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The cumulative defect curve: separation of local and diffuse components of visual field damage

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Abstract. We present a new display mode of the results of an Octopus visual field examination, which allows for an easy and reliable assessment of the local and diffuse components of the disturbances of a visual field. Essentially, this display consists of the cumulative distribution of the local defect values. Application to typical cases is discussed.

Introduction

There is a growing tendency in clinical practice to use program G1 when testing the visual field with the Octopus perimeter [5]. This program provides the individual values for the differential light sensitivity and, in addition, calculates the so-called visual field indices, derived automatically from the whole set of local thresholds. The indices describe the main characteristics of a visual field using only a few numbers and facilitate the interpretation of the results, especially in marginal cases. The two main indices, MD (mean defect) and CLV (corrected loss variance), allow a classification of damage to a visual field according to its main features [4]; for example, a purely diffuse defect may be recognized by an increased MD (MD > 2 dB) and a CLV within its normal range (CLV < 4 dB^2).

Whereas it is relatively easy to recognize local defects (scotomas) by inspecting the individual thresholds, it is much more difficult to decide whether the other parts of the visual field with apparently normal values are in fact normal or whether they suffer from an early stage of diffuse damage. An example of this difficulty is shown in Fig. 3 (see *insert B* for the observed local defects), where this question cannot be directly answered by means of the individual values or by means of the visual field indices. There is currently a growing interest in separating diffuse threshold changes from local disturbances and quantifying them separately [6]. This may be important for the understanding and identification of different pathogenic mechanisms in selected disorders [1–3].

Method

We present herein a new display of the set of individual results, which provides at a glance a reliable separation of localized and diffuse defects and aids substantially in their critical interpretation. This display is illustrated in Figs. 1–5 (*insert A*). Essentially, it consists of the cumulative distribution of the local defect values as measured in a given G1-examination, together with the empirical normal range for these values (see below). For each field, the underlying local defect values are displayed (*insert B*), corresponding to one of the standard presentations of he local results.

Figure 1 illustrates how the individual curve (*insert A*) is derived from the 59 local defect values (*insert B*). These defect values are sorted by the program in the ascending order D[1], D[2], ..D[r], ..D[59], where D[59] denotes the largest defect. The individual curve X is constructed by plotting the defects D[r] as a function of their rank r, which is marked along the abscissa (r = 1..59, see *insert A*). As indicated in Fig. 1, D[r] is plotted downwards according to the scale on the ordinate. (To give an example, the five largest defects in Fig. 1, *insert B*, amount to 22, 23, 23, 24, and 24 dB; since there are 59 test locations, their ranks are 55..59; see *insert A*, where a defect value of 22 dB is plotted under rank 55.)

The shaded zone (Figs. 1–5) is used for the interpretation of the individual curve obtained: for each rank, the N95 curve indicates the defect value that is not exceeded by 95% of normal visual fields. This data is based on a normal visual field study comprising more than 300 eyes [in preparation]. Likewise, the program plots the lines N5 and N99, corresponding to the 5th and 99th percentile, respectively. Roughly speaking, a normal visual field can be expected to yield a curve above the N95 line in most cases, or, in some cases, a curve closely following this line. On the other hand, patient curves falling clearly below the critical levels (N95 or N99) are indicative of visual field defects at the respective level of significance.

The notion of defect value

The notion of "defect value" as used in Octopus perimetry can be explained as follows: at any test location, the defect (or defect value, or local defect value) is defined as the deviation of the individual differential light sensitivity from the mean normal value for that test location and for the patient's age group. Defects are expressed in units of decibels (dB), 10 decibels corresponding to a 1-log-unit change of threshold stimulus luminance. Defect values typically range from values near zero up to about 35 dB. A test location exhibiting a defect that does not exceed a value of 4 dB is usually termed normal, whereas defects clearly

