REPRODUCIBILITY OF TOP ALGORITHM RESULTS VERSUS THOSE OBTAINED WITH THE BRACKETING PROCEDURE

MANUEL GONZÁLEZ DE LA ROSA, ÁNGELES MARTÍNEZ PIÑERO and MARTA GONZÁLEZ HERNÁNDEZ

Hospital Universitario de Canarias, Universidad de La Laguna, La Laguna, Canary Islands, Spain

Abstract

Purpose: To compare the reproducibility and accordance between global indices obtained with tendency-oriented perimetry (TOP) versus those obtained with a standard bracketing procedure (BP).

Methods: Fifty-four patients (54 eyes) with a mean age 55.2 ± 15.4 years: 14 normal subjects, 14 with ocular hypertension and early glaucoma (MD ≤7dB), 11 with advanced glaucoma (MD ≤7dB), 12 with neurological pathology, and three with chorioretinal lesions. All patients were examined four times using the Octopus 1-2-3 perimeter: twice with the standard 32 Program and twice with the TOP Program. This TOP version includes re-testing of the points to which the patient did not respond at the beginning of the examination.

Results: Test duration: 2:57 ± 0:15 minutes (TOP) and 13:56 ± 1:40 minutes (BP). Excellent correlation was found among the indices of the four examinations. Point-by-point differences were slightly smaller when each strategy was compared with itself, than when the comparison was made with the other strategy, but the dispersion was minimal in all cases. On average TOP produced 1.57dB higher thresholds. With TOP, threshold fluctuation was less (1.54 ± 2.14dB) than with the BP (1.95 ± 2.42dB) (p<0.01), and the reproducibility of the MD value was higher (r=0.997; MD fluctuation: 0.35 ± 0.31dB) than with the BP (r=0.977; MD fluctuation: 0.94 ± 0.92dB) (p<0.01).

Conclusions: TOP seems to offer better reproducibility, lower MD fluctuation (63%) and shorter test duration (78.8%) compared with the standard strategy. The differences between TOP and BP were almost the same size as those between two examinations performed at different times with the traditional bracketing strategy.

Introduction

Neighboring test locations in the visual field are anatomically related because of the structure of the retinal architecture, as well as the configuration of the optic pathways going to the occipital cortex. In general, characteristic areas of different pathological processes affect relatively large areas of the visual field. With tendency-oriented perimetry (TOP), determination of the retinal threshold was accomplished by including the patient’s responses to adjacent stimuli. Only a single presentation was made at each tested point.

Address for correspondence: Manuel González de la Rosa, MD, C/ 25 de Julio, 34, 38004 Santa Cruz de Tenerife, Spain

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Fig. 1. Example of the progression of the sequential examination of four sub-matrices using the TOP-32 algorithm.
An earlier TOP perimetric program examined the same 76 points tested by program 32 using an Octopus 1-2-3 Automated Perimeter. The examination procedure is shown in Figure 1. The TOP strategy subdivides these 76 points into four intercalated matrices in which the points end up at a 12° distance.

The test of the first sub-matrix starts with estimated values. These are calculated as being half the expected normal sensitivity, according to the age of the patient. The points of this first matrix are examined with stimuli whose luminous intensity corresponds to these intensities. Each patient’s response (seen or not seen) creates a vector or step displacing the estimated threshold up or down by a factor equal to 4/16 of the normal age-corrected threshold at that particular point. At the same time, these step values are also applied to the neighboring points (belonging to the three unexamined sub-matrices), using a linear interpolation procedure. Thus, a new value table is obtained at the end of each sub-matrix, and the first examination is used as a starting point for the next sub-matrix.

The second sub-matrix, intercalated with the first, is examined using the luminous intensities calculated at the end of the first phase. In the same way as before, the patient’s responses modify the threshold predictions at the points examined, and are applied to the three remaining sub-matrices using interpolation. The step or vector size is equal to 3/16 of the normal age-corrected threshold value.

The two last sub-matrices are examined in the same way, applying steps or vectors which are 2/16 and 1/16 of the normal value.

We noted that the initial version of the program sometimes produced some false scotomas when the patient erroneously did not respond. This usually occurred during the examination of the first two sub-matrices. In these cases, the examination algorithm transferred the influence of this fault to the neighboring points. To correct this problem, a second version of the program was developed that repeated the examination of these isolated, unseen points, to eliminate possible errors. The present study was designed to evaluate the reproducibility and precision of the TOP procedure after this modification had been introduced.

Material and methods

Fifty-four patients (54 eyes), with a mean age 55.2 ± 15.4 years, were examined with Octopus 1-2-3 four times: twice with the standard 32 program and twice with TOP. Since we were interested in evaluating TOP’s performance in general, a variety of normal and pathological conditions affecting the visual field were included. The sample included 14 normal subjects, 14 with either ocular hypertension or early glaucoma (MD <7dB), 11 with advanced glaucoma (MD >7dB), 12 with neurological pathology, and three with chorioretinal lesions. The patients were examined during two sessions. At each session, one TOP and one Program 32 (bracketing) were carried out with the Octopus 1-2-3 perimeter. The interval between sessions was no longer than a week. To avoid fatigue effect, a rest period of at least 30 minutes was given between the two examinations. Half the time, TOP was performed first and vice versa.

