A method to identify the edge of visual field scotoma; the estimation of prediction error of the visual field sensitivity is large at the steep ‘edge’ of scotoma

Yuika Aoyama, Hiroshi Murata, Mayumi Tabara, Mieko Yanagisawa, Chihiro Mayama, Ryo Asaoka. University of Tokyo Graduate School of Medicine, Tokyo, Japan.

Purpose: Humphrey 24-2 visual field (VF) test grid has a spatial gap, since each test point is located six degrees apart. The purpose of this study was to create a method to identify the edge of VF scotoma and to investigate the relationship between the steepness of the ‘edge’ of scotoma and the prediction error of VF sensitivity.

Methods: Eleven clinically stable glaucomatous patients with reliable VFs were recruited. Then, using the latest VFs (Humphrey 24-2) of these patients, the gradient of the plane on the hill of vision from the sensitivity of adjacent four/three points is calculated, so that the ‘edge’ of VF damage is identified. Next, VF measurement was carried out, adding ten test points at the centre of adjacent four/three points (red circle, Figure 1) where the gradient of the plane is largest (Full threshold, Custom mode). The VF measurements were performed using two approaches; random target presentation of 62 test points together and showing ten added points following or prior (randomly selected) to 52 (24-2) points. Each measurement with each approach was repeated twice (in total four measurement for a patient) in a same visit. Then, the absolute value of the difference between the measured sensitivity of the added ten test points and the average of the sensitivities of surrounding three/four test points were calculated. Finally, the relationship between the gradient of sensitivity plane and the absolute difference was investigated using the multiple level modeling (MLM).

Results: MLM revealed significant relationship between the absolute difference and the gradient of plane with all of the four measurements (p<0.05).

Conclusions: The discrepancy between the estimated sensitivity from the surrounding test points and the actually measured sensitivity at the gap in the 24-2 grid became large where the edge of scotoma is steep. It may be advantageous to increase the spatial information by carrying out additional measurement at these areas, in order to estimate scotoma more accurately.

Commercial Relationships: Yuika Aoyama, None; Hiroshi Murata, None; Mayumi Tabara, None; Mieko Yanagisawa, None; Chihiro Mayama, None; Ryo Asaoka, None

Program Number: 3915 Poster Board Number: D0203
Presentation Time: 2:45 PM - 4:30 PM
Exploration of the Dynamic Range of the Moorfields MDT to Assess Suitability to Monitor Glaucoma
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Purpose: To compare the dynamic range between stimuli employed in Standard Automated Perimetry, SAP, and in the Moorfields Motion Displacement Test, MMDT.

Methods: Frequency-of-seeing curves (FOS) were obtained from data collected at 8 locations of the visual field (VF) in 23 subjects with a range of pointwise sensitivities (0 - 35dB on the Humphrey VF analyzer, Carl Zeiss Meditec., SITA-Standard). Four locations of the VF in one eye per subject were tested. The method of constant stimuli was used for both SAP- and MMDT-like stimuli with 15 bins and 8 presentations per bin used to build the FOS curve. SAP was performed using Goldmann size III stimuli presented for 200msec. For the MMDT, vertical lines of areas ranging from 0.27 to 6.10mm², depending on eccentricity, oscillated for 600msec. Both types of stimuli were presented on an EIZO G521 monochromatic monitor (0.17mm/pixel) using the MMDT software (v.1.8.3). The Psignifit toolbox (v.3.0) was used to plot the curves and estimate the 50%-seen threshold. Results were analyzed using a multiple linear regression analysis (least squares).

Results: SAP and MMDT thresholds were calculated from 184 FOS curves with truncation effects observed less frequently in SAP (7 cases) than in MMDT (19 cases). MMDT thresholds were measured across the range of SAP sensitivities from 36.8 to 7.8dB. The relationship between the two scales is significantly dependent (adjusted R² = 0.76, p-value = 0.003; Figure 1) on the MMDT stimulus area and can be described by the formula:

\[ \text{Threshold}_{\text{MMDT}} = -0.65 \times \text{Threshold}_{\text{SAP}} - 36.61 \]  

(Eq.1)