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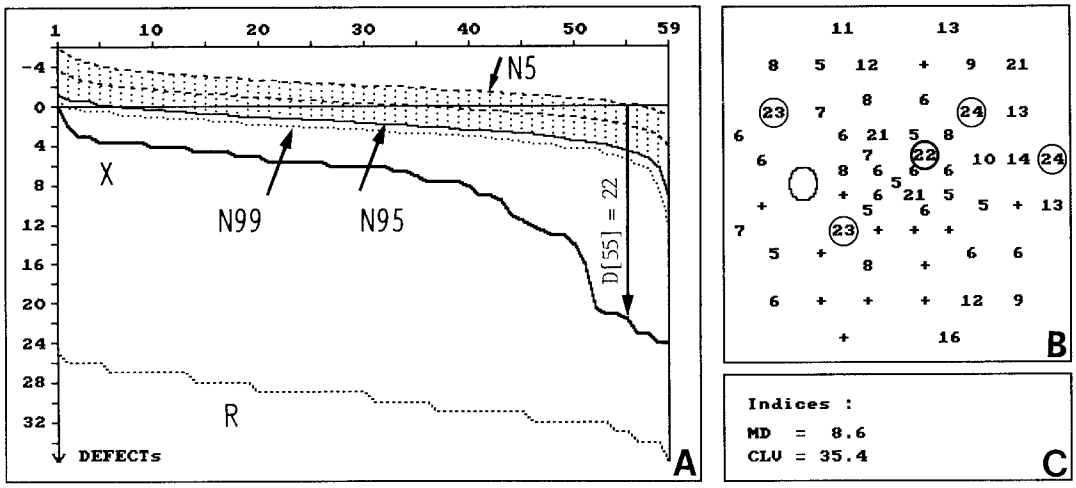

Fig. 1. B One of the standard presentations of local defects as found in the examination of an individual visual field (Octopus program G1, 59 test locations, central 26° field). Local defects not exceeding a value of 4 dB are represented by *plus signs*. **A** Same examination, plot of ranked defects. Abscissa: rank of defect (1..59). Ordinate (from top down): local defects, in ascending order. *X*: individual curve; *N5, N95, N99*: 5th, 95th, 99th percentile of distribution of defects of a given rank in normal visual fields. *R*: limiting curve (corresponding to absolute defect visual field). **C** indices *MD* (mean defect) and *CLV* (corrected loss variance). The example shown here exhibits a combination of localized defects with diffuse loss at the other test locations

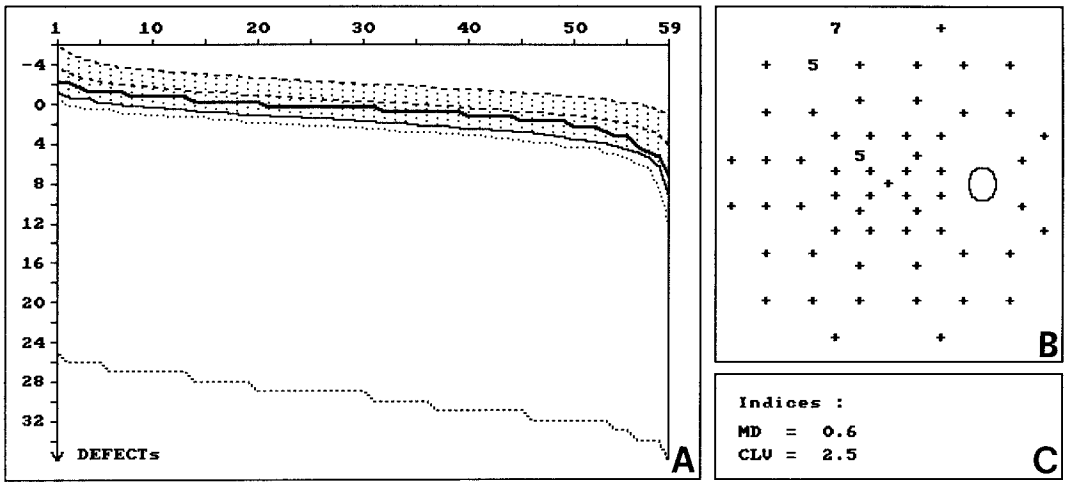

Fig. 2A–C. Normal visual field; this individual's curve is within normal range. (Curves and inserts explained in Fig. 1)

