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Short-wavelength automated perimetry and neuroretinal rim area

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PURPOSE. *To determine the correlation between neuroretinal rim area and functional losses detected by short-wavelength automated perimetry (SWAP) in a population of patients with suspected glaucoma.*

METHODS. *Forty-two eyes of 42 ocular hypertensive subjects who met the selection criteria (intraocular pressure greater than 21 mm of Hg and normal conventional visual fields) were studied. A planimetric optic nerve head study was performed, determining the total and sectorized neuroretinal rim areas. SWAP was also done, with a modified Humphrey field analyzer.*

RESULTS. *There were no significant correlations between the neuroretinal rim areas and the global perimetric parameters. However, the correlations between the inferotemporal neuroretinal rim area and some superonasal visual field regions (areas 3 and 4) were significant.*

CONCLUSIONS. *There is a relation in the topography of some visual field areas assessed by SWAP and the inferotemporal neuroretinal rim area, which may play a role in the diagnosis and follow-up of suspected glaucoma. (Eur J Ophthalmol 2000; 10: 116-20)*

KEY WORDS. *Short-wavelength automated perimetry, Optic nerve head, Diagnosis, Glaucoma*

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INTRODUCTION

Optic nerve head changes and visual field defects are characteristic findings in glaucoma. However, no test alone is able to detect all cases of glaucoma. The different diagnostic tests, assessing structure and function, must be evaluated together to render the maximum diagnostic potential. It would be interesting to assess the correlation between tests assessing structure and function to see how they correspond in suspected glaucoma.

Optic nerve head assessment is a basic exploration procedure in these patients. Changes at this level can be detected before the onset of glaucomatous visual field losses (by conventional automated perimetry-CAP) (1, 2).

Short-wavelength automated perimetry (SWAP) has proved more sensitive than CAP in detecting early visual field losses in glaucoma suspects (3-5). It also corresponds closely with the retinal nerve fiber layer (RNFL) assessment (6).

The purpose of this study was to determine the correlation between the neuroretinal rim area and visual field losses, assessed by SWAP, in glaucoma suspects.

METHODS

Subjects

Forty-two ocular hypertensive eyes of 42 patients (25 males and 17 females) were recruited prospectively from the Glaucoma Department of the "Miguel Servet" Hospital, Zaragoza, Spain. The inclusion criteria were age between 30 and 60 years; best corrected visual acuity 20/30 or higher; intraocular pres-

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sure greater than 21 mm of Hg on at least two occasions (by applanation tonometry); refractive errors less than 5 diopters spherical and 3 diopters cylindrical equivalent; transparent ocular media and normal CAP (Humphrey Instruments, San Leandro, CA; Central Threshold Test: Stimulus III white, background 31.5 apostilbs, Stacpac 2). Glaucomatous CAP visual field defects were defined as deficits that produced a cluster of three or more points lower than the 5% probability level, or a cluster of two or more points lower than the 1% probability level (points could not be located along the periphery or in the blind spot poles) and/or global indexes mean deviation and corrected pattern standard deviation: (MD, CPSD) deficits with $p<2\%$. Informed consent was obtained from all subjects, who were given a full explanation about the nature and possible consequences of the procedures.

Exclusion criteria were glaucomatous CAP visual field defects, as described above, personal history of ocular pathology, surgery or trauma, media opacities, systemic diseases with ophthalmic repercussions, or inability to perform the tests in the exploratory procedure.

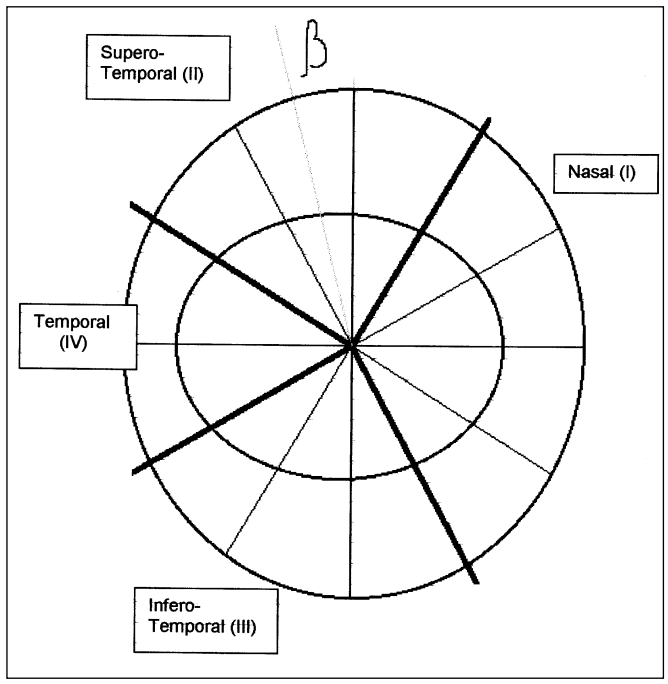

Fig. 1 - *The neuroretinal rim area was divided into four sectors for the planimetric study: I=Nasal, 120°, II=Supero-temporal, 90°, III=Infero-temporal, 90°, IV=Temporal, 60°. (β=15°).*

