European Journal of Ophthalmology / Vol. 17 no. 1, 2007 / pp. 63-68

Macular automatic fundus perimetry threshold versus standard perimetry threshold

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PURPOSE. *To evaluate if retinal sensitivity threshold obtained with an automatic fundus perimeter may be compared with a standard perimeter retinal threshold.*
METHODS. *Automatic full-threshold fundus perimetry (microperimetry) of the macular area (10° grid, 37 stimulated points) was quantified with a new automatic fundus perimeter (MP1 microperimeter) in nine normal subjects (18 eyes). Retinal threshold was also quantified using an identical grid projected with a standard Octopus 101 perimeter.*
RESULTS. *Mean threshold registered by MP1 microperimeter was 19.7±0.8 dB (range 16–20 dB; 4.38±0.96 asb, range 4–10 asb) versus 33.1±1.7 dB (range 27–38 dB; 0.53±0.22 asb, range 0.16–2 asb) obtained with Octopus perimeter. Mean SD of intraindividual variation was 0.74 dB in MP1 and 1.51 dB in Octopus. No statistically significant differences were documented between right and left eye with both instruments (p=0.64). No reliable mathematical relationship between retinal thresholds could be obtained with the two perimeters.*
CONCLUSIONS. *Fundus perimetry is a precise, functional fundus-related technique which allows threshold determination at selected retinal points even if fixation is unstable and visual acuity is low. This is beyond the possibility of any static standard perimetry. Normal threshold values obtained with MP1 automatic microperimeter cannot be currently compared with those obtained with standard Octopus perimeter. (Eur J Ophthalmol 2007; 17: 63-8)*

KEY WORDS. *Fundus perimetry, MP1 microperimeter, Normal values, Octopus 101 perimeter, Static perimetry*

Accepted: July 27, 2006

INTRODUCTION

The ubiquity and historical success of evaluating retinal sensitivity by static perimetry demonstrates that quantification of retinal threshold is critical in the diagnosis of many retinal and nonretinal ocular disorders (1). But conventional visual field examination is inadequate for the accurate functional evaluation of macular diseases, particularly when foveal function is compromised and the patient may have unstable or extrafoveal fixation (2). Moreover, the detection of the site and stability of retinal fixation (foveal or extrafoveal), and the quantification of retinal threshold over small, discrete retinal lesions is beyond the possibilities of conventional, automatic, and non-automatic perimetry. The introduction of scanning laser ophthalmoscope (SLO) fundus perimeter (microperimetry and fundus perimetry are synonyms) allowed us to analyze fixation characteristics and retinal threshold of selected retinal areas, under direct fundus control (3-8). But SLO fundus perimeter did not allow us to perform fully automatic examinations; moreover, fully automatic follow-up examinations to evaluate the same retinal points tested during baseline examination were unavailable. This fact limited the use of microperimetry in clinical practice. Recently,

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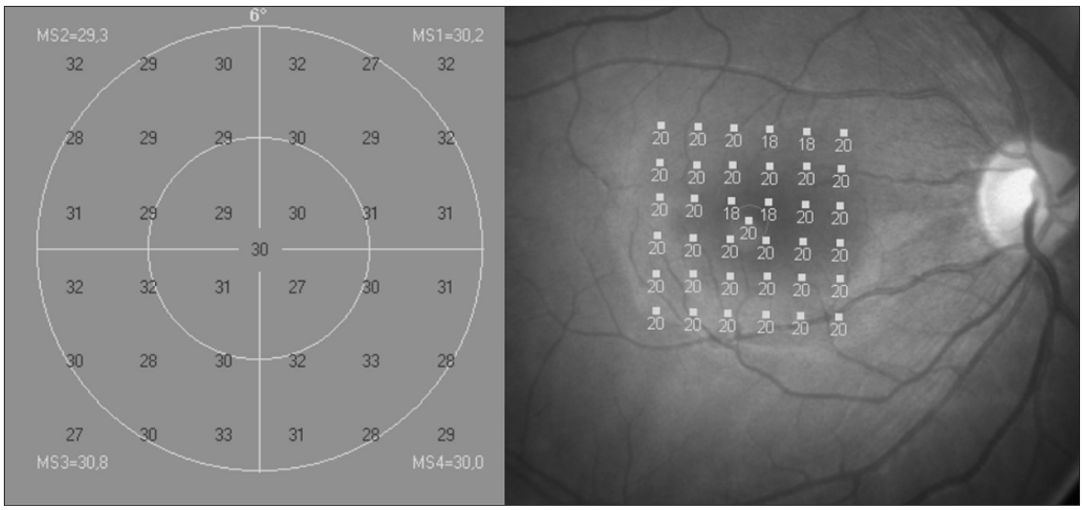

Fig. 1 - *A 37-point test grid centered on the fovea of Octopus 101 perimeter (on the left) and MP1 fundus perimeter (on the right).*

a new automatic fundus perimeter has been introduced in clinical practice (MP1 Microperimeter, Nidek Technologies, Padova, Italy). This instrument is reported to be able to perform automatic fundus perimetry, using an electronic eye tracking system, and it should allow automatic follow-up examinations irrespective of baseline fixation (9-12).

