Solving the Glaucoma Puzzle: the role of modern diagnostic tools

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1

Financial Disclosures- Ibach

Disclosure Statement:
Alcon – consultant/speaker
Allergan – consultant
Bausch Health- consultant/speaker
Dompe – consultant/speaker
Equinox/Balance Ophthalmics – consultant/shareholder
Glaukos - consultant/speaker
iCare -- consultant
NewWorld Medical – consultant
Sight Sciences – consultant/speaker
Sun – consultant
Tarsus pharmaceuticals -- consultant
Thea – consultant
Viatris – consultant/speaker
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All relevant relationships have been mitigated

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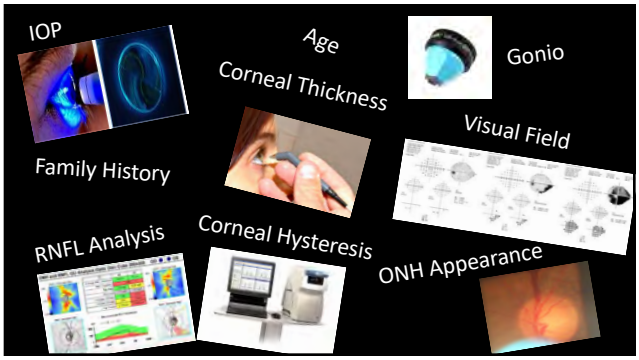

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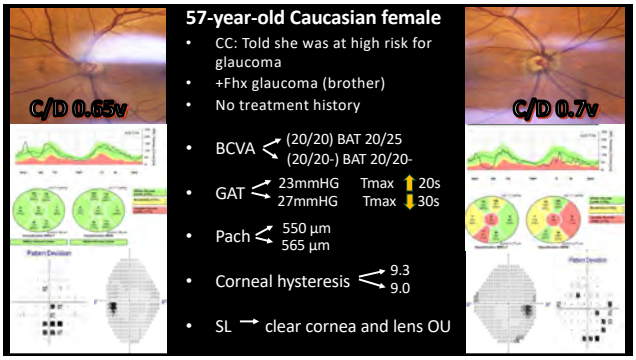
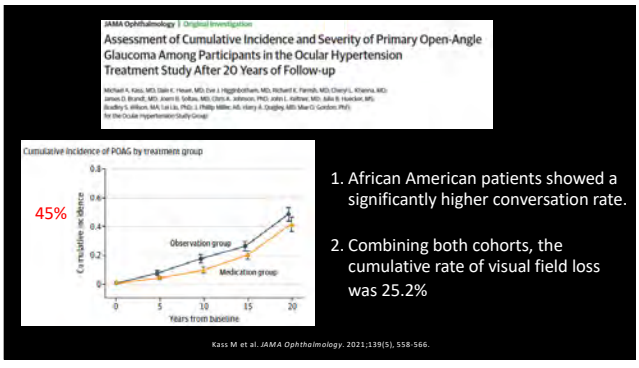


57-year-old Caucasian female

- CC: Told she was at high risk for glaucoma
- +Fhx glaucoma (brother)
- No treatment history
- BCVA (20/20) BAT 20/25 (20/20-) BAT 20/20-
- GAT 23mmHG Tmax ↑ 20s 27mmHG Tmax ↓ 30s
- Pach 550 µm 565 µm
- Corneal hysteresis 9.3 9.0
- SL → clear cornea and lens OU

4



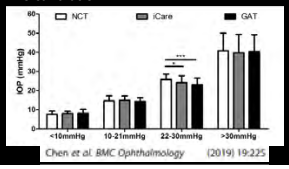
1. African American patients showed a significantly higher conversation rate.
2. Combining both cohorts, the cumulative rate of visual field loss was 25.2%

Kass M et al. *JAMA Ophthalmology*. 2021;139(5), 558-566.