Conclusions: A strong linear association between the values obtained with SAP and the MMDT was observed. Motion displacement threshold increased as VF sensitivity reduced. Although truncation of the FOS curves was more frequent with the MMDT, thresholds derived from staircase, as in clinical perimetry, would be more robust at this end of the scale. The results suggest that the MMDT has the potential to be used for monitoring glaucoma deterioration.
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82.7±9.3%. Visual field retest performed after the chewing gum was removed became reliable: fixation loss decreased to 6.3±5.7% (p=0.011 vs. the test with chewing gum in the mouth). Three healthy volunteers did not demonstrate difference in fixation loss rate with and without having chewing gum in the mouth (0.67±0.33% vs. 0.33±0.58%, p=0.42).

**Conclusions:** For some individuals, the pattern or magnitude of spontaneous movements resulting from chewing gum during visual field examination causes significant increase in reported fixation loss rate. This phenomenon appears sensitive to the individual’s technique of gum chewing. Clinicians should be aware of this possible cause of high fixation loss and the simple remedy; remove chewing gum prior to visual field testing.

**Commercial Relationships:** Tamara L. Berezina, None; Eileen Buroff, None; Albert S. Khouri, None; Amir Cohen, None; Robert D. Fechtner, None

**Program Number:** 3937 **Poster Board Number:** D0225

**Presentation Time:** 2:45 PM - 4:30 PM

**Glaucoma Monitoring with Frequency Doubling Perimetry in the Groningen Longitudinal Glaucoma Study**

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**Purpose:** To determine the suitability of frequency doubling perimetry (FDT) for glaucoma monitoring.

**Methods:** One hundred twenty six eyes of 126 glaucoma patients were included. Patients were followed prospectively with the Humphrey Field Analyzer (HFA; 30-2 SITA) and FDT (C20-1 full threshold) in the Groningen Longitudinal Glaucoma Study, an observational cohort study. The rate of progression (ROP) was calculated. We used the mean deviation (MD) for HFA and the number of test locations with p < 1% in the total deviation probability plot for FDT. Patients were stratified in three equally sized groups (tertiles; slow, average and fast progressors) based on their ROP, for both HFA and FDT.

**Results:** On average 8.1 HFA and 4.5 FDT tests were available after a mean follow-up (identical for HFA and FDT) of 6.4 years. The mean (SD) HFA MD at baseline was -7.9 (6.4) dB; the mean (SD) number of abnormal FDT test locations at baseline was 6.1 (4.5). The mean (SD) HFA ROP was -0.28 (0.55) dB/yr and the mean (SD) FDT ROP was 0.12 (0.50) abnormal test locations per year. There was a highly significant association between HFA and FDT ROP (chi-squared test: p=0.001; see figure).

**Conclusions:** Using frequency doubling perimetry for the monitoring of glaucoma patients can give some insight in disease progression. This suggests that FDT can be used in patients who cannot be reliably tested with standard automated perimetry.

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Adaptation abnormalities in Primary Open-Angle Glaucoma
Shira Radner, Robert Ennis, Barry Lee, Mitchell W. Dul, Qasim Zaidi. Graduate Department of Biological and Vision Sciences, SUNY State College of Optometry, New York, NY.

Purpose: Dynamic color and brightness adaptation are crucial for visual functioning. Does the effect of Glaucoma on retinal ganglion cells compromise these functions? Zaidi, Ennis, Cao, & Lee (Neural locus of color afterimages. Current Biology, 22(3), 220 - 224, 2012) used psychophysics and in vivo single-cell recordings to show that ganglion cells are the adaptation locus for color afterimages at moderate intensities. We used the same procedure to test the hypothesis that adaptation is weaker in patients with glaucoma (POAG) compared with age-matched controls.

