SHORT-WAVELENGTH AUTOMATED PERIMETRY AT BASELINE AND FOLLOWING LASER PHOTOCOAGULATION IN PATIENTS WITH CLINICALLY SIGNIFICANT DIABETIC MACULAR EDEMA

A series of illustrative case reports

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Abstract

Purpose: The aim was to present a series of case reports that: 1. demonstrated the improved sensitivity of short-wavelength automated perimetry (SWAP) for the psychophysical detection of abnormality in patients with clinically significant diabetic macular edema (DME), i.e., compared to that of conventional perimetry; and 2. illustrated the localized visual field loss that can occur following grid laser photocoagulation for clinically significant DME.

Methods: The three cases were selected on the basis that their results were typical of the findings of a larger sample of patients (n=24) with clinically significant DME. All three cases exhibited clinically significant DME (age range, 45-70 years) and were Type II diabetic patients (duration range, 10-17 years). One eye of each patient was selected. All patients had a logMAR visual acuity of 0.25, or better. Exclusion criteria included lenticular opacity. Each patient underwent perimetry using SWAP and conventional parameters in conjunction with Program 10-2 of the Humphrey Field Analyzer on two separate occasions prior to treatment; the results of the second perimetry session were taken as baseline. Perimetry was then repeated within one week of, and at one, two, four and 12 weeks after, treatment. A point-wise horizontal hemifield asymmetry analysis was used for SWAP (thereby negating the influence of pre-receptoral absorption). A database of 400 normal subjects (range, 18-84 years) who had undergone SWAP using Program 30-2 was employed. A weighted linear interpolation procedure was utilized to establish confidence limits for the asymmetry of Program 10-2 point-wise horizontal hemifield sensitivity values.

Results: Prior to treatment, the depth and extent of localized visual field loss was more obvious for SWAP than conventional perimetry for all three patients. Case 3 demonstrated the localized visual field loss that typically occurs within 10° eccentricity of the fovea as a result of grid laser photocoagulation for clinically significant DME. The spatial position of the post-treatment localized sensitivity loss corresponded with the area of retinal ablation. The greater extent of SWAP localized field loss prior to treatment minimized the apparent impact of laser photocoagulation on the SWAP visual field.

Conclusions: SWAP offers improved sensitivity for the psychophysical detection of clinically significant

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DME. Despite proven benefit in the stabilization of visual acuity, grid laser photocoagulation for clinically significant DME invariably results in a localized loss of perimetric sensitivity within 10° eccentricity of the fovea.

Introduction

Short-wavelength automated perimetry (SWAP) utilizes a narrow band blue stimulus to preferentially stimulate the short-wavelength sensitive (SWS) pathway and a 100 cd/m² yellow background to saturate both the medium- and long-wavelength sensitive pathways and simultaneously suppress rod activity. Numerous research studies have demonstrated that SWAP, also referred to as blue-on-yellow perimetry, detects glaucomatous visual field defects at an earlier stage in the disease process than conventional perimetry (which employs a white stimulus and a white background). SWAP has also been demonstrated to correlate with optic nerve head morphology in patients with glaucoma, and to reveal a greater extent of visual field loss in patients with optic neuritis than that revealed by conventional perimetry. More recent studies on normal subjects have demonstrated, however, that SWAP exhibits a significantly greater inter-individual variability, and greater short- and long-term fluctuation, than conventional perimetry. The clinical utility of SWAP may be limited, especially for the long-term follow-up of glaucomatous visual field defects.

A selective loss of SWS pathway sensitivity has also been demonstrated in diabetic patients with minimal retinopathy using laboratory paradigms and foveal stimuli. Interestingly, the selectivity of the SWS pathway sensitivity loss in diabetic retinopathy has been shown to be comparatively greater than in glaucoma, i.e., the associated reduction of white-on-white sensitivity is less in diabetic retinopathy than in glaucoma. Furthermore, the magnitude of the SWS sensitivity loss has been suggested to reflect the magnitude of diabetic macular edema (DME). Substantial evidence has accumulated from the findings of laboratory studies to suggest that SWAP may have a clinical role for the psychophysical detection of diabetic retinopathy, particularly DME.

