Glaucoma Management
Glaucoma Advances and Updates

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1

Disclosure

- Sanofi Speaker
- Innova System Consultant
- EyePromise Employee

The content and format of this course is presented without commercial bias and does not claim superiority and commercial products or service.
"All relevant financial relationships have been mitigated"

2

Glaucoma an epidemic/ endemic

- Glaucoma in USA more than **3 million**;
- Ocular hypertensive 4.5% of population >40 age
  - **Reaches 8% in people aged ≥ 80 yr**
- Glaucoma suspects 4 times more than glaucoma
- worldwide 76 million 2020 ; 111.8 by 2040

3

Diagnosis

- 50% undiagnosed
- Over diagnosed in clinics
- How can it be both?

4

Intraocular pressure

- Diagnosis- not helpful
- Treatment- only proven method
- Progression- very closely associated with IOP
- Risk factor- without a doubt most important risk factor
- In fact, the only alterable risk factor!

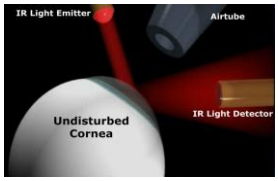
5

Ocular Response

- IOPG - Goldmann Correlated IOP
- IOPCC - Corneal Compensated IOP
- CH - Corneal Hysteresis

6

Ocular response analyzer



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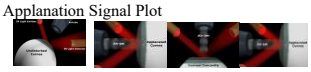
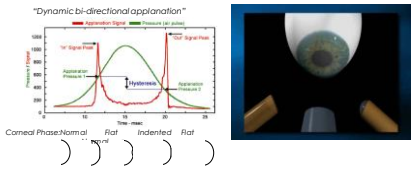
Applanation Signal Plot





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Corneal hysteresis

Corneal hysteresis (an assessment of the cornea's ability to absorb and dissipate energy) was significantly associated with the rate of VF loss in a cohort of glaucoma patients over time. Eyes with lower baseline hysteresis tended to progress significantly faster than those with higher hysteresis values.[94] (Evidence Grade: B) Assessment of corneal biomechanical properties supports corneal hysteresis as a glaucoma progression risk factor.[95] (Evidence Grade: B)[96] (Evidence Grade: B)

94. Medeiros FA, Freitas D, Lisboa R, et al. Corneal hysteresis as a risk factor for glaucoma progression: a prospective longitudinal study. *Ophthalmology* 2013;120(8):1533-40. doi: 10.1016/j.ophtha.2013.01.032
95. Susanna BN, Ogata NG, Jammal AA, et al. Corneal biomechanics and visual field progression in eyes with seemingly well-controlled intraocular pressure. *Ophthalmology* 2019;126(12):1640-46. doi: 10.1016/j.ophtha.2019.07.023
96. Estrela T, Jammal AA, Mariottoni EB, et al. The relationship between asymmetries of corneal properties and rates of visual field progression in glaucoma patients. *J Glaucoma* 2020;29(10):872-77. doi: 10.1097/IJG.0000000000001625

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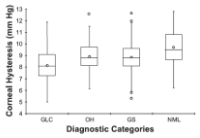
Practical issues

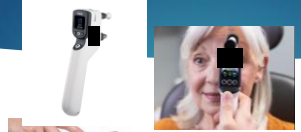


Ocular Response Analyzer in Subjects with and without Glaucoma

10

Rebound tonometers

11



12

A Comparative Study of the Hand-held IC200 and Slit Lamp-mounted ST500 rebound tonometers with Goldmann Applanation Tonometry

- 156 participants
- Age 45-72 years
- Average CCT 553 microns
- IOP range GAT 8.5-53 mmHg
- Median IOP 17.1

Excellent intraclass correlations

Conclusions: The ST500 shows good agreement with GAT over a large range of IOP and significantly higher repeatability compared to the IC200 and GAT, suggesting it may be advantageous in clinical settings where topical anesthesia or skilled staff are unavailable.

13

Agreement between the Icare HOME tonometer and the Goldmann Applanation Tonometry in the assessment of the Peak Intraocular Pressure in the Water-Drinking Test

Results: The agreement between iCare and Goldmann Applanation Tonometer was high during the WDT: the intraclass correlation coefficient (r) between the two methods from basal to 45 min: 0.94 (p < 0.001), at basal: 0.91 (p < 0.001), at 15 min: 0.94 (p < 0.001), at 30 min: 0.94 (p < 0.001), at 45 min: 0.95 (p < 0.001) and for peak IOP: 0.94 (p < 0.001). There was no significant difference between peak IOP with GAT and iCare 18.3 ± 4.6 (10-33) and 18.5 ± 5.0 (0-33) (p = 0.533), nor between the delta of fluctuation between basal and peak IOP with GAT and iCare 3.96 ± 3.22 and 4.54 ± 3.92 (p = 0.054).

Conclusion: Our study demonstrated a high agreement between iCare HOME and Goldmann Applanation Tonometer during the WDT in a clinical environment with supervision.

14

Rebound tonometer

- When to use?- Screenings
- Why?
- When not to use? Glaucoma patients except for childhood glaucoma
- Concerns ?
  - Can't be used when wearing contact lenses

15

Disposable tips- Goldmann tonometer

- 10% Bleach soak 5-minutes and wash with water and let dry…effective against most microbes
- No disinfectant technique works against prions.

