Humphrey Field Analyzer 3
Humphrey Field Analyzer 3
Introduction
# HFA3 version 1.5 Innovations

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<td>SITA Faster 24-2C</td>
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SITA Faster – tests in 2 minutes or less without compromise to test results

Two minute test for near normal patients
- ~50% faster than SITA Standard; ~30% faster than SITA Fast
- Clinically equivalent to SITA Fast and Standard
- Same SITA algorithm and normative data as Standard and Fast
- Removes unnecessary “dead time” during the test
- No Blind Spot or False Negatives
  - Uses Gaze Monitoring and False Positives for test quality monitoring

Mixed SITA GPA Reports
- Allows mixing all SITA test strategies for GPA reports
- Helps immediately adopt SITA Faster
- Clinical equivalence of tests allows intermixing
What's New in Testing Function?

A New SITA Perimetric Threshold Testing Algorithm: Construction and a Multicenter Clinical Study

ANDERS HEIJL, VINCENT MICHAEL PATELLA, LUKE X. CHONG, AIKO IWASE, CHRISTOPHER K. LEUNG, ANJA TUULONEN, GARY C. LEE, THOMAS CALLAN, AND BOEL BENGTSSON

PURPOSE: To describe a new time-saving threshold visual field–testing strategy—Swedish Interactive Thresholding Algorithm (SITA) Faster, which is intended to replace SITA Fast—and to report on a clinical evaluation of this new strategy.

Six Steps to Visual Field Analysis

1. Do the Right Test
2. What’s the Reliability
3. Review Probability Plots
4. Review Indices (GHT)
5. Pattern of loss
6. Repeat
   - Confirm the diagnosis
Six Steps to Visual Field Analysis

• Confirm
  – Compare to previous defect
    • Unchanged
    • Worse
    • Better
Variability of Field Defect
No Confirmation
Progression in Glaucoma

- Earliest diagnosis
- Disease management
- Forecasting
  - Rate of progression
  - Quality of vision
Humphrey Field Analyzer
Guided Progression Analysis (GPA)

Guided Progression Analysis (GPA)
Summary Report Example

TREND Analysis

EVENT Analysis

VFI Plot

Linear Regression Analysis of VFI

Baseline 2

Baseline 1

VFI Value

VFI Bar
Progression Detection

• 2 approaches
• Event-based analysis
  – AGIS, CIGTS, CNTGS, EMGT and OHTS
• Definition: An Event is a statistically significant change from baseline
  – Important to differentiate statistically significant & clinically significant events
• Most appropriate for slowly progressive disease
Event-based Analysis

![Graph showing event-based analysis](image)
Event-based Analysis
Guided Progression Analysis (GPA)

Multiple Exams

Baseline

Follow-up
Progression: Spectralis - RNFL Trend Report

- Shows change over time for each sector.
- Compares measurement to normative database.
- Results are displayed numerically and as a trend graph.
Trend-based Analysis

- Most appropriate to identify rapid progression
- Rate of change over time
- Typically performed using linear regression
  - Summary field index
  - Pointwise analysis
Trend-based Analysis

\[ y = -0.19x + 25.8 \]
\[ R^2 = 0.51 \]
\[ p = 0.03 \]
Progression in Function: HFA GPA
Trend Analysis: Limitations

- Data reduction: Can get significant focal change without much change in global measures
- Event analysis will better detect focal change
- Severly influenced by poor data
- Need to adjust baseline
Progression Analysis

- *Trend-based analysis* should be initiated as early as possible in patients whose rate of progression is rapid
  - Younger patients
  - IOP not adequately controlled

- *Event-based analysis* more appropriate in patients who progress slowly
1. At least 2 VFs should be performed in the first 6 months (3 if progression suspected)
   i. A good baseline is essential to monitor for progression
   ii. Unless obvious learning effects, high false-positive errors or rim artefacts, examinations should not be removed from the analyses

2. A further 3 VFs should be performed within the next 18 months
   i. Every 6 months

3. VF testing should be repeated sooner if possible progression identified using “event” analysis
   i. 6 VFs in the first 2 years detection of rapid progression (>2 dB/year) and establishes a good set of baseline data
   ii. Identification of possible progression may be on the basis of an “event” criterion
Recommendations of the Glaucoma Societies
Frequency of Testing for Visual Fields

To identify rapidly *progressing* patients early requires more frequent field testing the first years after diagnosis!