5

Rebound Tonometry

- iCare
  - No anesthesia required
  - Compares well with GAT over a range of IOPs
  - Disposable probes
  - No calibration



Chen et al. BMC Ophthalmology (2019) 19:225

6

Tono-Vera® Tonometer

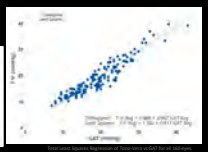
- Tono-Vera is the newest handheld tonometer used by eyecare professionals: Opticians, Optometrists, Ophthalmologists and eyecare technicians
- Utilizes rebound technology
- ActiView™ Positioning System: ***quickly*** guides user to the apex of the cornea, providing ***confidence*** in IOP readings
- Automatically measures when aligned, providing a more objective and repeatable result in as few as **three measurements**

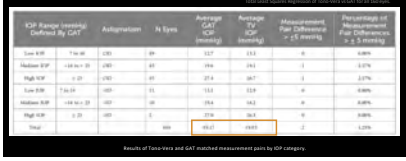
7

Clinical Study: Tono-Vera® Tonometer VS GAT

RECEIVED 30 May 2024
ACCEPTED 17 July 2024
PUBLISHED 16 August 2024

Evaluation of agreement of IOP measurements by Tono-Vera tonometer to Goldmann applanation tonometry





Results of Tono-Vera and GAT matched measurement pairs by IOP category.

RESULTS

- *Average IOP values from Goldmann Applanation and Tono-Vera were not significantly different (19.17 and 19.03 respectively, p=0.40, paired t-test).*
- *The total least squares regression analysis indicated strong agreement between the two tonometers (slope +0.97, offset +0.49 mmHg, standard deviation 2.11 mmHg).*
- *There were 2 IOP measurement pairs that exceeded the ± 5 mmHg limits of agreement required in ANSI Z80.10-2014 and ISO 8612-2009, which is within the range of acceptability specified in the standards.*

CONCLUSION

- *We evaluated IOP measurements by Tono-Vera Rebound Tonometer vs Goldmann Applanation Tonometry for eyes with a wide range of IOP values and found no statistically significant differences in the results.*
- *Tono-Vera meets the requirements of ANSI Z80.10-2014 and ISO 8612-2009, demonstrating accuracy comparable to Goldmann tonometry*

8

Reducing the Corneal effect on Measured IOP

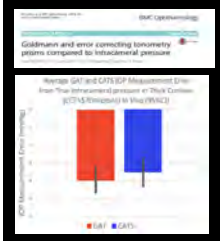
ORA's Patented IOPcc

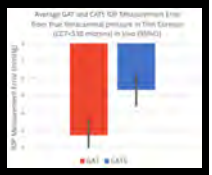
IOP and cornea
You can't measure two things with one number!

- ***How can we overcome the corneal influences?***
  - ***CATS***
  - ***ORA/IOPcc***

9

The Correcting Applanation Tonometer Surface (CATS)



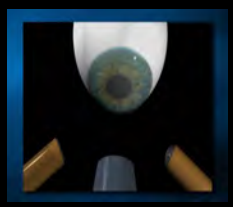


- Modified Goldmann prism with concave applanation surface
- Corrects for corneal biomechanics
- Clicks into slit lamp housing

McCafferty S. et al. *BMC Ophthalmology.* 2018;18:2

10

Hysteresis Matters in This Case



(Low) corneal hysteresis has been consistently shown to be independently and strongly associated with or predictive of glaucoma progression

11

Corneal Hysteresis and Glaucoma in Suspects

287 eyes → 54 (19%) developed repeatable visual field defects

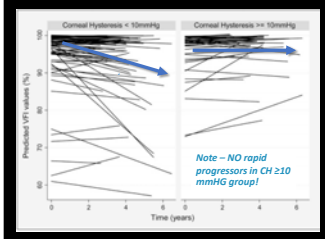
Glaucoma vs no glaucoma
9.5 +/- 1.5 vs 10.2 +/- 2.0 mmHg

Conclusion: Baseline lower CH measurements were significantly associated with increased risk of developing glaucomatous visual field defects over time. The prospective longitudinal design of this study supports a role of CH as a risk factor for developing glaucoma.

