FLICKER-TOP PERIMETRY IN NORMALS AND PATIENTS WITH OCULAR HYPERTENSION AND EARLY GLAUCOMA

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Abstract

Purpose: To evaluate sensitivity, specificity and the capabilities of diagnosing early glaucoma using the tendency-oriented perimetry (TOP) algorithm adapted to flicker perimetry.

Methods: A regular TOP Program for Octopus 1-2-3 was modified using the examination protocol proposed by Matsumoto et al. as follows: grid type 32, background 31.5 asb, size Goldmann III, constant intensity of 4000 asb, sampling time of one second and variable frequency. Taking into account the normal values described by these authors and those regularly used by the perimeter, stimuli were generated using a value-denominated dB-flicker equivalent. Each dB was equivalent to 1.25 Hz, but no other modifications were made to the TOP strategy. Forty-five eyes of 45 normal subjects were examined (17 with previous perimetric experience and 28 without), 30 patients with ocular hypertension (normal TOP standard visual field and optic nerve head) and 23 patients with early glaucoma (MD <7dB).

Results: Mean duration of the TOP flicker test was 4:01 ± 0:22 minutes. The results for flicker MD were: normal, -0.94 ± 1.67dB; ocular hypertension, 6.58 ± 6.04dB; and early glaucoma, 9.37 ± 6.66dB. The majority of normal patients had normal results with TOP flicker (93.3% for MD <2dB). Some of the normal subjects without perimetric experience had hyper-normal results (36% for MD <-2dB). Twenty-one (70%) eyes with ocular hypertension had pathological TOP flicker perimetry results (MD >2dB). Flicker perimetry results were abnormal in all the early glaucoma cases and more abnormal than standard perimetry in 19 (82.6%) patients. The correlation between both types of perimetry was low (r=0.39 for MD and r=0.20 for LV), but was noted to be better in Bjerrum’s area than elsewhere (r=0.50). Point-by-point correlation was also very low (r=0.25).

Conclusions: TOP flicker perimetry demonstrated a specificity of 93.3% and sensitivity of 100% in patients with early glaucoma. It classified 70% of eyes with ocular hypertension as being pathological. Flicker perimetry may prove to be a good screening system for earlier stages of glaucomatous damage.

Introduction

Considerable research is being carried out to find strategies and methods to allow detection of neuro-retinal fiber abnormalities in patients with early glaucoma before this damage introduces a disorder into the visual field or the optic nerve head.1

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Among the different ocular physiology functions where research has been aimed at the early diagnosis of glaucoma, temporal resolution testing \(^2\)-\(^{10}\) seems to be one of the most promising. It tends to be affected earlier than spatial resolution functions \(^{11}\) and conventional perimetry, perhaps because it involves magnocellular cells which are well known to be affected early in the glaucomatous process \(^{12,13}\).

There are different modalities to test temporal resolution: simultaneous investigation of all or part of the central field \(^{14}\), constant frequencies and variable contrast (temporal modulation perimetry, TMP) \(^{15}\). More common is the fixed contrast and variable frequency (critical flicker frequency, CFF). The threshold itself has generally been determined utilizing the same bracketing strategy as conventional white-on-white automated perimetry. With this strategy, prediction of the threshold is obtained through successive approximations, according to the responses of the patient to stimuli shown in each tested position. In contrast, the newer TOP strategy \(^{16,17}\) modifies the prediction in a positive or negative direction according to the responses to the stimuli shown in the same or in circumscribing points.

Based on the work of Matsumoto et al. with automated flicker perimetry \(^7\), we have adapted the TOP algorithm to flicker perimetry.

Material and methods

TOP strategy has been used to test the 76 points of the perimetric Program 32. The points are divided into four intercalated sub-matrices, which are studied consecutively. Each point receives four successive influences (Fig. 1): a. one from the direct examination of that position; b. one from examining the upper and lower neighboring positions; c. one from examining the positions located at each side; and d. one from examining the four points located diagonally adjacent up (left or right) and down (left or right).

With the Octopus 1-2-3 perimeter, we have used the same parameters as utilized by Matsumoto et al.: grid type 32, background illumination 31.5 asb, Goldmann size III, constant intensity of 4000 asb, sampling time of one second and variable frequency.

![Fig 1. Neighboring influences or areas that affect the calculations of the threshold at point 1.](image)
The normal values for conventional perimetry with this perimeter were analyzed, as well as those published by Matsumoto et al. for flicker perimetry using the same instrument. An almost perfect relationship was found in the entire visual field between these two types of values, so that normal CFF may be calculated by multiplying conventional sensitivity (dB) by 1.25, i.e., 1dB = 1.25 Hz (Fig. 2).

The normal perimetric values were preserved without change for the program design as well as for the various storing systems and graphic representation. The only modification was at the moment of presenting the stimulus, and involved substituting luminous intensity in dB with a flicker stimulus of 4000 asb in intensity, one second in duration and a frequency obtained by multiplying the value in decibels of the stimulus that would have shown in luminosity threshold perimetry (‘dB flicker equivalent’) by 1.25. As a result, the mean defect (MD) index is obtained in dB which may be transformed to Hz by multiplying it by 1.25.

The age variation of the flicker threshold reported by Matsumoto et al.7 (0.1 Hz/year) is slightly higher than that predicted by the apparatus for conventional perimetry (0.065 dB/year) considering that 0.065×1.25 = 0.08 Hz/year. This difference ends up being smaller than 0.5 Hz at 20 or 65 years. This concept of a larger deterioration with age of the threshold occurring with flicker perimetry than with conventional thresholds perimetry is not shared by all authors. While some confirm it, others have reported exactly the opposite findings18,20.