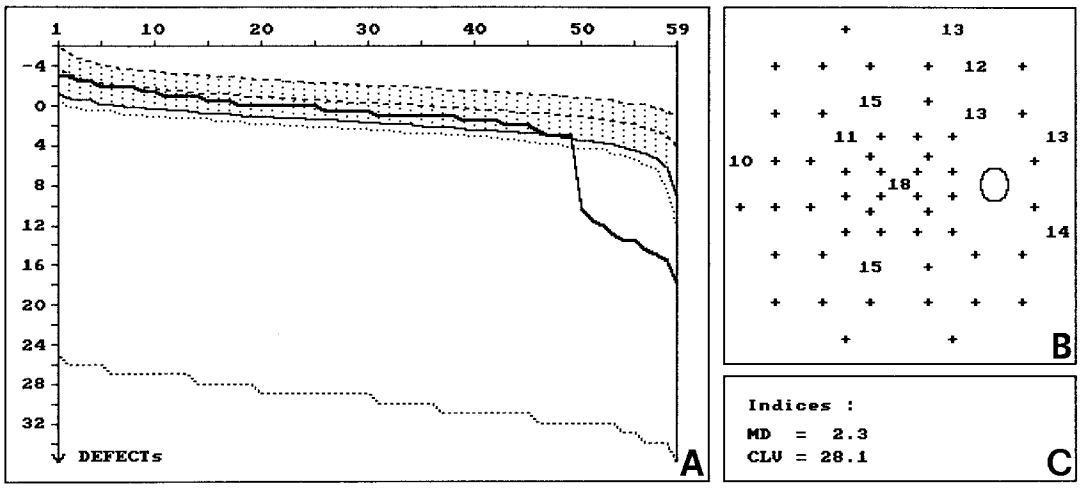

Fig. 3A–C. This individual's curve shows local defects but no diffuse loss at the remaining test locations. (Curves and inserts explained in Fig. 1)

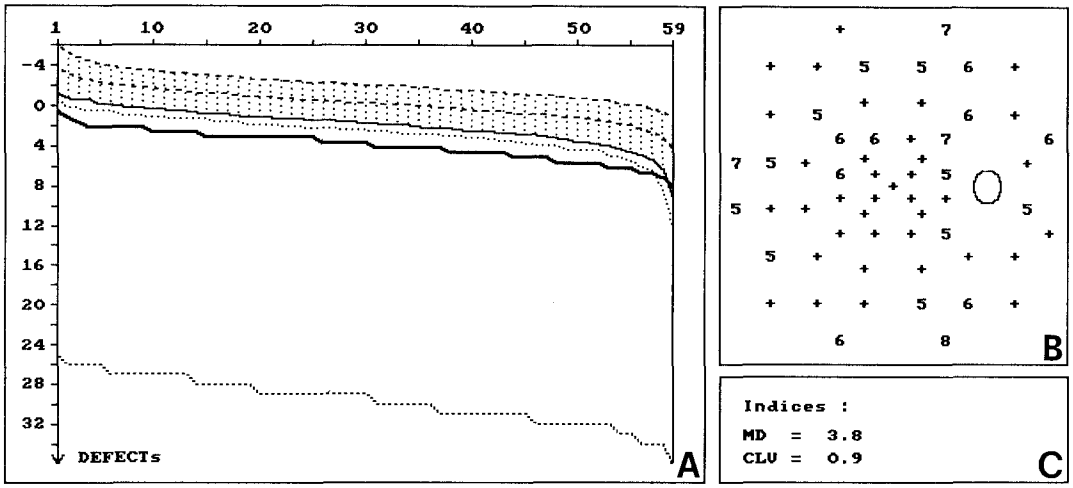

Fig. 4A–C. Purely diffuse loss; this individual's curve is shifted downwards. (Curves and inserts explained in Fig. 1)