Susanna CN et al. *American Journal of Ophthalmology.* 2018

12

CH as a Predictor of Progression



114 POAG eyes followed at 6 month intervals for 4 years.

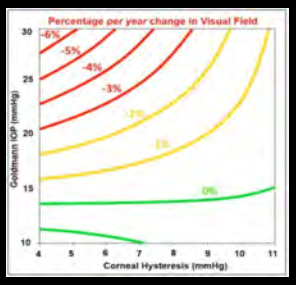
CH was 2x more predictive of VF progression than GAT and 3X more predictive than CCT

The prospective longitudinal design of this study supports the role of CH as an important factor to be considered in the assessment of risk for glaucoma progression

Medeiros FA et al. *Ophthalmology.* 2013;120:1533-1540.

13

CH as a Predictor of Progression

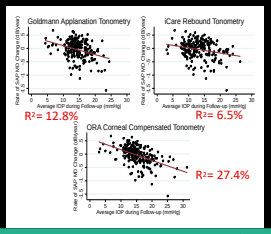


Medeiros FA et al. *Ophthalmology.* 2013;120:1533-1540.

14

Corneal Compensated IOP (IOP_{cc})

- IOP_g – correlates strongly to Goldmann IOP
- IOP_{cc} – Corneal compensated IOP
  - IOP less influenced by corneal properties (meant to disagree with GAT)
  - Not related to CCT
  - Minimally influenced by corneal refractive surgery



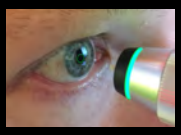
IOPcc had the strongest association with rates of visual field loss vs GAT and RBT

CCT, central corneal thickness. GAT, Goldmann applanation tonometer. RBT, rebound tonometry
Susanna B et al. Presented at American Glaucoma Society meeting

16

Home IOP Monitoring

A device is intended as an adjunct for monitoring IOP of adult patients (self-use). The tonometer is designed for use at home or on the go.



17

Patient JH

Tmax: 45 OD, 50 OS

Corneal hysteresis:
OD: 9.1 OS: 9.3
+FHx- mom, brother

Gonio ciliary body

48-year-old male
Chief complaint: "Don't let me go blind"

BCVA: 20/25 OD
20/30 OS

Noncompliant w Meds

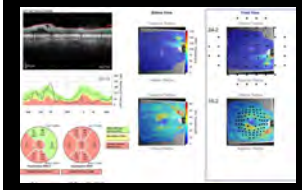
IOP: 13 OD; 15 OS

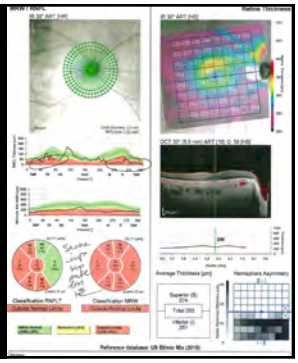
Pachymetry: 553 OD
535 OS

ONH Eval: 0.80/0.80 OD
0.75/0.75 OS

18

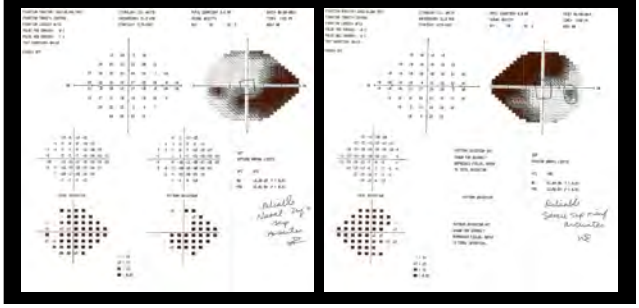
Optical Coherence Tomography (OCT)





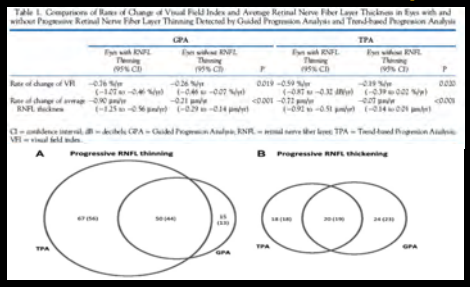
20

OS Visual Field OD



21

What We Do Know: OCT Helps!