Optic nerve head assessment

Sequential stereophotographs of the optic nerve head were taken with a Canon CF-60-Z fundus camera after full pupil dilatation. A planimetric optic nerve head study was performed, and the total and sectorized neuroretinal rim areas were measured. The ocular magnification factor was corrected following Littmann's method (7, 8).

The cup and disc areas were outlined by the same observer without any clinical information about the subject. The area between both perimeters was defined as the neuroretinal rim area (NRA) and was divided into four sectors, as shown in Figure 1. All these areas were digitized and quantified by an image analysis program (Visilog 4.1).

The coefficient of variability of this planimetric technique for this operator is 3% (9).

Short-wavelength automated perimetry

SWAP was done using a modified Humphrey field analyzer (HFA I, Humphrey Instruments, San Leandro, CA), with the program 30-2 test procedure. The manufacturer includes these modifications in the HFA I. The test uses a bright yellow background of 100 cd/m^2 (Shott OG-530 filter), blue stimuli (440 nm) and a Goldman size V stimulus, with a dynamic range of 0 to 36 dB (10). All the patients and controls underwent at least three conventional automated perimetries and two SWAPs to avoid or minimize learning effects.

The index of lens density for each eye was determined employing a previously described and validated procedure (11) that can correct the SWAP results individually for each eye to separate optical from neuronal short-wavelength sensitivity losses.

Analysis and interpretation of the SWAP visual fields of the study subjects were carried out by a statistical program we have developed. This program compares each subject's visual field data to that of the age-matched normal population using the formulae of Heijl et al (12).

To establish standard values for the SWAP test, we evaluated one eye of 128 normal control subjects, aged from 30 to 60 years.

Controls met the same inclusion criteria as the ocular hypertensive patients, except for IOP, which had to be less than 21 mm Hg. For each age decade, con-

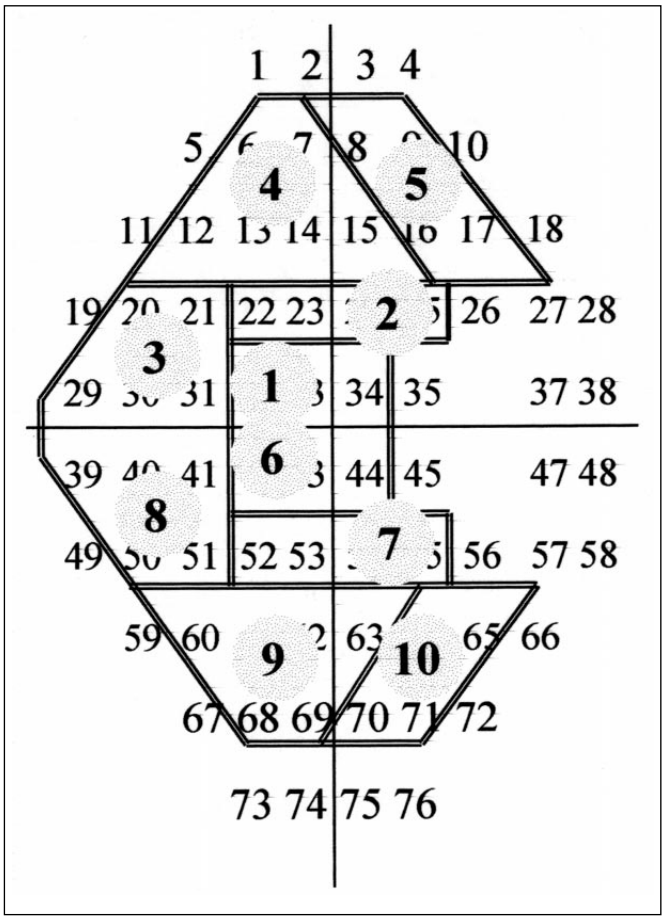

Fig. 2 - *Division of the central SWAP visual field (glaucoma hemifield test areas).*

fidence intervals of 95 and 99% were established at each of the 76 exploration points of the visual field. The SWAP data were corrected for ocular media transmission losses measured for each eye.

The criteria used to define abnormal perimetry consisted of deficits that produced a cluster of three or more points that were lower than the normal 5% probability level, or a cluster of two or more points lower than the normal 1% probability level. These points could not be located along the periphery of the 30-degree visual field (24 points excluded), nor in the blind spot poles (2 points excluded).