The aim of the present study was to test if normal macular values obtained with the above mentioned automatic microperimeter could be compared with those obtained using a standard static perimeter in the same healthy subjects.

MATERIALS AND METHODS

Eighteen eyes of nine volunteers were included in this study. All examined subjects underwent full ophthalmologic examination. Inclusion criteria for this study were normal anterior and posterior segment of the eye, transparent ocular media, normal intraocular pressure, best-corrected visual acuity of 20/20 or more, and refractive error lower than 3 diopters. This study was approved by the Ethics Committee of Padova University Hospital.

Microperimetry

Fundus perimetry was performed on all subjects using a new automatic fundus-related perimeter: the MP1 Microperimeter (9-12). The fundus is imaged in real time on a video monitor using an infrared fundus camera (1392x1038 pixels resolution; 45° field of view). Fixation target and stimuli are projected onto the retina by a liquid crystal color monitor completely controlled by a dedicated software. The operator views the retinal image on a monitor, with the stimulus as part of the image. Background illumination is set at 4 apostilbs (1.27 candles/square meter; 1 asb = 0.31831 cd/m^2; perimetric standard of the Octopus automat-

TABLE I - RETINAL SENSITIVITY THRESHOLD OBTAINED WITH OCTOPUS AND MP1 FUNDUS PERIMETER USING A 37-POINT GRID

		Mean	SD	Min	Max	Median
Right eye	Octopus	33.1	1.7	28	38	33
	MP1	19.6	0.9	16	20	20
Left eye	Octopus	33.1	1.7	27	38	33
	MP1	19.8	0.6	16	20	20
Total	Octopus	33.1	1.7	27	38	33
	MP1	19.7	0.8	16	20	20

Mean, SD, Min, Max, and Median are reported in dB. SD = Standard deviation

ed perimeter). Stimulus intensity may be varied on 1 (0.1 log) step scale from 0 to 20 dB, where 0 dB represents the brightest luminance of 400 asb (127 candles/square meter). Stimulus size may also be varied by the examiner: from I to V Goldmann standard size. Infrared fundus camera has a correcting system for refractive errors (range: –12.5 up to +16 diopters). The fixation target, set at 100 asb, may be varied in size and shape (a cross or a ring are commonly used for central fixation, four crosses or a large ring for paracentral fixation) according to the patient's visual acuity and/or macular scotoma. In this study, the following parameters were used: background at 4 asb, stimulus size Goldman III, customized square grid of 37 stimuli covering central 10° (centered onto the fovea), 1° circle as fixation target (Fig. 1).

A 4-2-1 double staircase strategy was used (the standard in automated perimetry). The starting stimulus light attenuation was set at 10 dB. The stimulus is projected exactly onto the predefined retinal position by means of an automatic eye-tracker, which compensates for eye movements. This allows a correct matching between expected stimulus position onto the retina and the actual projection position. Light stimuli are randomly presented during the examination, as in standard static perimetry. Results are reported in decibels. A false positive test stimulus is projected every 60 seconds onto the optic nerve head area to check for false positive answer. To allow for better clinical correlation between fundus perimetric data and retinal details, functional results are displayed onto a color digital retinography, acquired by a CCD color camera (1392x1038 pixels, Xenon flash). Pretest training is performed in each subject and 5 minutes visual adaptation is allowed before starting the test. All subjects underwent microperimetry with undilated pupils.

Subjects were randomized as test sequence (fundus perimetry or standard automatic perimetry). Both instruments were performed in the same day for each subject.

Static automatic perimetry

A computerized full static threshold perimetry with a standard Octopus 101 perimeter (Interzeag, Schlieren, Switzerland) was performed. This instrument was chosen because background illumination (4 asb) is the same as MP1 fundus perimeter. Stimulus size Goldman III was used. A custom made 10° grid (center onto the fovea) with 37 stimulated retina points, ideally corresponding to the fundus perimetry grid, was used to test each eye (Fig. 1). All subjects underwent Octopus perimetry test with undilated pupils.