Methods: On a CRT at a distance of 83 cm, a 4° central disk was divided into two halves. Beginning and ending at mid-grey, sinusoidal half-cycles slowly modulated the colors of the hemi-disks for 16 sec at 1/32 Hz to opposite ends of the cardinal axes (red-green, yellow-violet and white-black) that respectively isolate parvo, konio and magno ganglion cells (Sun, Smithson, Lee, and Zaidi, Specificity of cone inputs to macaque retinal ganglion cells. J. Neurophysiology, 95: 837-849, 2006). Observers perceived the difference between the two colors as first increasing and then decreasing to identity, followed by increasing and decreasing differences between the complementary colors forming an afterimage. Due to ganglion cell adaptation, the identity point preceded the end of the physical modulation, and the physical contrast at that point estimated the magnitude of adaptation. A second 2° circle was presented as a clock with a central dot as the fixation point, at either the central location or peripherally at 8° left, right, top or bottom. Observers used the clock to report the time of the identity point and a button press to report the end of the afterimage. We measured identity points and afterimage durations for the affected eyes of 13 POAG patients and 15 age-matched controls. The 3 fixation locations times the 3 cardinal axes were presented in random order, with 3 repetitions.

Results: In 14 out of the 15 comparisons (locations x colors), mean identity points were later for glaucoma patients than for controls (probability of chance occurrence < .0001). All observers reported prolonged afterimages, but the measurements were noisier, and differences in duration were not significant.

Conclusions: Neural adaptation is slower in glaucoma patients for all three classes of retinal ganglion cells.

Commercial Relationships: Shira Radner, None; Robert Ennis, None; Barry Lee, None; Mitchell W. Dul, None; Qasim Zaidi, None

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Online Peristat identifies scotomas by interrogating four quadrants of a visual field.

Commercial Relationships: Sean K. Wang, None; Jing Hou, None; Sean Ianchulev, transcend medical (E), keepyourself foundation (S); Brian Chon, Transcend Medical (C); Ying Han, None; Robert Chang, None

Program Number: 3959 Poster Board Number: D0247 Presentation Time: 2:45 PM - 4:30 PM A novel method to predicting quality of visual life and identifying essential visual field locations Hiroyo Hirasawa1, Hiroshi Murata1, Yuka Aoyama1, Makoto Araie2, Chihiro Mayama1, Makoto Aihara1,2, Ryo Asaoka1,3, Ophthalmology, University of Tokyo Graduate School of Medicine, Tokyo, Japan; 2Kanto Central Hospital, the Mutual Aid Association of Public School Teachers, Tokyo, Japan; 3Shirato Eye Clinic, Tokyo, Japan. Purpose: The purpose was to perform comparative evaluation of the several machine learning algorithm to predict quality of visual life (QoVL) in glaucomatous patients. Furthermore, we aimed to identify important visual field (VF) test points for QoVL considering the inter-relationship among visual acuity (VA) and VF test points. Methods: QoVL score was surveyed in 164 glaucoma patients using the 'Sumi questionnaire' (Ophthalmology 2003;;110:332-339). The relationship between VAs of better/worse eye, total deviation (TD) values of all of the test points on integrated binocular visual field (IVF), and the general and each QoVL score (letters/sentences, walking, going out, dining) were investigated using four machine learning algorithm: the Random Forest (RF), Gradient Boosting machine (Boost), Support vector machine (SVM) and Feed forward neural network (NNET). For comparison, multiple regression (MR) method was also investigated. The cross validation was carried out using the one leave out method and the prediction errors of those four methods were compared. Then the contributing IVF test points for the general and each QoVL scores were determined using the algorithm with tightest prediction error. Results: The prediction errors from RF, Boost, NNET and SVM were 1.97, 1.96, 2.59 and 2.23, respectively, which were significantly smaller compared to that from MR (3.38). Thus, we adopted RF for the following analyses. The important VF test points for general QoVL score existed widely around the horizontal line and some points existed at peripheral area (Figure 1). Specific test points were chosen for each QoVL task (Figure 2); VF test points along the horizontal line were chosen for the letters/sentences, and walking. In addition, peripheral points in the left hemi-field were chosen for letters/sentences, and peripheral inferior hemi-field was chosen for the walking. For going out, test points just beneath the horizontal line in the left hemi-field and also those in the peripheral superior hemi-field was chosen. For dining, the selected test points were scattered widely in peripheral areas. Conclusions: Accurate prediction of QoVL was obtained by...
Clinical Utility of Web-based Office and Home Peristat for the Detection of Visual Field Defects in Patients with Glaucoma

Sean K. Wang1, Jing Hou2, Tsontcho Ianchulev2, Brian Chon2, Ying Han2, Robert T. Chang1