16

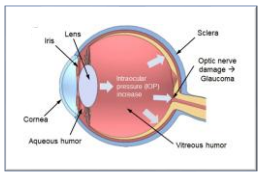
Disposable CATS tonometer probe FDA approved

17

Intraocular Pressure (IOP)
Target Ranges
Staging of disease

18

Intraocular pressure



Overview[a,b]

- Imbalance between production and drainage of aqueous humor
- IOP > 21 mm Hg is considered elevated
  - Most important known risk factor for OH and POAG
- All current treatments target IOP levels
- Patients with POAG should be offered lifelong control of IOP
  - Require monitoring of optic nerve appearance and visual function

a. Tapply I, et al. Patient Prefer Adher. 2021;15:1477-1489; b. Pereira ICF, et al. Eye. 2021;35:3202-3221.
Image by Kim Y, et al. Scientific Reports. 2019;9:15235.

19

Criteria for glaucomatous damage

1) GHT outside normal limits

2) PSD < 5% of normal individuals

3) A cluster of three or more **non-edge** points (pattern deviation plot) all of which are depressed at a p<5% and one of which is depressed at a p<1% on two occasions (respecting horizontal meridian)

- This criterion was written for 30-2, if 24-2 field is analyzed edge points are included.
- Criteria should be met on 2/3 issues mentioned above
- Confirmed on two occasions!

20

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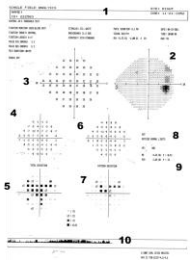


21

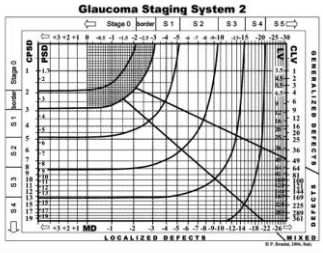
Staging based on MD

- Better than-6 db- Mild
- Worse than -6.0 dB but better than -12 dB – Moderate
- Worse than -12.0 dB severe

22

22

Glaucoma Staging System 2



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23

Staging POAG

Stage/Severity	Symptoms/Signs
1 – Suspected	✓ IOP ≥ 22 mm Hg ✓ Asymmetry of vertical C/D ratio (> 0.2 between the 2 eyes) ✓ Suspect appearance of the optic disc ✓ Suspected central-field defect
2 – Mild (early)	✓ Slight glaucomatous changes in the cup (C/D ratio ≤ 0.65 for an optic nerve of average diameter) ✓ Slight visual-field defect outside the central 10°
3 – Moderate	✓ Moderate glaucomatous changes in the cup (C/D ratio 0.7-0.85) ✓ Moderate visual-field defect outside the central 10°
4 – Advanced	✓ Significant glaucomatous changes in the cup (C/D ratio ≥ 0.9) ✓ Visual-field defect within the central 10°

C/D, cup/disc
Fontaine N, et al. Semantic Scholar. Published 2013. Accessed June 6, 2023.

24

IOP Target Ranges

	Glaucoma Severity		
	Mild	Moderate	Advanced
Target range	High teens	Mid teens	Low teens
Acceptable fluctuation	< 5 mm Hg	< 4 mm Hg	< 3 mm Hg*

*Least fluctuation tolerance

Asrani S. Rev Ophthalmol. Published 2016. Accessed May 15, 2023.

25

Management of OHT and OAG

26

The Scoring Tool for Assessing Risk (S.T.A.R. II) calculator FOR Ocular Hypertensive

Probability of conversion in 5- years
<5% observe and monitor
5 to 15% consider treatment
>15% treat

- OHTs and EGPS data
- Intended for use only in untreated OHT patients
- Age (30-80)
- IOP 20-32 mmHg
- CCT 475 to 650 microns
- PSD 0.50 to 3.00 dB
- C/D ratio vertical 0.00 to 0.8

https://ohts.wustl.edu/risk/

27

- Early medical treatment should be considered for individuals with ocular hypertension (OH) who are at moderate or high risk of developing primary open-angle glaucoma (POAG).[10,11,73] *(Evidence Grade: A, Strong Recommendation)*

28

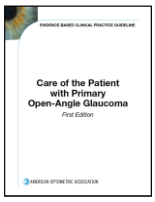
Visual fields and early glaucoma

- True variability
- Lower Repeatability on testing
- Learning curve

29

Open-angle glaucoma and ocular hypertension

- Primary open-angle glaucoma
- Normal tension glaucoma'
- Ocular hypertension

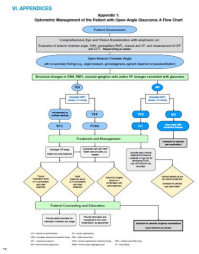


30

Evaluation and Examination

- The examination of a person suspected of having primary open-angle glaucoma (POAG) should include all aspects of a comprehensive eye and vision examination, with emphasis on the evaluation of the anterior chamber angle, optic nerve head (ONH), peripapillary retinal nerve fiber layer (RNFL), macula and visual fields (VF), and measurement of intraocular pressure (IOP) and central corneal thickness (CCT).[71,77,178,185,188,237] *(Evidence Grade: B, Recommendation)*
- Eye doctors should be persistent in providing education and training to patients with primary open-angle glaucoma (POAG) to improve adherence/compliance with recommended therapy.[416-418,424,425,431,432,451-453] *(Evidence Grade: B, Recommendation)*