Statistical analysis

For each of the stimulus locations of the test grid, mean sensitivity among 18 normal eyes (mean ± SD, min and max) for both instruments was calculated, converting left eyes to right ones. The Octopus test grid values were considered inverted top to bottom corresponding directly to retinal points. Statistical analysis was performed on the basis of mean sensitivity of each location of right and left eye, and then of both eyes tested with the two perimetric techniques. In addition, variance analysis (ANOVA) was performed to verify if the mean values of Octopus, MP1 differ between the left and right eye and from one another in several locations of tested grid. Because MP1 and Octopus 101 use different paradigms in retinal sensitivity recording, although expressed by the same

TABLE II - RETINAL SENSITIVITY THRESHOLD OBTAINED WITH OCTOPUS AND MP1 FUNDUS PERIMETER USING A 37 POINTS GRID

		Mean	SD	Min	Max	Median
Right eye	Octopus	0.54	0.22	0.16	1.58	0.50
	MP1	4.50	1.10	3.99	10.02	3.99
Left eye	Octopus	0.53	0.22	0.16	2.00	0.50
	MP1	4.25	0.78	3.99	10.02	3.99
Total	Octopus	0.53	0.22	0.16	2.00	0.50
	MP1	4.38	0.96	3.99	10.02	3.99

Mean, SD, Min, Max, and Median are reported in asb. SD = Standard deviation

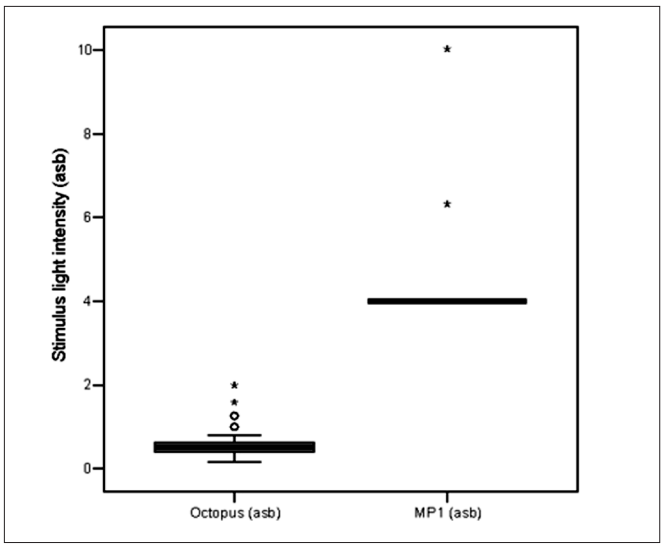

Fig. 2 - *Graphic comparison between normal values obtained with Octopus 101 perimeter (on the left) and MP1 fundus perimeter (on the right) (light intensity scale in apostilb).*

measurement unit (decibel), in order to fully compare the values of retinal sensitivity between the two instruments, values were also converted from decibel to apostilb (1 asb = 0.31831 cd/m^2) according to the following expressions: MP1: asb = 400 $e^{-0.2304\ dB}$; Octopus: asb = $10^{3\text{-}dB/10}$.

The mathematical relation reported by Andersen for SLO fundus perimeter vs Octopus perimeter was also considered for applicability (14). In Octopus perimetry background intensity (I) is set at 4 asb (1.27 cd/m^2), maximum stimulus intensity (Δ Imax) is 1000 asb (318.3 cd/m^2), therefore maximum contrast (Δ Imax/I) is 2.4 log units. In MP1 fundus perimeter background intensity (I) is 4 asb (1.27 cd/m^2), maximum stimulus intensity (Δ Imax) is 400 asb (127 cd/m^2), therefore maximum contrast (Δ Imax/I) is 2.0 log units.

Values are considered statistically significant when p is less than 0.01. All analyses were performed by SPSS statistical package on personal computer (SPSS v12.0, 2003; Inc. Technologies, Chicago, USA).

RESULTS

The mean age of the nine enrolled normal subjects was 29.9±5.02 years (range 24–41 years). In all cases fixation was stable and predominantly central during fundus perimetry, as documented by the eye-tracker registration. Mean duration of MP1 fundus perimetry was 4.53±1.8 minutes (range 2.9–8.9 min). Mean duration of Octopus computerized static visual field test was 3.46±1.2 minutes (range 2.7–7.6 min). The mean value of sensitivity threshold of 37 locations registered by MP1 was 19.7±0.8 dB (range 16–20 dB; 4.38±0.96 asb, range 4–10 asb). The mean value of sensitivity threshold of 37 registered locations quantified with Octopus perimeter was 33.1±1.7 dB (range 27–38 dB; 0.53±0.22 asb, range 0.16–2 asb) (Tab. I, Tab. II, Fig. 2). Mean SD of intraindividual variation at every single test with MP1 was 1.51 dB and with Octopus was 0.74 dB.