1Department of Ophthalmology, Stanford University
2Department of Ophthalmology, University of California, San Francisco

Introduction

The primary goal of this project was to investigate the performance of Peristat, a free new virtual perimetry device for online office-based and home-based detection of scotomas. We characterized the reliability of home-based, self-administered Peristat screening and correlated it with office-based testing, a modality that has already been validated under controlled clinical supervision.1

Peristat Technology

Peristat simulates gold-standard perimetry tests on a desktop computer screen. The program consists of sequentially displayed stimuli in a preset algorithm, interrogating a visual field of 24 degrees from fixation horizontally and 20 degrees vertically. Stimuli may be of four threshold levels of contrast ranging from 16.7 to 26.7 dBs. To maintain fixation, patients completely cover their non-testing eye and are presented with two targets: one directly located in the center of the screen and one positioned in the user’s blind spot as a control. This results in an always constant distance from the screen.

Prior to the test, background levels and methodology. Supervised office-based Peristat was performed at both Stanford and UCSF locations.

Methods

Nineteen patients undergoing routine examinations for glaucoma were enrolled from the University of California, San Francisco Medical Center and the Byers Eye Institute at Stanford University. All patients performed Peristat testing under two sets of conditions: once in the office under controlled clinical supervision and once individually at home. Office-based Peristat testing was performed on a standardized 17” computer setup. Screening took approximately five minutes per eye for a total of ten minutes if both sides were examined. After online Peristat, patients were briefly surveyed and provided instructions on how to self-test on a home computer.

Scoring

Visual field results from each tested eye were divided into four quadrants, each of which was independently scored as normal or abnormal. A quadrant was defined as abnormal if it contained a cluster of ≥3 adjacent points with ≥ 6.7 dB loss from background or ≥2 adjacent points with ≥ 10 dB loss from background. Peristat findings were deemed reliable for tests with ≤ 33% rate for false positives, false negatives, and fixation loss in the same eye.

Results

Of the 19 enrolled patients, 11 (57.9%) obtained reliable results for both office- and home-based Peristat. A total of 16 eyes represented 64 visual field quadrants, 52 (81.3%) of which consistently identified possible defects as abnormal or within normal range. For 3 (4.7%) quadrants, normal office-based findings were subsequently graded as abnormal at home. For 9 (14.1%) quadrants, abnormal home-based findings were subsequently graded as normal at home. All fields were de-identified before evaluation.

Statistical Analysis

Comparing all office versus home Peristat quadrants, the Cohen’s kappa coefficient was 0.750. According to statistical analysis, no clinically significant differences were observed between the groups with respect to frequency rates of fixation loss (p = 0.2225), false negatives (p = 0.1093), or false positives (p = 0.3319) during the tests.

Conclusions

Self-administered Peristat at home shows comparable efficacy in detecting scotomas as office-based testing under clinical supervision. Our results suggest that Peristat has the potential to be used as a self-administered home screening perimetric test.

Table 1: (Below) Quadrant-by-quadrant categorization of office- and home-based Peristat. Test results were defined as accurate in a quadrant if both office and home Peristat agreed on “Normal” or “Abnormal” findings.

<table>
<thead>
<tr>
<th>Office Result</th>
<th>Home Result</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>All Quadrants</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Normal</td>
<td>9</td>
<td>9</td>
<td>14</td>
<td>13</td>
<td>45</td>
<td>70.31</td>
</tr>
<tr>
<td>Abnormal</td>
<td>Abnormal</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>7</td>
<td>10.94</td>
</tr>
<tr>
<td>Normal</td>
<td>Abnormal</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>4.69</td>
</tr>
<tr>
<td>Abnormal</td>
<td>Normal</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>9</td>
<td>14.06</td>
</tr>
<tr>
<td>Total</td>
<td>Total</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>64</td>
<td>100</td>
</tr>
</tbody>
</table>

Figure 1: (Above) General timeline depicting key steps in study design and methodology. Supervised office-based Peristat was performed at both Stanford and UCSF locations.