The program obtains the unweighted global indexes, mean deviation (MD), corrected pattern standard deviation (CPSD) and the total and pattern deviation probability maps. The mean sensitivity threshold was also calculated from the results for the entire visual field and for each of the ten sectors used for the glaucoma hemifield test (central 30°) as shown in Figure 2 (13). These figures are regional mean sensitivities of age-corrected values at each sector.

A linear regression model was used to correlate the paired values (NRA and SWAP) for the global and sectorized data; $p<0.05$ was considered significant.

RESULTS

No correlation was found between the NRA and the global perimetric data (Tab. I). Table II shows the correlations between the sectorized parameters of the NRA and SWAP. There was a significant correlation between the inferotemporal NRA (sector III) and some superonasal regions of the visual field (areas 3 and 4).

DISCUSSION

Glaucomatous damage associates morphological changes in the optic nerve head and RNFL, and psychophysical abnormalities, some of which can be detected with different perimetric tests. Nevertheless, the correlation between the anatomical and functional alterations remains controversial (14, 15).

In our study we correlated the morphometric parameters of the optic nerve head with the functional results of SWAP tests in glaucomatous suspects, as defined by CAP. We did not find any correlation between the total NRA and the perimetric data.

This result is in agreement with Tsai et al (14), who also found no real correlations between total NRA and MD in the SWAP test. Teesalu et al (15) found a significant correlation between MD and NRA in glaucomatous subjects with different levels of damage, but the correlation was no longer significant when the most advanced cases were excluded.

Sectorized analysis of the NRA and SWAP showed a significant correlation between the inferotemporal NRA sector (sector III) and some superonasal visual field areas (areas 3 and 4). Tsai et al (14) reported a significant correlation between most NRA sectors and their corresponding visual field areas. The differences can be explained by the inclusion criteria, because Tsai included glaucomatous patients with an abnormal CAP, while we excluded these subjects. Also, these correspondences seem to be influenced by different

TABLE I - CORRELATION BETWEEN THE GLOBAL SWAP PARAMETERS AND THE NEURORETINAL RIM AREAS (NRA)

	Total NRA	NRA I	NRA II	NRA III	NRA IV	NRA /disk
DM	0.31	0.18	0.27	0.33	0.07	0.20
CPSD	0.05	-0.09	0.11	0.03	0.10	0.08
Average sensitivity	0.23	0.14	0.15	0.13	–0.03	0.19

None of the correlations were significant

TABLE II - CORRELATION BETWEEN NEURORETINAL RIM AREAS (NRA) AND SWAP MEAN SENSITIVITY IN THE DIFFERENT VISUAL FIELD AREAS

	Total NRA	NRA I	NRA II	NRA III	NRA IV	NRA/ disk
Area 1	0.12	0.03	0.05	0.23	0.27	0.17
Area 2	0.08	0.05	0.02	0.27	0.25	0.20
Area 3	0.02	0.06	0.05	0.44 (*)	0.18	0.14
Area 4	0.03	0.04	0.07	0.41 (*)	0.09	0.19
Area 5	0.01	0.01	0.10	0.19	0.08	0.12
Area 6	0.09	–0.03	0.12	0.21	0.18	0.15
Area 7	0.10	–0.03	0.36	0.19	0.17	0.11
Area 8	0.15	0.12	0.31	0.17	0.08	0.07
Area 9	0.13	0.05	0.21	0.20	0.10	0.04
Area 10	0.05	0.06	0.11	0.15	0.14	0.07

* ($p<0.05$)

The correlation was significant between the inferotemporal neuroretinal rim sector (sector III) and certain superonasal visual field areas (areas 3 and 4)

non-specific factors and by individual variability.

The correlations between certain NRA sectors and visual field areas suggest a relative topography of the SWAP defects in glaucomatous subjects and support previous findings (16), particularly involving the superior paracentral area and the nasal areas around the '3 to 9' meridian (Polo, Honrubia; 1997, unpublished data). As the inferotemporal NRA is a preferential location for early glaucomatous damage, it seems logical to find a certain correlation between this sector and the visual field areas mentioned above. This relationship is supported by Yamagishi et al (16), who divided the central visual field into 21 areas and the NRA into 36 sectors, describing the topographic relationships between the structural changes and the functional visual field data. The highest correspondence was between the superior paracentral areas (named 13, 14 and 15) and certain NRA sectors (named 25 to 28).

For several years now CAP has been considered the "gold standard" in glaucoma diagnosis, but it seems clear that changes in the optic nerve head and RNFL, and also SWAP abnormalities, can be detected before CAP visual field defects. Our study found topographical relations between some SWAP visual field areas and certain structural parameters, which may play a role in the diagnosis and follow-up of suspected glaucoma.

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