31



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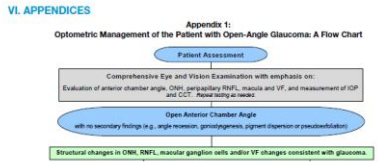

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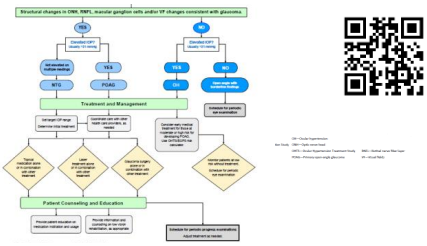


34

Disc hemorrhages

35

Disc hemorrhage

- Location- Infero temporal followed by superior temporal regions
- Does not mean glaucoma always
- Is not the only location of damage
- More likely to progress to POAG
- POAG progression is greater in eyes with DH

36

Disc hemorrhages

- RNFL changes – Wedge shaped defects
- Associated notching of rim
- Vertical elongation of cupping after an episode

37

Disc Hemorrhages Are Associated With Localized Three-Dimensional Neuroretinal Rim Thickness Progression in Open-Angle Glaucoma

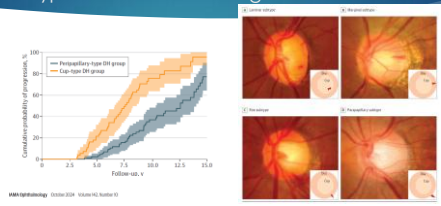
MILICA A. MARGETA, KITIYA RATANAWONGPHAIBUL, EDEM TSIKATA, MICHELE ZEMPLENYI, COURTNEY L. ONDECK, JANICE KIM, ANNE L. COLEMAN, FEI YU, JOHANNES F. DE BOER, AND TERESA C. CHEN

124 OAG patients
5 year follow-up
19 showed hemorrhage (15.3%)

• CONCLUSIONS: Glaucoma progression detected by high-density 3D SD-OCT neuroretinal rim measurements preceded DH occurrence in the majority of patients. These findings support the hypothesis that DHs are indicators of ongoing glaucoma progression rather than discrete events that cause subsequent progression. (Am J Ophthalmol 2022;234: 188–198. © 2021 The Author(s). Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/))

38

Types of disc hemorrhages



39

Cornea , Disc and Visual fields in Normal tension glaucoma

40

Can IOP be underestimated in NTG?

- Yes, absolutely
- CCT is lower in NTG patients compared to POAG or OHT
- POAG vs NTG – 21 cut off
- An NTG patient can have lower than 21 pressure, borderline pressure and IOP > 21 with
  - ORA, DCT, 7CR, CORVIS ST (CCT independent measures)

41

Corneal Stiffness and Modulus of Normal-Tension Glaucoma in Chinese

YUNZHI XU, YIMING YE, ZIDONG CHEN, JIANGANG XU, YANGFAN YANG, YANMEI FAN, PINGPING LIU, IOK TONG CHONG, KEMING YU, DAVID C. C. LAM, AND MINBIN YU

• CONCLUSIONS: The corneas of NTG patients were softer than those of HTG patients and controls, as assessed by CID, which were associated with thinner CCT. These might suggest different ocular biomechanical properties in NTG and HTG. (NOTE: Publication of this article is sponsoredby the American Ophthalmological Society. Am J Ophthalmol 2022;242: 131–138. © 2022 The Authors. Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/))

42

VF loss in NTG

- Progression of NTG tends to be slow
- Some people reported differences in location of defects of visual field.
- VF defects focal, deeper and central (closer to fixation)

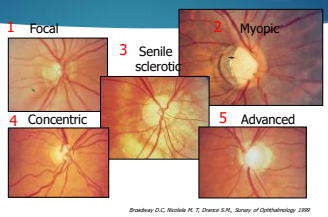
43

VF loss in NTG -2

- A dense paracentral scotoma encroaching on fixation is not an unusual finding as the initial defect
- The findings of visual field differences is supported by some researchers where as others failed to confirm them

44

Glaucomatous Disc Classifications



Broadway D.C, Nicolela M. T, Drance S.M, Survey of Ophthalmology 1999

45

Optic disc and NTG

- NTG patients have a thinner rim inferiorly and inferiotemporally when compared to other glaucoma with similar total VF loss

46

Optic disc appearance-NTG

- Senile sclerotic group
  - Shallow, sloping of NRR
- Focal ischemic
  - Deep focal polar notching in the neuroretinal rim
  - Shallow saucerlized cupping
  - Senile sclerotic nerve
  - Commonly found hemorrhage- locations
  - Proximal constriction of retinal arteriole
  - Importance of large peri-papillary atrophy and its blood flow associations
  - Loss of superficial capillaries and delayed filling of the nerve head

47

48

Differential diagnosis

- Diurnal IOP is a useful in determining the peak IOP
- Also useful in establishing target IOP
- CCT and IOP issue

49

Microvasculature Dropout and Development of Normal Tension Glaucoma in Glaucoma Suspects: The Normal Tension Glaucoma Suspect Cohort Study

YOUNSHIA JUNG, HAE-YOUNG LOPILLY PARK, HEEJONG SHIN, SI EUN OH, SEONG AH KIM, JI-YOUNG LEE, DA YOUNG SHIN, SOO JI JEON, YONG-CHAN KIM, HYE-YOUNG SHIN, JIN A. CHOI, NA YOUNG LEE, AND CHAN KEE PARK

• CONCLUSIONS: NTG suspects with baseline MvD or a lower laminar deep VD on OCT-A had a higher risk of conversion. (Am J Ophthalmol 2022;243: 135–148.