Key Items:

- Target Stimulus interrogates visual field of patient
- Blind Spot Marker sets head position and screen distance
- Fixation Target marks center of testing screen

Figure 2: (Below) Sample Peristat user interface during an office-based left-eye screening test on a standard 17” desktop computer. Location and brightness of the Target Stimulus vary throughout the test.

Figure 3: (Above) Office-based (top) and home-based (bottom) Peristat both identify scotomas. Q1 and Q2 would be scored as abnormal, while Q3 and Q4 would be normal.

Table 2: (Left) Comparison of three error metric frequencies used to exclude unreliable patient data. No significant difference was observed between office and home Peristat.
Introduction

• Glaucoma is the leading cause of irreversible blindness in the world.

• It is a so-called “silent disease” because patients are mostly asymptomatic until late stages when the optic nerve is severely damaged.

• Currently, there is no practical population-wide screening test for glaucoma due to the inconsistent results of screening when glaucoma is at an early stage and due to the high cost of eye examinations performed by professionals.

• Peristat is a new online Perimetry System that allows self-testing on any standard computer monitor via Internet connection, which is costless, labor spare, time saving, and suitable for population screening.

Objective

• To compare a new online Perimetry (Peristat) with Humphrey visual field (HVF) for patients with mild, moderate and severe glaucoma.

Methods

• Seventy-seven glaucoma patients with 129 eyes and 12 controls with 14 eyes were enrolled.

• All subjects performed 30-2 SITA-standard HVF and Peristat (www.keepyoursight.org) in the office.

• A reliable field for both tests was defined as fixation loss, false positive and false negative ≤ 33%.

• HVF defect in each quadrant was defined as clusters of ≥3 adjacent points with P ≤ 5% on the pattern deviation plot or ≥2 adjacent points with P ≤ 1%. Peristat defect in each quadrant was defined as clusters of ≥3 adjacent points with ≥ 6.7 dB (light grey) loss from background or ≥2 adjacent points with ≥10 dB (dark grey) loss. An abnormal eye was identified if there was ≥1 abnormal quadrant.

• ROC analysis to evaluate the Peristat for diagnosis of mild, moderate and severe HVF defects.

Results

Examples of HVF and Peristat in each group

• Sixty-three glaucoma patients with 84 eyes and 12 controls with 14 eyes obtained reliable HVF and Peristat tests.

• The numbers of eyes with mild, moderate and severe glaucoma were 51 (60.7%), 18 (21.4%), and 15 (17.9%), respectively.

• When fields were analyzed per quadrant, the sensitivity and specificity of Peristat to identify abnormal quadrant were 52.6% and 93.0% for moderate glaucoma, and 78.4% and 95.4% for severe glaucoma, respectively.

• When fields were analyzed per eye, the sensitivity and specificity of Peristat to identify glaucomatous eye were as below.

<table>
<thead>
<tr>
<th>Diagnostic characteristic</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>53.7%</td>
<td>83.3%</td>
<td>93.3%</td>
</tr>
<tr>
<td>Specificity</td>
<td>87.5%</td>
<td>85.7%</td>
<td>85.7%</td>
</tr>
</tbody>
</table>

ROC Analysis for diagnosis of mild, moderate, or severe HVF defects

<table>
<thead>
<tr>
<th>Technique for counting points</th>
<th>Mild (MD&lt;6)</th>
<th>Moderate (6-12)</th>
<th>Severe (&gt;12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Grey</td>
<td>0.8491</td>
<td>0.8759</td>
<td>0.8950</td>
</tr>
<tr>
<td>Dark Grey</td>
<td>0.7667</td>
<td>0.8810</td>
<td>0.9104</td>
</tr>
<tr>
<td>Black</td>
<td>0.7449</td>
<td>0.8636</td>
<td>0.8754</td>
</tr>
<tr>
<td>P-value comparing 3 curves</td>
<td>P=0.004</td>
<td>P=0.57</td>
<td>P=0.24</td>
</tr>
</tbody>
</table>

Conclusion

• Web-based Peristat has a good to very good agreement with HVF to identify eyes with moderate and severe glaucoma.

• The spatial correlation between Peristat and HVF is fair for those eyes.

• Given that Peristat has high sensitivity and specificity to identify eyes with moderate to severe glaucoma, it could be a good glaucoma-screening tool.

Reference