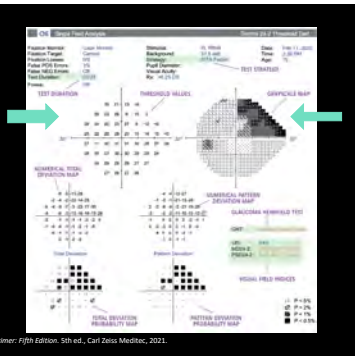


Marco Y et al. *Ophthalmology*. 2016;123(6), 1201-1210.

22

Analyzing a Threshold VF

1. Threshold values: measured decibel sensitivity at each point
2. Gray scale: Patient education map; darker areas equal less sensitivity

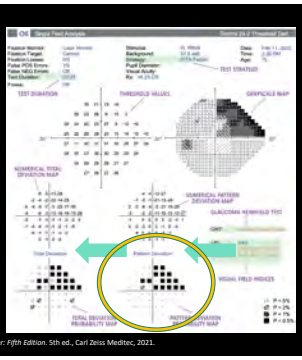


Marrelli D. *Review of Optometry*. 2021. Heiji, Anders, et al. *The Field Analyzer Primer: Fifth Edition*. 5th ed., Carl Zeiss Meditec, 2021.

23

Analyzing a Threshold VF

1. Total deviation: deviation from age-matched normal on each test point
2. Pattern deviation: deviation measured in decibels but removes distractors
3. Probability maps: TD and PSD→ plots statistical significance of missed points

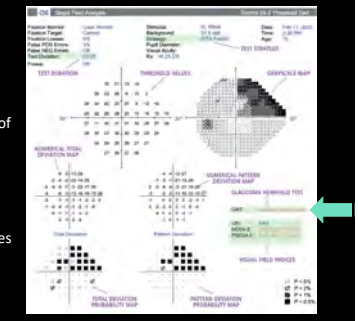


Marrelli D. *Review of Optometry*. 2021. Heiji, Anders, et al. *The Field Analyzer Primer: Fifth Edition*. 5th ed., Carl Zeiss Meditec, 2021.

24

Analyzing a Threshold VF

1. GHT: compares mirror image clusters of points above and below midline
2. MD-24: weighted average of values in TD plot
3. Visual Field Index (VFI): enhancement of MD with emphasis on central field
4. PSD-24: summarizes VF loss but ignores general depression

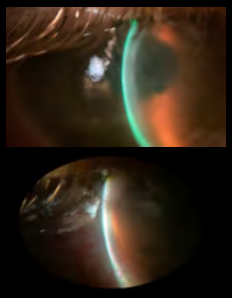


GHT, glaucoma hemifield test. MD, mean deviation. PSD, pattern standard deviation.
Marrelli D. *Review of Optometry*. 2021. Heiji, Anders, et al. *The Field Analyzer Primer: Fifth Edition*. 5th ed., Carl Zeiss Meditec, 2021.