50

Vascular parameters and endothelin-1 measurements in glaucoma patients with low- and high-tension optic disc hemorrhages

Izabela N. F. Almeida[1], Elise Taniguchi[2], Cecília Victoria Agapito Tito[1], Diego Torres Díaz[1,3], Michele Ushida[1], Syril Dorairaj[4], Robert Ritch[5], Sérgio H. Teixeira[2], Augusto Paranhos Jr[2], Carolina P. B. Gracitelli[1,6], Cristiane Kayser[1] & Tiago Santos Prata[1,5,6,7]

Patients developing DH and had low IOP (<16) have higher endothelin -1 and more peripheral vascular dysfunction

Compared to DH in higher IOP

51

Myopia-Glaucoma-OCT

52

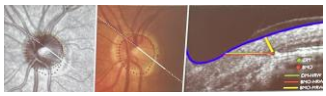
Stats and why should it be concerning

- 2050 – 5 billion people will have myopia (half the worlds population)
- About 1/3 will have high myopia ≥ -6D

53

Issues with myopia and OCT

Clinical Disc versus disc margin identified by Bruchs membrane openining



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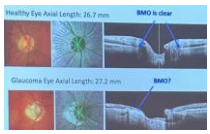
BMO is not clear in all patients



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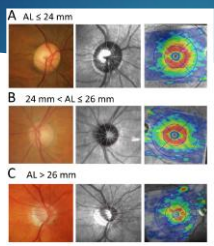


Macula structural and vascular differences in glaucoma eyes with and without high axial myopia

56

Can OCT values be trusted in myopia?

- Axial length is not adjusted? Magnification is off so away from true value
- The disc analysis is off given the tilted appearance and myopic type stretched disc
- Bruchs membrane opening is displaced
  - Thus clinically what is considered as a an edge of disc is not the same
- Nerve fiber layer may be utilized
- Macula may be more sensitive to changes
- But macula can also be pathological !
- Visual field defects also seen in myopic eyes!
- Management of glaucoma in high myopes is a tough situation.

57

Blood pressure and Glaucoma

58

Independent risk factors

- Low Diastolic blood pressure
- Low Mean Ocular Perfusion Pressure
- Low Diastolic Perfusion Pressure

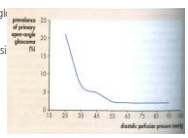
- Measure Blood pressure after 5 minutes being seated
- Measure BP twice, 5 minutes apart
- If SBP was 10 mmHg or DBP was 5mmHg different measure 3rd time
- Average two measurements that are the closest.

Zheng et al. IOVS 2010

59

Systemic hypertension and glaucoma

- Blood pressure and pathogenesis of gl
  - Hospital based study
- Baltimore Eye Survey examined perfusi
- Diastolic perfusion pressure= DBP-IOP



Tielsch et al Hypertension perfusion pressure and primary open angle glaucoma Arch ophthalmol 1995

60

Mean Ocular perfusion pressure-

- MOPP = 2/3 [DBP + 1/3(SBP – DBP)] – IOP.

Blood pressure

IOP	120/80	120/70	120/60	110/70	110/60	100/60
22	40.2	35.7	31.3	33.5	29.1	26.8
24	38.2	33.7	29.3	31.5	27.1	24.8
26	36.2	31.7	27.3	29.5	25.1	22.8
28	34.2	29.7	25.3	27.5	23.1	20.8

61

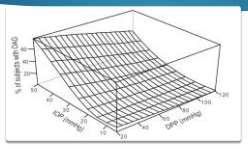
Mean Ocular perfusion pressure-

- MOPP = 2/3 [DBP + 1/3(SBP – DBP)] – IOP.

Blood pressure

IOP	120/80	120/70	120/60	110/70	110/60	100/60
18	44.2	39.7	35.3	37.3	33.3	30.8
16	46.2	41.7	37.3	39.3	35.3	32.8
14	48.2	43.7	39.3	41.3	37.3	34.8
12	50.2	45.7	41.3	43.3	39.3	36.8

62



Perfusion pressure and IOP

Zheng et al. IOVS 2010

63

Summary perfusion pressure

Greater the IOP lower the blood flow

Elevated IOP with Lower blood pressure – Bad combination

In terms of Perfusion pressure

Low IOP (12 mmHg) but with lower BP (100/60) = Elevated IOP(26 mmHg) at "normal BP" 120/80

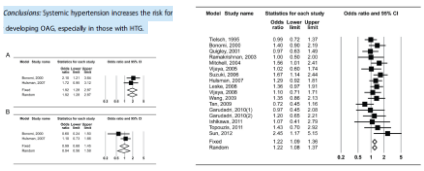
Clinical tip: Measure BP and Pulse rate on all glaucoma patients
Particularly in suspects that IOP is not high, but nerves appear suspicious

64

Systemic Hypertension as a Risk Factor for Open-Angle Glaucoma: A Meta-Analysis of Population-Based Studies

Hyoung Won Bae[1], Naeun Lee[1,2], Hye Sun Lee[3], Samin Hong[1], Gong Je Seong[1], Chan Yun Kim[1,*]

Conclusions: Systemic hypertension increases the risk for developing OAG, especially in those with HTG.