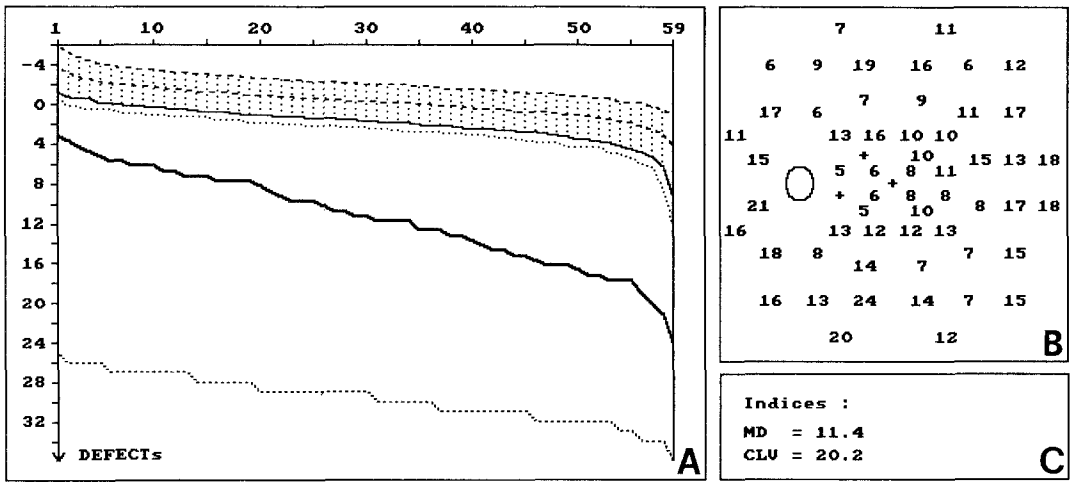

Fig. 5A–C. Broad distribution of defects, all test locations affected; this individual's curve is outside normal range and not parallel to normal curves. (Curves and inserts explained in Fig. 1)

exceeding a value of 4 dB point to a pathologic behavior of the visual field at that test location; however, due to fluctuations a strict separation is not possible at individual test locations. In some conventional displays (see *insert B*, Figs. 1–5), defects not exceeding a critical value of 4 dB are replaced by a plus sign (+). (Note, however, that the hidden values are still available from other standard displays.)

Cases

An absolutely normal visual field is shown in Fig. 2. Since the individual's curve remains clearly within the normal range, the spurious defects exceeding a value of 4 dB (*insert B*) are probably only fluctuations.

A visual field defective in about ten test locations is shown in Fig. 3. This information is also available directly from the usual presentation (*insert B*). In addition, the cumulative defect curve clearly reveals the absence of diffuse loss in the remaining parts of the visual field – a conclusion that is not as obvious in a standard display of individual thresholds.

The interpretation of the visual field shown in Fig. 4 is self-evident: the visual field damage is purely diffuse (in fact, superimposing the same defect value onto all local thresholds will shift the individual curve downwards without changing its shape). Because of the fluctuations, even an experienced user might hesitate to draw this conclusion from the display of local defects (*insert B*). However, the same conclusion may be drawn directly and reliably from the indices (*insert C*).

Discussion

The new display format should be interpreted as a *supplement* to conventional displays of the results of a visual field examination. It may provide substantial assistance in the critical interpretation of individual cases.

The cumulative defect curve may be helpful for the classification of visual fields according to essential features, such as the extent and depth of localized defects (if any) and the degree of diffuse sensitivity loss. An essential category not illustrated by the examples thus far presented may not fit into this simplified pattern; a curve that falls rather regularly but more steeply than the N95 line points to a wide distribution of defect values. An example is shown in Fig. 5.

The visual field fluctuations and the natural individual deviations from the mean local normal values are automatically dealt with, at least to some extent. These effects are

reflected by the descent of the N95 or N99 limiting line, which serves as a reference for the critical interpretation of an individual field. This is a remarkably simple and easy way of taking the *average* level of intraindividual fluctuations into account.

Finally, we add a word of caution. Whereas qualitative conclusions from an individual patient's curve and rough estimates of the main parameters may be correct, attempts to read quantitative details into them (such as "true defect values") may be misleading. It should be noted, for example, that the amount of purely diffuse damage is exhibited by the vertical shift of an individual's curve with respect to normal curves, whereas the numerical values of purely local defects (existing at a relatively small number of test locations) correspond more directly to the readings on the ordinate. In situations where both occur, the correspondence is more complex: due to the ordering process, the diffuse part of an individual curve is slightly bent downwards by the existence of local defects. Moreover, the interindividual fluctuations should be kept in mind, as expressed here by the height of the shaded zone.

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