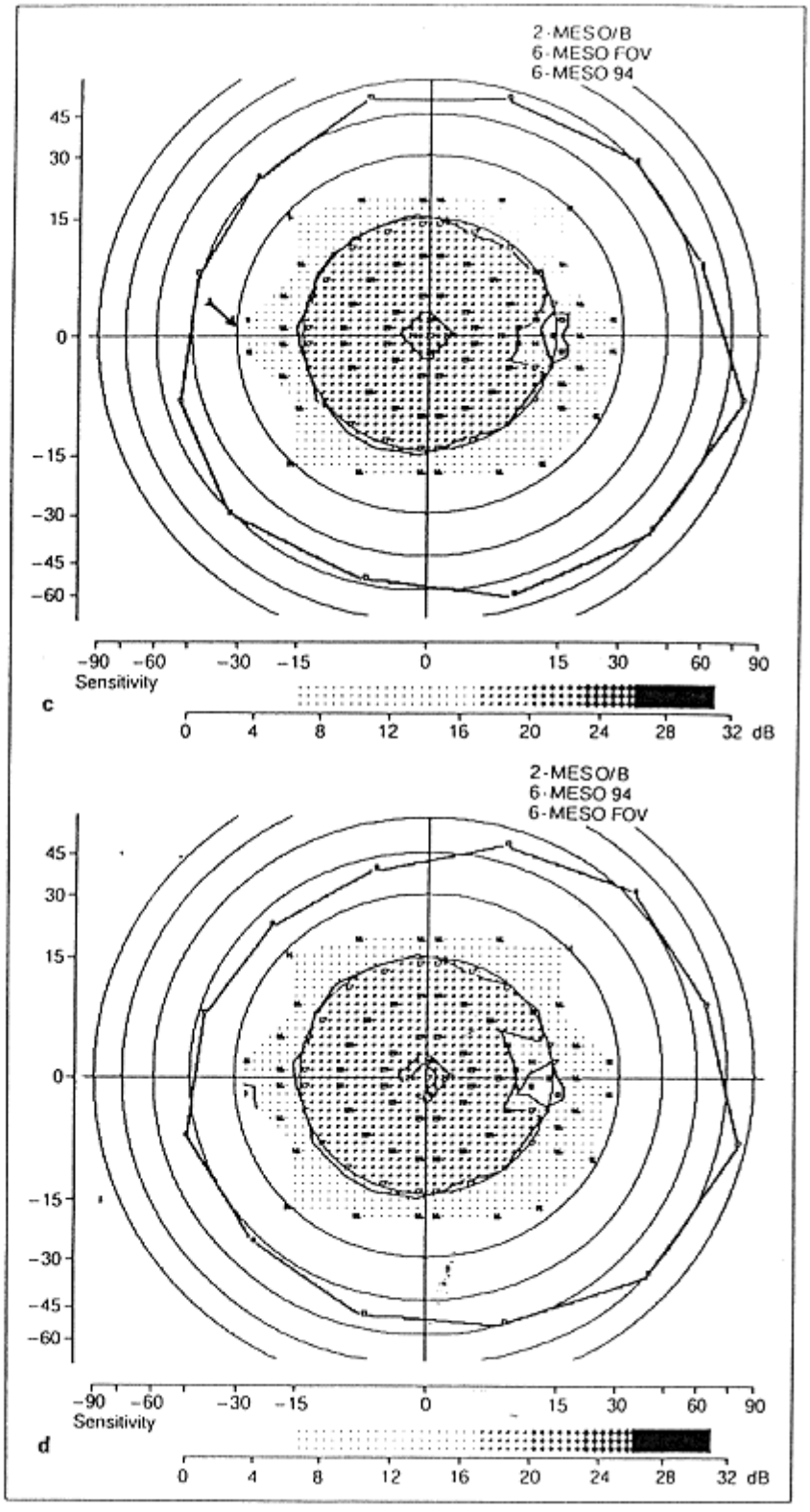

Fig. 3. c PCS + Rönne's step. **d** Levelling + Seidel + Rönne's step.

without PCS results in no significant difference with the Student's t test ($p = 3.942$).

A comparison of the mean age of patients presenting PCS + levelling versus patients without was once again not significant ($p = 0.87$). A comparison of the mean age of patients with PCS and Bjerrum versus others was also not significant ($p = 0.63$).

Discussion

The 68 eyes we studies showed a predominance of PCS and levelling. Most of the time, they are associated, though this association is not statistically significant, and the PCS is frequently found besides glaucoma. These two early signs can appear as an alarm signal.

In contrast, Seidel's and Bjerrum's scotomas and Rönne's step appear with a low frequency. Short- and long-term fluctuations [4] were not considered in this survey. We thought it necessary to gather the early-sign measurements of the perimetric defects in beginning glaucoma. But the different visual field measurements gathered on the same patients show definite variations in sensitivity steps. We have seen that age does not play a role regarding the presence of defects, and no statistical correlation has been found. The highest frequency of PCS was seen in patients between 54 and 72 years of age, which seems to correspond to possible vascular disease at that age; the higher frequency of patients without PCS is within a younger age range.

Evolution of the Early Signs

Ten aggravations and 1 improvement have been observed. The aggravations were the development of a Bjerrum or a Seidel scotoma or a cupping with an enlargement of PCS, or an enlargement of the levelling.

Single Case of PCS Improvement, but the Rönne Step Remains

A possible improvement has been observed by Rolando and Facino [5]. The use of the mesopic adaptation, as has been since long suggested by Jayle [6] and Ourgaud [7] which decreases the photopic central peak, shows a frequent levelling.

The persistence of the PCS should be considered as an alarm signal. The peripheral kinetic exploration never shows any loss of sensitivity. The static exploration is highly beneficial in the detection of Rönne's step which usually remains unnoticed with a kinetic perimetry and requires several repetitive trials [8].

However, as Fankhauser [9] noted in 1976, all the nasal steps are not pathognomonic of glaucoma. Consequently this sign is not considered in our survey as an early and constant sign but as an indication for the clinician in the presence of a suspected glaucoma. Seidel and Bjerrum, on the other hand, appear to be lesss frequent and less early signs.

In this study, we have noted the cup-on-disc ratio to be between 3–4/10 and 6/10 in 15 patients and equal to 7–8/10 in 6. This cupping confirms the role of an ischemic history as depicted by Bechetoille [10] at the early steps of glaucoma neuropathy and hardly gives a pathognomonic aspect to the most current PCS. As a result, a treatment should be applied as soon as the early signs appear in order to preserve the visual field [11].

Conclusion

This survey advises the use of a mesopic luminance of 0.3 apostilbs and the identification of search for two perimetrically unusual signs in the evaluation of early perimetric signs in beginning-stage glaucoma: the presence of an evolving PCS around the blind spot and the slight decrease of a central mesopic sensitivity called levelling.

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