65

Hypertension/hypotension

Systemic hypertension increases the risk for developing POAG.[92] Low nocturnal blood pressure (BP), especially more than 10 mmHg below daytime mean arterial pressure, is predictive of progression of VF defects in NTG.[93] (Evidence Grade: B)

66

Advances in perimetry

67

Opportunities for Improvement in Central 10 Degrees

Glaucomatous damage of the macula

Donald C. Hood, Ali S. Raza, Carlos Gustavo V. de Moraes, Jeffrey M. Liebmann and Robert Ritch

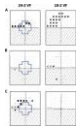
- glaucomatous damage of the macula is common and can occur early in the disease
- can be missed and/or underestimated with standard 24-2 VF tests that use a 6°grid

The Prevalence and Nature of Early Glaucomatous Defects in the Central 10° of the Visual Field

Irena Turpin, Carlos G. De Moraes, Ali S. Raza, Jeffrey M. Liebmann, Robert Ritch, Donald C. Hood

24-2 and 10-2 VF Examples

Blue cross region on the 24-2 VF = central 10-2 VF.
(A)Both are abnormal.
(B)24-2 VF normal; 10-2 VF abnormal
(C)24-2 VF abnormal; 10-2 VF normal



68

Highest Importance Locations Chosen from 10-2 Pattern

Selecting additional test locations to enhance the 24-2 pattern using a scoring system

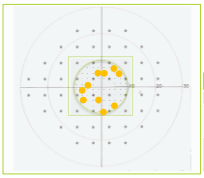
- Expert group selected specific 10-2 test point locations
- Prevalence and depth of glaucomatous macular defects were systematically evaluated to select optimum test points
- Pattern covers areas known to be susceptible to glaucomatous defects both from structural and functional studies

Selected test locations are shown in red boxes

The expert group: Donald C. Hood, Stuart K. Gardiner, Allison M. McKendrick and William H. Swanson.

69

Resulting SITA Faster 24-2C Pattern on HFA3



The 24-2C test pattern combines all 24-2 points + ten selected 10-2 points (shown in OD orientation)

Large Gray	24-2 pattern
Large Orange	Ten additional 24-2C points
Small Gray	10-2 pattern

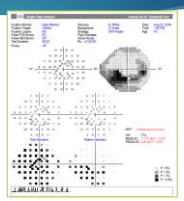
70

Minimize Time and Maximize Information in VF Testing with HFA3

SITA Faster 24-2
- test in 2 minutes or less
- ~50% faster than SITA Standard; ~30% faster than SITA Fast

SITA Faster 24-2C
- more information in central field
- ~20% faster than SITA Fast 24-2

Add new tests to patient progression
- Mixed SITA GPA
- Includes SITA Faster, Fast, Standard, 24-2, 30-2, and 24-2C in progression analysis

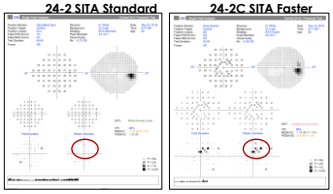


71

24-2C SITA Faster

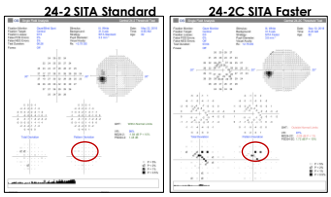
Flagged points detected centrally in OD

24-2 SITA Standard | 24-2C SITA Faster



72

24-2C SITA Faster
Flagged points detected centrally in OS



73

Thresholding requires time

- 62 points in 3 minutes or so.
- Is SITA Faster too fast?
- Can it threshold reliably ?

74

New 24-2C SITA Faster protocol

- Free upgrade if you have HFA III
- Gives more macula points.
- Results comparable to 24-2 SITA FAST
- Thresholds are ± 3 dB
- Gives you some macula information
- You need 10-2 if damage is noticed in macula region

75

Virtual reality perimetry- Are you ready for prime time?

76

Poll

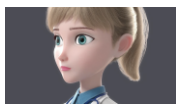
Do you believe the virtual reality perimeter is the wave of the future?

a) Yes, that will be ideal, given the flexibility.
b) No, that is just a fad.
c) Definitely, if it can do more than just fields.
d) Depends on if I can sell my current device

77

VisuALL

- VisuALL is a Virtual Reality Platform (VRP) that is cloud enabled to monitor the eye function
- VisuALL S: Enhanced version for eyecare professionals
- VisuALL H: Simplified model for Home



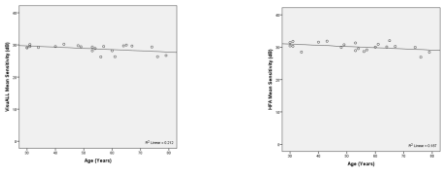
78

ORIGINAL STUDY

Preliminary Report on a Novel Virtual Reality Perimeter Compared With Standard Automated Perimetry

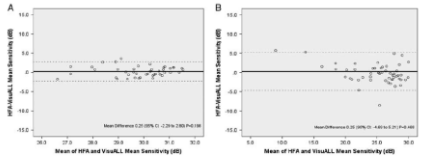
Reza Razeghinejad, MD, Alberto Gonzalez-Garcia, MD,† Jonathan S. Myers, MD,* and L. Jay Katz, MD**

(*J Glaucoma* 2021;30:17–23)