In a recent study, Hudson and co-workers compared the sensitivity of SWAP and conventional perimetry for the psychophysical detection of abnormality in 24 untreated patients with clinically significant DME (all patients had a logMAR visual acuity of 0.25, or better, i.e., Snellen equivalent 6/10). A point-wise hemifield asymmetry analysis was derived for SWAP to negate the influence of ocular media absorption and light scatter. All of the 24 patients exhibited localized SWAP visual field defects while only eight demonstrated localized visual field loss using conventional perimetry (equivalent criteria for abnormality were employed to compare SWAP and conventional perimetry). The topographic position of the localized SWAP defect corresponded with the clinical mapping of the area of DME. Furthermore, Hudson and co-workers utilized the same methodology to investigate the influence of laser photocoagulation for clinically significant DME on macular visual function. The study found that immediately following laser treatment, diabetic patients exhibited a significant increase in the extent of localized visual field defects; similar localized visual field defects were apparent at three months post-treatment. The post-laser increase in the extent of localized visual field defects was more pronounced for conventional perimetry than for SWAP. The spatial position of the post-laser localized visual field loss corresponded with the area of retinal photocoagulation.
Short-wavelength automated perimetry at baseline

The aim of the paper was to present a series of case reports that: 1. demonstrated the improved sensitivity of SWAP for the psychophysical detection of abnormality in patients with clinically significant DME (compared to that of conventional perimetry); and 2. illustrated the localized visual field loss that can occur following grid laser photocoagulation for clinically significant DME.

Methods

The precise methodology has been described elsewhere\(^\text{15}\). In brief, all patients exhibited clinically significant DME using the ETDRS criteria\(^\text{17}\) and a logMAR visual acuity of 0.25, or better. The diagnosis of clinically significant DME was independently confirmed by two medical retina specialists. Exclusion criteria included a family history of glaucoma in a first degree relative, any other eye disease or disorder, including lenticular opacity (i.e., LOCS III grades\(^\text{18}\) >NC2, >NO2, >C2 and ≤P1), the presence of proliferative retinopathy and its sequelae and any previous laser treatment.

Patients underwent automated static threshold perimetry using Program 10-2 of the Humphrey Field Analyzer 640 for both conventional and SWAP stimulus parameters. The standard full threshold strategy was utilized on every occasion. One eye was assigned to the study and a refractive correction appropriate for a viewing distance of 33 cm and the age of the patient was employed; the refraction was checked at each visit prior to perimetry. Patients were rested at least every five minutes to minimize the effects of perimetric fatigue. Perimetry was undertaken on two occasions prior to laser and the results of the second pre-laser session were taken as baseline to minimize learning. After visit 2, all patients underwent a single session of argon green grid laser photocoagulation. Perimetry was then repeated within one week, and at one, two, four and 12 weeks after, laser photocoagulation. The order of perimetry (i.e., SWAP or conventional) at visit 1 was varied between patients and subsequently systematically varied between visits.

Analysis

The results of the patients were compared with databases of normal fields. For conventional perimetry, the Statpac II database of HFA Program 10-2 was utilized. For SWAP, the Statpac for SWAP database of HFA Program 30-2 was utilized, which comprised the results of 400 normal subjects, i.e., 230 subjects of 18-50 years of age, 90 subjects of 51-65 years and 80 subjects of 66-84 years. A weighted linear interpolation procedure, based upon the angular distance between the 10-2 stimulus location to be derived and the four surrounding 30-2 locations, was utilized to calculate program 10-2 normal SWAP sensitivity values.

The analysis was designed to assess the shape of the visual field relative to the database of normal fields, i.e., a method of analysis was adopted that was independent of absolute sensitivity. For conventional perimetry, the point-wise pattern deviation plot of STATPAC II was utilized. For SWAP, a point-wise horizontal hemifield asymmetry analysis that reflected deviation of the shape of the SWAP ‘hill of vision’ from normal was derived, thereby negating the influence of pre-receptoral absorption (i.e., lenticular\(^\text{19}\) and macular pigment\(^\text{20}\)) and light scatter\(^\text{21}\). A point-wise vertical hemifield asymmetry analysis was also undertaken to reveal the full extent of any localized field loss, i.e., the full extent of the
defect could be under-estimated if a localized visual field defect was evenly distributed across, and of equal magnitude on either side of, the horizontal mid-line. The difference of interpolated SWAP Program 10-2 sensitivity values between corresponding stimulus locations in opposite hemifields was calculated for each normal field. The group mean of differences and the standard deviation of the differences were calculated for each decade and were used to establish confidence limits for the asymmetry of point-wise hemifield SWAP sensitivity values.

**Results**

**Case 1**

Case 1 was a 45-year-old female Type II diabetic patient of ten years’ duration. The logMAR visual acuity of the right eye prior to laser treatment was 0.00. The clinical assessment of the extent of DME (using either Volk, or contact lens, stereo fundus biomicroscopy) prior to treatment revealed retinal thickening within 500 µm of the fovea in each of the supero-nasal, supero-temporal and infero-nasal quadrants.

Prior to treatment, the total and pattern deviation plots of conventional perimetry revealed scattered stimulus locations with statistical probability levels of \( p \) less than 5% in both inferior quadrants (Fig. 1). The horizontal and vertical hemifield asymmetry plots of SWAP revealed clusters (i.e., three or more, contiguous locations) of stimuli with statistical probability levels of \( p \) less than 5% in both inferior quadrants (Fig. 1); the localized visual field defects were more obvious with the vertical hemifield asymmetry analysis. The depth and extent of localized visual field loss was more obvious for SWAP than conventional perimetry.