Inclusion criteria were prior perimetric experience, minimal visual acuity of 0.5 (20/40) and stable pathology.
Table 1. Linear regression analysis, including results of the four examinations

<table>
<thead>
<tr>
<th></th>
<th>r: corr. coeff.</th>
<th>s.e.: st.error YX (dB)</th>
<th>s.e.</th>
<th>s.e.</th>
<th>s.e.</th>
<th>s.e.</th>
<th>s.e.</th>
<th>r</th>
<th>s.e.</th>
<th>s.e.</th>
<th>Dif. Fluct.</th>
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</thead>
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<tr>
<td>TOPa Vs TOPb</td>
<td>0.997</td>
<td>0.66</td>
<td>1.73</td>
<td>1.66</td>
<td>1.26</td>
<td>1.42</td>
<td>0.98</td>
<td>0.67</td>
<td>3.66</td>
<td>0.09</td>
<td>0.35</td>
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<td>32a Vs 32b</td>
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<td>1.89</td>
<td>1.22</td>
<td>2.55</td>
<td>1.9</td>
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<td>4.29</td>
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<td>TOPa Vs 32a</td>
<td>0.983</td>
<td>1.58</td>
<td>2.27</td>
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<td>2.07</td>
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<td>TOPb Vs 32b</td>
<td>0.979</td>
<td>1.74</td>
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<td>2.48</td>
<td>2.4</td>
<td>2.02</td>
<td>0.9</td>
<td>1.42</td>
<td>4.74</td>
<td>1.49</td>
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</table>

Fig. 2. Scattergram comparing mean defect (MD) values between the two TOP tests.

Results

The examination lasted 2:57 ±0:15 minutes with the TOP program and 13:56 ± 1:40 minutes with the bracketing strategy, resulting in a reduction of 78.8% of time for completing the TOP test.

Total mean defect (MD), MD for each quadrant, square root of the loss of variance (sLV), and individual thresholds, were compared among the four examinations. The visual field coordinate points X=15° (temporal), Y=−3° (inferior) (which correspond to the position of the blind spot), were eliminated from the statistical calculation. Excellent correlation was found among the indices in the four examinations (Table 1).

The correlation between the MD obtained in the two TOP examinations showed a value next to one (r=0.997) (Fig. 2), and greater than that observed between the two bracketing examinations (r=0.977) (Fig. 3).

Point-by-point differences were slightly smaller when each strategy was compared with itself (Figs. 4 and 5) than between the two different strategies (Fig. 6), but in all cases there was only a minimal dispersion. On average, TOP produces 1.57dB higher thresholds (1.64dB on average between the two first tests and 1.49dB between the second two). The difference between both programs was smaller for those points
Reproducibility of TOP algorithm results

Fig. 3. Scattergram comparing mean defect (MD) values between the two standard 32 tests using the traditional bracketing approach.

Fig. 4. Frequency distribution of the point-by-point differences between the thresholds obtained with TOP examinations.
Fig. 5. Frequency distribution of the point-by-point differences between the thresholds obtained with bracketing tests.

Fig. 6. Frequency distribution of the point-by-point differences between the thresholds obtained with TOP and those obtained with bracketing examinations.
Reproducibility of TOP algorithm results

situated less than 15° out of fixation (0.61dB) than for those points located between 15 and 30° (1.91dB).

With TOP, threshold fluctuation was less (1.54 ± 2.14dB) than with the BP (1.95 ± 2.42dB) \((p<0.01)\). TOP reproducibility of the MD value was higher \((r=0.997, \text{s.e.}(YX)=0.66dB, \text{MD fluctuation: 0.35 ± 0.31dB})\) than with the bracketing procedure \((r=0.977, \text{s.e.}(YX)=1.85dB, \text{MD fluctuation: 0.94 ± 0.92dB})\) \((p<0.01)\) (Fig. 7).

Discussion

The first studies with TOP were performed with a simulation model and suggested that this novel algorithm had a potential for obtaining perimetric results similar to those obtained with conventional perimetry\(^1\). This positive correlation between the results obtained by traditional approaches and TOP pathology was subsequently confirmed in patients with diverse pathology\(^2,3\). TOP has also demonstrated the ability to achieve high specificity\(^4\). This high specificity has been further improved with the modification described in this paper.

Our study shows that TOP can be two to three times (2.7 times in our sample) more reproducible in MD estimation than the conventional strategy. The constant nature of MD is crucial for evaluating the course of the disease. In conventional perimetry, as long as an MD reduction of 3.7dB is required for a 95% reliability in order to decide that the visual field has worsened, with TOP, this same reliability is obtained with a mean sensitivity reduction of only 1.3dB.

We believe that the approximate difference of 1.5dB found between the TOP thresholds and the bracketing estimates is a consequence of reducing the usual perimetric time to one-fifth. Our experience studying ‘fatigue effect’\(^6\) has shown a threshold reduction of between 0.17 and 0.21dB per minute. The ‘fatigue effect’ is probably
related more to retinal neuronal depletion than to a decrease in the psychological attention span. The difference between the results of both strategies is larger in the periphery than in the center of the visual field. This is very similar to the variation in visual thresholds observed in relation to the 'fatigue effect'.

The TOP algorithm, with the modification described in this paper, demonstrates better reproducibility and estimates the visual field threshold more precisely than the initial version. It produces similar results to a standard bracketing procedure, but requires only one-fifth of the time. It seems to have better reproducibility and less fluctuation than the standard bracketing approach.

References