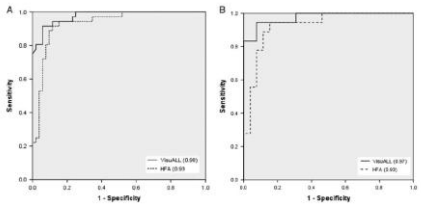
79

Comparison to HFA

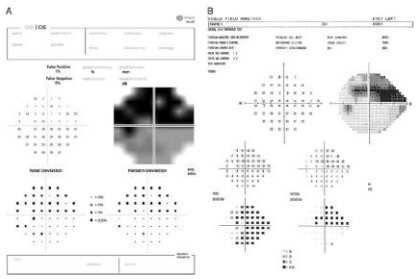


80

Sensitivity, specificity and ROC- Accurate diagnosis



81



82

VisuALL Tests/Protocols

- Perimetry
  - 24-2 Adults & Pediatrics
  - 10-2 Adults & Pediatrics
  - Supra-threshold Adults & Pediatrics
  - Other
- Visual Acuity Test
  - Landolt C Near
  - Landolt C 20'
- Color Vision Test
  - Isochromatic
  - D-15

83

The RadiusXR Platform Components

84

Multi-Center Clinical Trial: NOVA

STUDY DESIGN

Each participant performed four 24-2 VF tests, two with HFA and two with Radius

Order was randomized: HRHR or RHRH; only one eye tested per participant

Two key objectives:

1. Compare estimated sensitivities of RATA-Standard to SITA-Standard for the 24-2
2. Measure concordance in glaucoma staging using Medicare definitions

Conclusion: Estimated sensitivities of RATA-Standard are comparable to SITA-Standard between 23 to 40 dB with high concordance in glaucoma staging

March 2024
Volume 13, Issue 3

ORIGINAL REPORT | Glaucoma | March 2024

Validation of a Wearable Virtual Reality Perimeter for Glaucoma Staging, The NOVA Trial: Novel Virtual Reality Field Assessment

Chris Bradley, Iqbal Ike K. Ahmed, Thomas W. Samuelson, Michael Chaglasian, Howard Barnebey, Nathan Radcliffe, Jason Bacharach

85

Multi-center Clinical Trial: NOVA

Novel Virtual Reality Field Assessment[1]

The NOVA Clinical Trial validates RadiusXR's advanced diagnostic accuracy and innovation in Visual Field Testing for Virtual Reality Perimetry.

The trial revealed remarkable findings, including statistical non-inferiority to current clinical standards for sensitivities at individual test locations, with high concordance in glaucoma staging using Medicare definitions.

[1]Chris Bradley, Iqbal Ike K. Ahmed, Thomas W. Samuelson, Michael Chaglasian, Howard Barnebey, Nathan Radcliffe, Jason Bacharach; Validation of a Wearable Virtual Reality Perimeter for Glaucoma Staging, The NOVA Trial: Novel Virtual Reality Field Assessment. Trans. Vis. Sci. Tech. 2024;13(3):39. https://doi.org/10.1167/tvst.13.3.10

Page 86

86

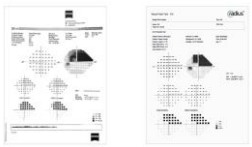
NOVA Clinical Trial

Clinically Validated, Reliable Results

The NOVA Clinical Trials results underscore the unparalleled accuracy and reliability of RadiusXR's approach to visual field testing for head-mounted virtual reality perimetry.

Read the Study:

https://tvst.arvojournals.org/article.aspx?articleid=2793455



Example output of SITA-Standard and RATA-Standard

Page 87

87

NOVA Clinical Trial

High Degree of Concordance in Glaucoma Staging using Medicare Definitions

A weighted kappa of 0.81 or above is widely considered almost perfect agreement. Radius results are 0.91 and 0.92 respectively

There were no statistically significant differences in sensitivities at ANY test point location.

Weighted kappa results:

0.91 0.92

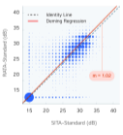
Confusion matrices (original staging data) for grader 1 and grader 2. Weighted kappa was 0.91 for grader 1 and 0.92 for grader 2.

Page 88

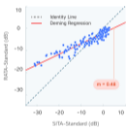
88

NOVA Clinical Trial

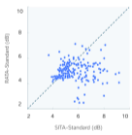
Proven Diagnostic Accuracy



A) Deming Regression
For statistical analysis between legacy fields and RadiusXR, set <15 dB legacy to 0 dB Radius



B) Mean Deviation



C) Test Duration

Page 89

89

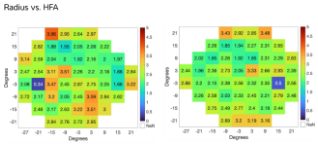
NOVA Clinical Trial

High Correlation in Mean Deviation

Out of 100 study participants, half were previously diagnosed with moderate or severe glaucoma, and the other half with mild or suspected.

Correlation in mean deviation (MD):

0.94



Mean absolute difference in dB at each test location for OS and OD (left and right columns), between RATA-Standard and SITA-Standard.

Page 90

90

How do I correlate structure and function ?