1. Perform a sufficient number of visual field examinations to assess progression.
   The progression status of the patient is unknown unless there is enough information. This guide shows you how to determine the number of examinations you need to detect different amounts and rate of visual field change. Use all available and reliable examinations.

2. Estimate the rate of visual field progression.
   This is invaluable for guiding therapeutic decisions and estimating the likelihood of visual impairment during the patient’s lifetime. In most cases, establishing this rate requires several years and frequent examinations.

3. Perform 6 visual field examinations in the first 2 years of follow-up.
   This rules out the presence of rapid progression (≥ 2 dB/year or worse) and establishes a good set of baseline data.

4. Use the same threshold test.
   Any analysis of progression can only be undertaken if the same threshold algorithm and test pattern is used.

5. Pay attention to examination quality.
   Poor quality examinations will lead to an erroneous assessment of progression. Do not automatically rely on the reliability indices. Unless there are clear reasons (obvious learning effects, high false positive errors, non-artefacts, etc.), examinations should not be removed from the analyses.

Gain certainty sooner

One Visual Field per year means 3 visual fields after 2 years

Reading a trend from 3 Visual Fields is not recommended*

Gain certainty sooner

A field every 6 months gives you 6 fields in 2.5 years

Enough to rule out rapid progression and to start acting*

1) Trend Analysis – Rate of Progression
2) Event Analysis – Progression Probability
3) Glaucoma Hemifield Test & Progression Label

-1.5 ± 0.4% / year (95% confidence)

Follow-up: Aug 14, 2008 Full Threshold
GHT: Outside Normal Limits
Likely Progression
Slow Progression May Not Necessarily Be Vision Threatening

If current therapy is continued, what is this patient’s risk of further visual impairment? → rate of progression uncritical for life expectancy of patient
Practice example – 1) Visual Field
Application of the rate of progression, r-o-p concept

Set Baseline
- After events like surgery and change of treatment reset the Baseline
- Evaluate the rate of progression in light of the confidence interval
- After the last event, there are only 5 examinations

Rate of Progression
- The yearly r-o-p is 
  -1.5% +/- 6.1% respectively
  -0.3dB/yr +/- 1.6dB
- Since the confidence interval is higher than the r-o-p, the patient might be stable now
Is the patient now stable, or is further treatment escalation appropriate?
Excluding Non-Representative Exams
What do we know?

- Rate of progression important
- Early progression easier to detect in structural measures?
- Function increasingly important as disease progresses
Combining Structure-Function

- Can change in one modality be used to increase the probability that change in another parameter is true?
- Can coincident borderline results be considered abnormal?
Retinal nerve fibre layer and visual function loss in glaucoma: the tipping point

Gadi Wolstein,1 Larry Kagemann,1,2 Richard A Bitnick,1 Hiroshi Ishikawa,1,2 Lindsey S Folk,1 Michelle L Gabrille,1,2 Allison K Ungar,1 Jay S Duker,1,2 James G Fujimoto1,3,4 Joel S Schuman1,5,6

ABSTRACT

Aims To determine the retinal nerve fibre layer (RNFL) thickness at which visual field (VF) damage becomes detectable and associated with structural loss.

Methods In a prospective cross-sectional study, 72 healthy and 40 glaucoma subjects (one eye per subject) recruited from an academic institution had VF examinations and spectral domain optical coherence tomography (SD-OCT) optic disc cube scans (Humphrey field analyser and Cirrus HD-OCT, respectively). Comparison of global mean and sectoral RNFL thickness with VF threshold values showed a plateau of threshold values at high RNFL thickness and a sharp decrease at lower RNFL thicknesses. A "broken stick" statistical model was fitted to global and sectoral data to estimate the RNFL thickness tipping point where the VF threshold values become associated with the structural measurements. The slope for the association between structure and function was computed for data above and below the tipping point.

Results The mean RNFL thickness threshold for VF loss was 73.5 µm (95% CI: 68.9 to 81.8), reflecting a 17.3% RNFL thickness loss from age-matched normative values. Above the tipping point, the slope for RNFL thickness and threshold value was 0.03 dB/µm (CI: 0.02 to 0.07) and below the tipping point, it was 0.28 dB/µm (0.10 to 0.48), the difference between the slopes was statistically significant (p < 0.001). A similar pattern was observed for quadrant and clock-hour analysis.