We tested 45 eyes of 45 normal patients (17 with perimetric experience and 28 without), 30 eyes of patients classified as ocular hypertensives with intraocular pressure levels greater than 21 mmHg, normal perimetric tests with TOP-32 (MD <2dB and LV <6dB5) and normal optic nerve head; and 23 eyes of patients with early glaucomatous damage (MD <6dB). All the patients had a visual acuity greater than 0.5 (20/40) and absence of other related pathology.

The necessary response from the patient to this type of flicker perimetry is more complex than with conventional perimetry because the test is not performed under iso-luminance conditions and because the patient must only press the response button when the stimulus blinks. All patients were pre-trained in the flicker response for at least one minute before taking the test. A control group of patients without perimetric experience was also included to ascertain its effect on the specificity of the test. In these patients, no prior training was carried out for conventional TOP perimetry.
Results

Mean duration of the TOP flicker test was 4:01 ± 0:22 minutes. The results for flicker MD were: normal, -0.94 ± 1.67dB; ocular hypertension, 6.58 ± 6.04dB; early glaucoma, 9.37 ± 6.66dB. The equivalent values in terms of frequency were, respectively, -1.18 ± 2.09, 8.23 ± 7.55 and 11.71 ± 8.33 Hz.

As an orientational index of specificity, the normal patients who surpassed 2dB MD (equivalent to 2.5 Hz) were analyzed. Our results indicate that 35.71% of the normal subjects without perimetric experience (Fig. 3) demonstrated MD levels greater than 2dB with conventional perimetry, while this occurred in only 7.14% of normals with flicker perimetry. With flicker perimetry, ten subjects obtained what we called hyper-normal scores (35.71% for MD < -2dB).

None of the normal patients with perimetric experience had MD levels greater than 2dB with conventional perimetry, and only one (5.9%) with TOP flicker (Fig. 4).

Twenty-one eyes (70%) with ocular hypertension (Fig. 5) and all the patients with early glaucoma (Fig. 6) had MD > 2dB with TOP flicker perimetry. In the latter group, 19 (82.6%) had higher MD scores with flicker than with conventional perimetry.

The correlation between both types of perimetry was low ($r=0.39$ for MD and $r=0.20$ for LV), although it tended to be better in Bjerrum’s area ($r=0.50$ for MD). Point-by-point correlation was also very low ($r=0.25$).
Fig. 4. Comparison between flicker and conventional perimetry results in normal subjects with perimetric experience.

Fig. 5. Comparison between flicker and conventional perimetry results in ocular hypertensive patients.
Discussion

If length of the test is a problem in conventional perimetry, this problem is even worse in flicker perimetry because the stimulus time increases from 0.1-0.2 seconds in the first test to a full second in the latter. This means that the length of a traditional perimetric test, which tends to be too long in the first place, would be increased by about five to seven minutes using the conventional bracketing strategy with a precision level equivalent to conventional perimetry. TOP flicker strategy only takes one minute longer, preserving a relationship of 1/5 when compared with the time taken by the standard bracketing strategy.

In this study, TOP flicker perimetry demonstrated a specificity of 93.3% in normal subjects and 100% sensitivity in patients with early glaucoma. Interestingly, it produced pathological results in 70% of the ocular hypertensive patients. Given its capacity to detect an early functional defect, its inherent resistance to lack of focus and diffusion of the retinal image and its briefness, TOP flicker perimetry would seem to be a promising screening test for the early phases of glaucomatous damage.

More studies are needed to broaden this experience and to establish whether this is a transitory and reversible defect. If so, it could mean that flicker perimetry would be useful, not just in terms of early diagnosis but also, and more importantly, in the diagnosis of the disease at a pre-clinical stage. Thus, the decision could be made to start treatment before an irreparable, functional loss occurs.

No clear correlation has been found between the defects of conventional perimetry and flicker perimetry, although both present greater correspondence in Bjerrum’s area, perhaps because each one involves different physiological functions. This lack of correlation may be related to conventional perimetry having a better sensitivity than flicker in the early
stages of the disease. Nevertheless, the differences found between ocular hypertensive patients and those with early glaucoma do not seem to indicate that flicker perimetry is more useful than conventional perimetry in measuring the course of the disease once the anatomical damage process has begun.

Our results demonstrate that the higher complexity required for the subject's response (to decide whether the stimulus is blinking or not blinking) does not reduce specificity significantly, since patients with less perimetric experience and poor cooperation tend to be hypernormal and not falsely pathological. It is possible that the poor performance problems may reduce the sensitivity of the test. However, if we analyze the results obtained in hypertensive and glaucomatous patients, this effect does not seem to be significant.

The results obtained with TOP perimetry in normal patients without perimetric experience confirm that we should not accept the data when perimetry first shows abnormal results. Rather, it is crucial to carry out a second or third confirmatory test, given that false positives are frequently due to the absence of the ‘learning effect’. This rule is well known for traditional perimetry, but it is even more significant when using short duration strategies.

In this study, TOP flicker perimetry demonstrated high specificity and sensitivity in patients with early glaucoma, and it detected some abnormality in a high proportion (2/3) of ocular hypertensives patients. Further studies are necessary to decide whether this technique will be useful as a screening technique for the early stages of glaucomatous damage.

References