91

ARVO JOURNALS
From: The Structure and Function Relationship in Glaucoma: Implications for Detection of Progression and Measurement of Rates of Change
Invest. Ophthalmol. Vis. Sci.. 2012;53(11):6939-6946. doi:10.1167/iovs.12-10345

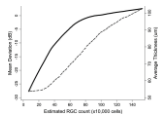
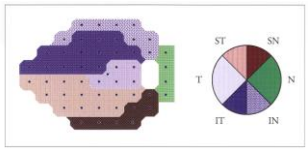


Figure Legend:

Relationship between MD, average RNFL thickness measurements, and estimated RGC counts. At early stages of damage (high RGC counts), changes in estimated RGC counts correspond to relatively smaller changes in MD (continuous line) and relatively larger changes in average RNFL thickness (dashed line). At advanced stages of damage (low RGC counts), changes in estimated RGC counts correspond to relatively large changes in MD, but only small changes in average RNFL thickness.

92

Structure function correlation



Perimetry Update 1998/1999, pp. 581–589

93

Narrow angle/acute attack/angle closure glaucoma

94

Risk factors Angle closure

- Race- Chinese Asians more common, Inuit population, higher prevalence compared to Caucasians
- Women- 70% cases; shallow chamber, smaller axial length compared to men
- Age-older individuals
- Hyperopia
- Smaller axial length
- Fellow eyes of an individual at risk
- First degree relatives of an angle closure patient

95

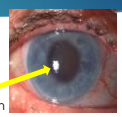
Precipitating factors

- Factors that produce dilation
  - Dim illumination
  - Emotional stress
  - Drugs
- Factors that produce miosis (rare)

96

Pupillary block

- Most common form of Primary angle closure
- Initiating event- increased resistance of to flow of aqueous humor at pupil and anterior surface of lens
- Forward bending of iris
- Closure of angle



97

Classification on clinical presentation

- Acute angle-closure/glaucoma
- Subacute angle-closure/glaucoma
- Chronic angle-closure/glaucoma
- Combined mechanism/glaucoma

98

Acute angle-closure

Symptoms
- Ocular pain
- Nausea and vomiting
- Blurred vision,
- Colored halos around lights
- Loss of vision

Signs
- Conjunctival and ciliary congestion,
- Corneal edema
- Shallow peripheral anterior chamber with cells and flare
- Intraocular pressure usually exceeds 40 mmHg

99

Gonioscopy- CPT 92020

A = Above Schwalbe line, totally occluded angle.
B = Behind the Schwalbe line, peripheral iris is in contact with TM.
C = Scleral spur Iris root at the level of scleral spur
D = Deep anterior ciliary body seen.
E = extremely deep

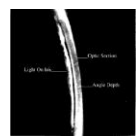
100

Angle Measurement with Quantification

Clinical tip: Angle 20 degree or less needs further evaluation

101

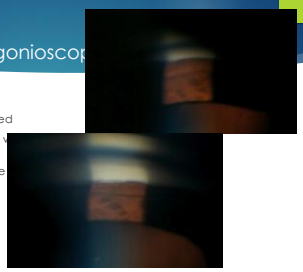
Van Herrick angle estimation



- 1:1 – Open angle, VH grade 4
- 1:1/2 – Open angle, VH grade 3
- 1:1/4 – Narrow angle, VH grade 2 (Angle Closure Possible)
- 1: <1/4 – Angle closure likely, VH grade 1

102

Indentation gonioscop



- Angle narrow
- Angle appears closed
- Angle structures not v
  in a quadrant
- Ruling out synechiae

103

Lowering IOP in office

104

Medical treatment- Goals

- Lower intraocular pressure
- Alleviate pain
- Clear cornea
- Prevent synechiae

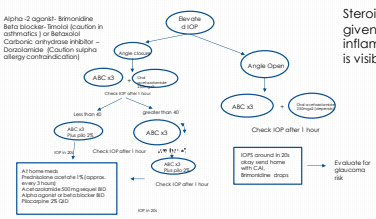
105

Intravenous medications

- Acetazolamide 500mg intravenous
- Intravenous Mannitol

- Best therapy however is not always available in clinics

106



Steroids are given is inflammation is visible

107

Take home medication

- Prednisolone acetate 1% q1-6 hours (approx every 3 hours)
- Acetazolamide 500 mg sequel BID
- Alpha agonist or beta blocker BID
- Pilocarpine 2% QID

108

Anti-VEGF and IOP

- Anti-vascular endothelial growth factor (VEGF) agents has dramatically changed the management of ocular diseases
- associated with macular edema, providing improved visual outcomes and a favorable safety profile
- ranibizumab, bevacizumab, pegaptanib and aflibercept and are commonly used in the treatment of diabetic macular edema, neovascular age-related macular degeneration and other pathologies characterized by retinal or choroidal neovascularization
- Less known fact there is a spike in IOP post injection typically returning to baseline in 1 hour
- Very rarely long-term spike in pressure 6-14.8%

109

Why is there an IOP spike with anti-VEGF?

- Volume of drug injected
- Associated factors repeated injections
- Prolonged treatments
- Mechanisms
  - Direct toxic effect of anti-VEGF on TM
  - Injury of TM from large volume
  - Inflammation secondary to anti-VEGF
  - Mechanical blockage of TM

110

Do we pretreat patient?

111

Why should we?

- RNFL defects after long term treatment and no glaucoma have been reported
- IOP does increase significantly after an injection

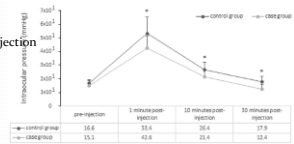
112

ORIGINAL PAPER

Prophylactic effect of brinzolamide–brimonidine fixed combination on intraocular pressure spikes after intravitreal anti-VEGF injections

Maria Dettoraki · Eloni Rapti · Dimitrios Fragkos · Ioannis Theopoulos · Anthi Legaki · Alexandra Gkounta · Despina Anyfantaki · Irini Riga

2 hour before injection



113

Can other medications be utilized?