Conclusions Substantial structural loss (~17%) is necessary for functional loss to be detectable using the current testing methods.

The structural and functional relationship in glaucoma has been extensively studied, but the point at which the clinical functional loss as measured by visual field (VF) becomes detectable and related to structural changes is unknown. Fundus photography demonstrated the occurrence of retinal nerve fibre layer (RNFL) defects before measurable VF defects. Longitudinal observations revealed that RNFL thinning was associated with future VF damage.2,3 Detection of structural changes that precede the loss of visual function could be used to improve disease management and preserve vision. Precise measurements of RNFL thickness are possible with optical coherence tomography (OCT).4,5 Previous studies proposed models to relate RNFL thickness and functional assessment, but none of them identified the threshold where functional changes can be expected to be detected clinically.6,7 Our hypothesis is that there is an RNFL thickness threshold at which VF loss becomes clinically observable, where for values above the threshold there will be little correspondence between OCT measured structure and VF measured function, and in values below the threshold there will be a strong association between RNFL thickness and VF. The purpose of this study is to determine the RNFL thickness at which VF damage becomes detectable and associated with structural loss.

Methods Subjects were consecutively enrolled from the Pittsburgh Imaging Technology Trial, a prospective longitudinal study designed to assess ocular structure and function over time carried out at the University of Pittsburgh Medical Center. The study followed the statements of the Declaration of Helsinki and was performed in accordance with the Health Insurance Portability and Accountability Act. Institutional review board and ethics committee approval was obtained, and all participants gave their informed consent to be enrolled.

Subjects Subjects were included if they were either healthy volunteers or stage I glaucoma patients of age 18 years or older. Subjects were excluded if any of the following were present: history of intraocular surgery except for uncomplicated cataract extraction at least a year prior to enrollment, best corrected visual acuity worse than 20/25, or any ocular disease other than glaucoma. One eye of each subject was randomly selected. In unilateral glaucoma cases, the affected eye was selected.

In order to prevent selection bias, a study that evaluated the relationship between structural and functional, the dichotomy of all subjects was based solely on VF findings without consideration of structural appearance. Healthy subjects had a normal VF examination in both eyes. Glaucoma subjects had typical and reproducible glaucoma manifestations: Subjects who were clinically suspected of having glaucoma due to optic nerve head or RNFL appearance or because of abnormal intraocular pressure but with normal VFs were included in the healthy group to ensure representation of the full spectrum of disease.

VF testing

Swedish Interactive Thresholding Algorithm standard 24-2 protocol (Carl Zeiss Meditec, Dublin).
Structure and Function in Glaucoma

What do we know?
- Linear relationship between S & F
- Different ranges of normality and variability
- Temporal factors

'Structure–function relationship' in glaucoma: past thinking and current concepts

Rizwan Malik MRCophth, PhD, MD, William H Swanson PhD, FAAO and David F Garway-Heath MD, FRCophth

Department of Biomedical Research Centre for Ophthalmology, Moorfields Eye Hospital NHS Foundation Trust & UCL Institute of Ophthalmology, London, UK, and Indiana University School of Optometry, Bloomington, Indiana, USA.
Structure and Function in Glaucoma

Harwerth et al. IOVS. 2004.
Will Perimetry Be Performed to Monitor Glaucoma in 2025?

Andrew S. Camp, MD, Robert N. Weinreb, MD

Visual field testing has played an essential role in the diagnosis and management of glaucoma for more than a century. Methods to examine the visual field have been refined from early kinetic perimetry to current standard automated perimetry (SAP). Clinicians now use SAP for the diagnosis and management of glaucoma throughout the world. Various testing paradigms and analytic methods have been developed to simplify the diagnosis of glaucoma and the interpretation of progression. Moreover, strategies have been implemented to improve patient experience with visual field testing and to increase reliability. Objective functional tests, such as electroretinography, provide an alternative to subjective visual field testing but are not yet ready for widespread adoption. Standard automated perimetry is being adapted and improved constantly. New devices may allow patients to complete visual field tests at home, which could relieve patients and clinicians from in-office testing and allow for more frequent examinations. Glaucoma detection and progression analysis also are incorporating progressively more information and will be improved as deep learning strategies are applied. Finally, perimetric and structural testing likely will become more closely intertwined as testing platforms and progression analysis incorporate both of these measures. Visual field testing will continue to have an important role in the diagnosis and management of glaucoma. Ophthalmology 2017;11-5 © 2017 by the American Academy of Ophthalmology