The analysis of variance (ANOVA) for repeated measures shows that the difference of mean values at 37 locations between right and left eye is not significant (p=0.640), and that mean values of 37 locations are not statistically homogeneous on all tested retinal areas [Octopus: F(36.620)=5.53, p<0.0001; MP1: F(36.620)=1.54, p=0.0250]. Even changing measurement unit from decibels to apostilbs statistical analysis is unmodified.

Assuming the reliability of the mathematical relation applied by Andersen to SLO fundus perimetry vs Octopus perimetry data, our results indicate a 0.4 log units (=4 dB) difference between Octopus data vs MP1 data. This means that MP1 retinal threshold at each tested point is 0.4 log lower than retinal threshold obtained with Octopus perimetry. This relationship appears inapplicable to our normal data, as shown by the graphic distribution of normal data particularly when reported in asb.

DISCUSSION

Fundus perimetry allows for exact correlation between morphologic appearance of the fundus and its sensitivity threshold. Its use as diagnostic tool in congenital and acquired macular diseases is continuously growing (5-16). The quantification of macular threshold and retinal fixation characteristics allow the clinician to improve diagnostic accuracy and better predict the outcome of surgical and nonsurgical treatments of different macular disorders (14-17). Any new device which enables us to perform fundus perimetry in a simple, standardized way (as it happened when computerized static perimetry was introduced in clin-

ical practice) may contribute to the diffusion of this relevant diagnostic tool. But any new device must be viewed with caution, because real fundus perimetry is not just a superimposition of retinography onto a perimetric map. Real time infrared examination is mandatory in fundus perimetry, and automatic compensation for eye movements is a critical step in fundus perimetry. MP1 fundus perimeter seems to accomplish these characteristics (9-12). Even if the fundamental paradigm of fundus perimetry–exact, fundus-controlled projection of stimuli onto the retina, independent from stability of fixation and/or visual acuity–is different from standard static perimetry, we were interested to evaluate if any relationship exists between MP1 fundus perimeter normal threshold values toward those obtained with Octopus 101 standard perimeter, an automatic perimeter with the same background illumination, as previously reported for SLO microperimeter (14, 18).

The correlation between conventional Octopus perimetry versus SLO microperimetry was tested by Andersen (14). He found that results obtained by SLO microperimeter were comparable to those obtained by Octopus perimeter in the same presumed location. Mean sensitivity at any location was approximately 7 dB lower with SLO microperimeter than with Octopus perimeter. The intraindividual variation was larger with SLO microperimeter than with Octopus perimeter. Rohrschneider et al also compared a custom made SLO microperimetry grid with a similar grid developed for Octopus (17, 18). They demonstrated that there is a systematic relative increment sensitivity of the SLO microperimeter which is about 4 dB higher than Octopus values (17, 18). Their results disagree with Andersen's data of about 3 dB (14). However, Rohrschneider et al reported that both instruments show a good correlation (18). Springer et al recently reported differential light threshold obtained with MP1 microperimeter and Octopus perimeter in a group of healthy subjects. These authors suggest a significant correlation between the two instruments even if they underline the different approaches of the two techniques: different bright luminance levels, different testing strategy, and stimuli presentation methods. A large variation in threshold was also reported, and many topics were not completely explained (19).

Our results also document normal retinal threshold data obtained with MP1 fundus perimeter in a small group of healthy eyes. These data show a limited variability of retinal threshold in normal subjects, and in both eyes. The distribution of normal data is concentrated in the upper sensitivity level for most of the healthy subjects tested with MP1 fundus perimeter (Fig. 2). Statistically significant differences were documented at different retinal tested points: these data need to be confirmed on a larger population. One of our major concerns, when analyzing our data, was to find a relationship between normal data obtained with the two instruments. Apart from different stimulation paradigm (direct projection with MP1 fundus perimeter vs indirect projection with Octopus perimeter), the major difference between the two instruments seems to be related to the very large difference in the dB scale. From a simple mathematical point of view, we tried to apply Andersen's mathematical relationship (14). Whereas a simple 0.4 log unit difference between MP1 and Octopus results seems available, it is inapplicable in clinical practice. All our normal MP1 20 dB tested points should correspond to 24 dB in Octopus scale, which means pathologic data with this last instrument. Mathematics is with us, but biology is against us. SLO microperimeter and Octopus perimeter dB scales are very similar, but probably the previously reported relationship about both SLO and MP1 microperimetry versus Octopus perimetry data should be reconsidered.

In conclusion, our data show that direct comparison between microperimetric data and data obtained with Octopus standard automatic perimetry is questionable. Comparison could be revisited when both instruments will be provided with the same physical parameters.

Proprietary interest: None.

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