25

Patient RM – Demographics and Entrance Testing

- 43-year-old male, uncontrolled IOP.
- Started on 1 drop, then a second, then a third. "Do I need a fourth?"
- GAT → 23, (3 months ago 39), Tmax 44
  → 22, (3 months ago 40), Tmax 50
- Meds: bimatoprost QD, brimonidine BID, dorzolamide BID – all OU
- PACH → 575
  → 568
- MRX → +2.25-0.25 x 33
  → +2.50 sph

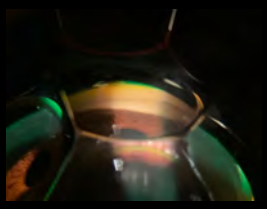


26

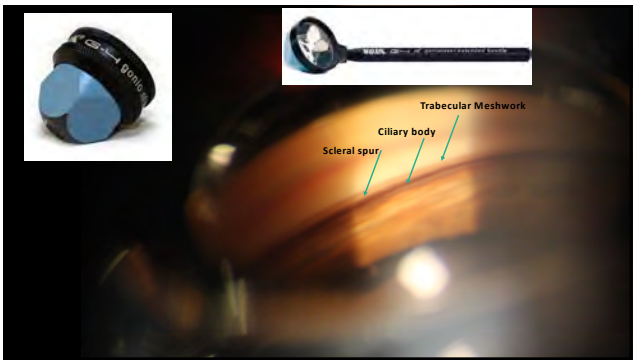
Next Step?

Which drop should we add?

Or should we do something else?



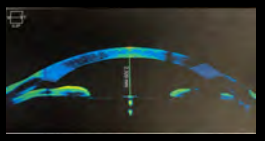
27



28

Anterior Segment OCT

Open



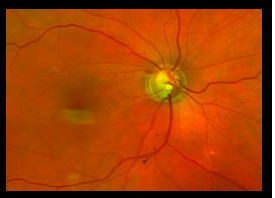
Narrow

Q-configuraton

29

Patient MW–Demographics and Entrance Testing

- 75-year-old female here LTG follow-up. OD worsening?
- GAT → 13, (6 months ago 14) Tmax 15
  → 9, (6 months ago 13, Tmax 17
- Meds: dorzolamide/timolol BID OU, bimatoprost QD OU
- PACH → 530
  → 520
- CH → 8.1
  → 9.3
- Gonio: open to scleral spur OU, mild pigment



C/D: 0.8v w/DH at 10:00

30

Is This Patient Progressing?

31

Corneal Hysteresis in Glaucoma

Association with Progression in Normal Tension Glaucoma (NTG)

Logistic regression with VF progression as a binary outcome (stepwise MV)	β (95% CI)	P-Value
Baseline VF MD (dB)	1.18 (0.96 to −1.44)	0.12
CCT (μm)	0.99 (0.97 to 1.01)	0.35
RNFL thickness (average)	0.96 (0.92 to 0.99)	0.04
RNFL thickness (temporal)	0.97 (0.94 to 1.01)	0.09
RNFL thickness (inferior)	0.98 (0.96 to 1.01)	0.13
Corneal Hysteresis (mmHg)	0.32 (0.17 to 0.62)	<0.01

- Of the **39 eyes with low CH, 26 (66.7%) showed progression** of VF damage while 13 (33.3%) showed no progression.
- Of the **43 eyes with high CH, 15 (34.9%) showed progression** of VF damage, whereas 28 (65.1%) showed no progression.

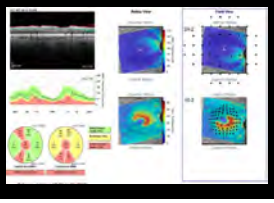
These findings suggest that CH can be used as one of the prognostic factors for progression, independent of corneal thickness or IOP

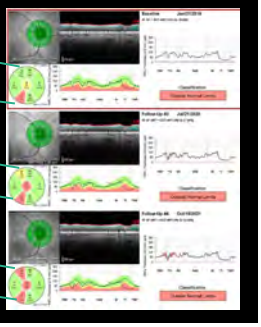
MV Multi-Variate; CCT Central Corneal Thickness; RNFL Retinal Nerve Fiber Layer; VF MD Visual Field Mean Deviation; CH Corneal Hysteresis, IOP Intraocular Pressure

Park Ev. Al Br J Ophthalmol. 2015 Jun 2. pii: bjophthalmol-2014-305962. doi: 10.1136/bjophthalmol-2014-305962.