To address the future of perimetry, the past, present, and future of visual field testing should be considered. Field testing has long had an important role in the diagnosis and management of glaucoma. Although it has been described in terms of both optic nerve excavation and visual field constriction since the 18th century, clinical management largely has been based on visual field changes. Continuous improvements in testing have provided a progressive understanding of the functional damage to the optic nerve. In 1886, Jamin quantified visual field testing through kinetic testing of the central 30°. Subsequently, Traquair further emphasized the importance of mapping visual field defects with formal perimetry. The concept of measurement of visual field defects with formal perimetry was introduced by Goldmann's standardization of the automated perimetry test, a test that led to the new era of visual field testing.

Kinetic perimetry provided considerable information, but was labor intensive and also required skilled operators. The limitations of manual kinetic perimetry led to the development of semiautomated static perimetry in the 1960s. Research using semiautomated static perimetry revolutionized the understanding of glaucoma. With the advent of computerized automated perimetry, the understanding of glaucoma was revolutionized. The significance of the presence of glaucomatous changes was not only dependent on elevated intraocular pressure. Advances in computerized automated perimetry provided a means to identify early changes in the optic nerve and not just in the visual field. It soon became apparent that strategies have decreased the time needed to complete the examination. A new algorithm for automated perimetry was developed that allowed for faster and more efficient testing. This new algorithm provided a means to identify early changes in the optic nerve and not just in the visual field. It soon became apparent that early changes in the optic nerve were associated with early changes in the visual field.
Relationships of retinal structure and Humphrey 24-2 visual field thresholds in patients with glaucoma
H Bogunović, YH Kwon, A Rashid, K Lee, DB Critser, MK Garvin, M Sonka, MD Abramoff. University of Iowa & Iowa City VA Health Care System
IOVS, 2014.

Figure 1. The Retinal-Ganglion-Cell Axonal complex (RGC-AC) consists of a set of ganglion cells and their axons, shown in gray, located in a single 24-2 based retinal region. Local RGC-AC structural indices, can be calculated for its ganglion cell layer, which forms the RGC-AC origin (block outlined in bright green), where RGC-AC function is measured, for its patient-specific nerve fiber layer trajectory (adjoining regions in black) and for its terminal optic nerve head wedge shaped region (in dark green) – the last not in the present study. The RGC-AC has multiple segments: A ganglion cell body segment localized in the RGC layer; multiple NFB segments localized in the retinal NFL between the ganglion cell body and ONH in a patient-specific trajectory; and an ONH segment located in the neural rim of the ONH.

(a) (b) (c)

Figure 2. Multi-field alignment. a) 9 SLO fields imaged consecutively, corresponding OCT volumes not shown. b) Mosaic of SLO image covering the nine retinal subfields mutually registered from the 9 single field images. c) Corresponding wide-field composite OCT image (en-face projection shown).
Figure 11. Mean (std) values for all predicted thresholds across the studied population stratified according to glaucoma severity (rows). First column, predicted population average 24-2 VF threshold (dB) of each sector shown in retinotopic orientation, i.e. inferior hemifield thresholds are superior in this figure. Second and third columns are grayscale maps of the predicted and measured population average of each sector's VF threshold oriented according to the clinical standard, i.e. inferior hemifield thresholds are inferior in the figure. The labels S, I, T and N denote superior, inferior, temporal and nasal retina, respectively.
Figure 12. Visual fields presented as simulated HFA II printouts for each of the 122 subjects used in the study. Each pair displays the actual perimetry measured thresholds (left) and the predicted visual field thresholds for that eye. The pairs are sorted column-wise (top-to-bottom, left-to-right) by the decreasing mean deviation and stratified (top-bottom) by early, moderate and advanced glaucoma. The fields of the subject illustrated in Figure 7 are outlined.
HFA – Structure Driven Functional Testing

Structured-derived VFs may **reduce test times up to 30% in glaucoma eyes**

AI may enable estimation of VFs from Structural Data (e.g. OCT, OCTA)

Use AI to estimate VF inputs (Prior)

Accelerated VF Exam
Thank You