**Case 2**

Case 2 was a 70-year-old male Type II diabetic patient of 16 years’ duration. The logMAR visual acuity of the left eye prior to laser treatment was 0.20. The clinical assessment of the extent of DME prior to treatment revealed retinal thickening in both inferior quadrants that encroached upon the fovea.

Prior to treatment, the total and pattern deviation plots of conventional perimetry revealed clusters of stimuli with statistical probability levels of \( p \) less than 5% in both superior quadrants (Fig. 2). The horizontal and vertical hemifield asymmetry plots of SWAP also revealed clusters of stimuli with statistical probability levels of \( p \) less than 5% in both superior quadrants (Fig. 2); the localized visual field defects were more obvious with the horizontal hemifield asymmetry analysis. The depth and extent of localized visual field loss was more obvious for SWAP than conventional perimetry.

**Case 3**

Case 3 was a 66-year-old male Type II diabetic patient of 17 years’ duration. The logMAR visual acuity of the right eye prior to laser treatment was 0.00. The clinical assessment of the extent of DME prior to treatment revealed retinal thickening in both nasal quadrants that encroached upon the fovea.
Short-wavelength automated perimetry at baseline

Prior to treatment, the point-wise probability plots of both conventional perimetry and SWAP were clearly abnormal; localized defects were particularly apparent in the nasal visual field. The depth and extent of localized visual field loss, however, was more pronounced for SWAP (Fig. 3a). At visit 3 (Fig. 3b), localized visual field defects had subsequently developed in both temporal quadrants, especially for conventional perimetry. The spatial position of the post-laser localized sensitivity loss corresponded with the area of retinal ablation. At visit 7 (Fig. 3c), the extent of post-laser localized visual field loss had recovered to some degree, particularly in the superior temporal quadrant.

Discussion

The evidence of the three case reports presented in this paper suggests that SWAP offers improved sensitivity for the psychophysical detection of abnormality in patients with
clinically significant DME when compared to conventional perimetry. These findings have been confirmed in a sample of 24 patients with clinically significant DME by Hudson and co-workers; this study found that all 24 patients exhibited localized SWAP defects, while only eight of the patients demonstrated localized visual field loss using conventional perimetry.

SWAP could have useful clinical application as a screening procedure for ‘at risk’ diabetic patients, and may be of value in evaluating the outcome of controlled treatment trials of new treatment regimes. However, there is a need to determine the specificity of the point-wise hemifield asymmetry analysis prior to using the technique in a clinical setting. Preliminary analysis of data obtained from 32 normal subjects with previous experience of perimetry would suggest that a specificity in excess of 80% (paper in preparation) can be obtained using the database described in this paper, i.e., derived from normal Program 30-2 sensitivity values. The collection of normal Program 10-2 values is currently in progress (i.e., to establish a ‘true’ normal database and to determine the resultant specificity). In addition, studies are also in progress to establish the specificity of SWAP in a sample of...
diabetic patients with background retinopathy, and to determine the utility of SWAP to monitor change in the extent of DMO over time.

The point-wise probability plots of Case 3 demonstrate the typical impact of grid laser photocoagulation for clinically significant DME on perimetric sensitivity within 10° eccentricity of the fovea. Laser treatment invariably results in a localized loss of perimetric sensitivity. These findings have been confirmed by Hudson and co-workers in a sample of 24 patients with clinically significant DME who underwent a single session of argon green grid laser photocoagulation. Conventional perimetry revealed an increase in the group mean number of abnormal contiguous stimulus locations from 2.4 (SD 4.3, range 0-14) immediately prior to treatment to 12.4 (SD 7.8, range 0-30) within one week of treatment. At 12 weeks post-treatment, the group mean number of abnormal contiguous stimulus locations using conventional perimetry was 8.1 (SD 6.5, range 0-20). Similar but less pronounced changes were observed using SWAP. The greater extent of SWAP localized field loss prior to treatment minimized the apparent impact of laser photocoagulation on the SWAP visual field. Despite proven benefit in the stabilization of visual acuity, grid laser photocoagulation for clinically significant DME invariably results in a localized loss of perimetric sensitivity within 10° eccentricity of the fovea.

Fig. 3. Automated perimetry point-wise probability plots for Case 3 (right eye). a. Visit 2 prior to treatment.
Fig. 3b. Visit 3 three days post-treatment.

SWAP has potential application as a clinical ‘tool’ in the detection and management of DME. Rigorous clinical studies are necessary, however, to establish the benefits of the technique, and to determine the etiology of the SWS pathway sensitivity loss, before SWAP can be used in a clinical setting.

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References