32

OCT Progression





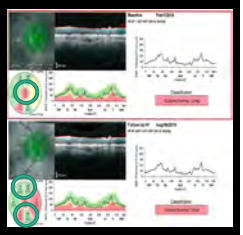
35

What Change Matters?

Average RNFL = ~ 4 microns

Superior/inferior RNFL = ~ 7 microns

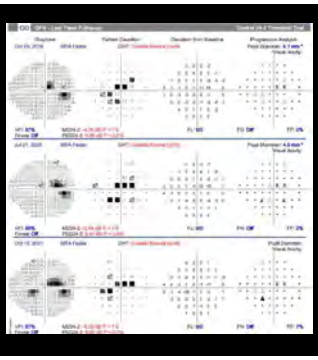
Macular ganglion cell layer-inner plexiform layer = ~ 4 microns



Mwanza JC et al. *Ophthalmology.* 2011;118(2):241-8.e1. Kim KE et al. *Invest Ophthalmol Vis Sci.* 2015;56(8):4857-4864

36

HFA Visual Field



PSD 4.96

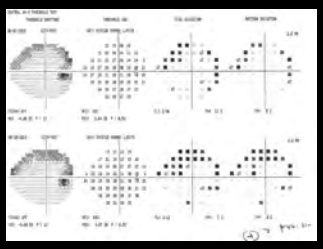
PSD 5.51

PSD 6.82

37

Manual Progression Analysis

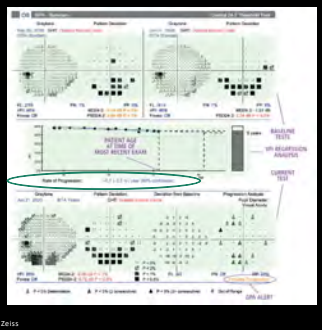
1. MD and PSD quantitative values
2. PSD Plot
3. **Compare to structure**



38

Guided Progression Analysis (Zeiss)

1. 3 tests needed to assess
2. Focus on glaucoma shifting from "Is there progression," to "What is the rate of progression?"



Heijl, Anders, et al. *The Field Analyzer Primer: Fifth Edition*. 5th ed., Carl Zeiss

39

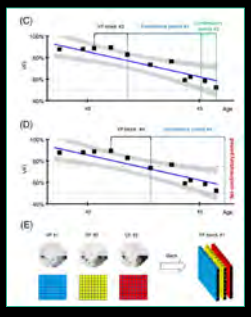
Can Artificial Intelligence Predict Glaucomatous Visual Field Progression? A Spatial–Ordinal Convolutional Neural Network Model

KILHWAN SHON, KYUNG RIM SUNG, AND JOONG WON SHIN

- The best-performing NN model had an AUROC of 0.864 with a sensitivity of 0.42 at a specificity of 0.95.
- In contrast, an AUROC of 0.611 was estimated from a sensitivity of 0.28 at a specificity of 0.84 for the PLR.

Conclusions:

- The NN models incorporating demonstrated significantly better performance than the linear models in the prediction of glaucomatous VF progression.



Am J Ophthalmol 2022;233: 124–134

40

Step #1 in Glaucoma is Diagnosis

41

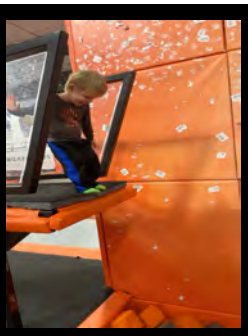
The Role of the Medically Minded OD/MD in Glaucoma

Diagnose Early 👀 → ⬇ IOP (treatment) → Monitor for progression → Save vision/ visual field 🤓

42

Let's Dive Into Questions

Mitch.ibach@vancethompsonvision.com



43

On behalf of Vision Expo, we sincerely thank you for being with us this year.

Vision Expo Has Gone Green!

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44