- Apraclonidine 1%
- Brimonidine timolol fixed combination
- Dorzoalamide tomolol fixed combination

114

Current consensus

- None
- prophylactic use of hypotensive medications only in patients with glaucoma
- Some recommended their routine use in both glaucomatous and non-glaucomatous eyes
- Whereas others have proposed IOP checking in all patients and treating accordingly.
- Topical prophylactic treatment cannot prevent the immediate IOP rise

115

Does LPI prevent angle closure? ZAP trial

116

ZAP-trial

Laser peripheral iridotomy for the prevention of angle closure: a single-centre, randomised controlled trial

Zhongshan Angle Closure Prevention (ZAP) Trial

- 11,991 screened
- 889 enrolled
- 889 eyes treated fellow eye 889 not treated
- Primary outcome Angle closure by 72 months
- Incidence of angle closure
  - 4.19 per 1000 treated
  - 7.97 per 1000 untreated
- Small but significant protective effect of treatment
- Widespread prophylactic laser for angle closure suspects not recommended

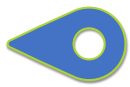
www.thelancet.com Vol 393 April 20, 2019

117

Effectiveness of early lens extraction for the treatment of primary angle-closure glaucoma (EAGLE): a randomised controlled trial

OA

EAGLE trial



www.thelancet.com Vol 388 October 1, 2016

118

EAGLE trial

Hypothesis tested –

- clear lens extraction after primary angle closure glaucoma
- leads to **better quality of life, lowering of IOP and less need for glaucoma surgery** than standard care
- Standard care – Laser iridotomy and medications

Interpretation Clear-lens extraction showed greater efficacy and was more cost-effective than laser peripheral iridotomy, and should be considered as an option for first-line treatment.

119

Selective laser trabeculopalsty

120

SLT and glaucoma

- Great first or second line option.
- Non-compliant individuals
- Individuals that fluctuation of IOP is a concern
- In theory can be repeated to lower IOP.
- Is the IOP lowering the same second attempt?

121

Primary Selective Laser Trabeculoplasty for Open-Angle Glaucoma and Ocular Hypertension

Clinical Outcomes, Predictors of Success, and Safety from the Laser in Glaucoma and Ocular Hypertension Trial

- A total of 611 eyes (195 OHT and 416 OAG) of 355 patients received SLT, and 622 eyes (185 OHT and 437 OAG) of 362 patients received topical medication at baseline.
- At 36 months, 536 eyes (87.7% of 611 eyes) of 314 patients (88.5% of 355 patients) were available for analysis.
- Some **74.6% of eyes (400 eyes) treated with primary SLT achieved drop-free disease-control at 36 months; 58.2% (312 eyes) after single SLT**.
- Six eyes of 6 patients experienced immediate post-laser IOP spike (>5 mmHg from pretreatment IOP) with 1 eye requiring treatment.

122

Primary Selective Laser Trabeculoplasty for Open-Angle Glaucoma and Ocular Hypertension

Clinical Outcomes, Predictors of Success, and Safety from the Laser in Glaucoma and Ocular Hypertension Trial

- Conclusions: Primary SLT achieved comparable early absolute IOP-lowering in OHT and OAG eyes compared to medications.
- Drop-free disease-control was achieved in approximately 75% eyes at 36 months after 1 or 2 SLTs, the majority of these after single SLT.
- These analyses are exploratory but support primary SLT to be effective and safe in treatment-naive OAG and OHT eyes.

123

tvst

Article

Automated Direct Selective Laser Trabeculoplasty: First Prospective Clinical Trial

Mordechai Goldenfeld[1], Michael Belkin[2], Masha Dobkin-Bekman[3], Zachary Sacks[1], Sharon Blum Meirovitch[1], Noa Geffen[4,5], Ari Leshno[1,4], and Alon Skaat[1,4]

Clinical science

OPEN ACCESS

Direct selective laser trabeculoplasty in open angle glaucoma study design: a multicentre, randomised, controlled, investigator-masked trial (GLAUrious)

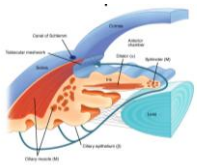
120 shots over 2 seconds at the limbus
1.4-1.8 mJ
400 micron 3ns

124

MIGS MIGS AND MORE MIGS- WHAT SHOULD OPTOMETRIST KNOW

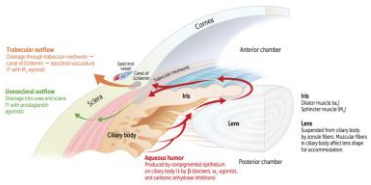
125

PRODUCTION



126

DRAINAGE



127

WHAT ARE MIGS?

- Minimally invasive glaucoma surgeries (microinvasive ?)
- Cardinal features as proposed by Saheb and Ahmed in 2012
  - Ab interno, micro-incisional approach (*note: Some use an ab-externo approach.)
  - Minimal trauma/disruption to normal anatomy and physiology
  - Demonstrable/reliable IOP lowering
  - Extremely high safety profile
  - Rapid post-op recovery, with minimal need for follow-up

128

WHEN AND HOW

- MIGS typically require shorter operation time and allow for more rapid recovery.
- MIGS can be combined with/without cataract extraction for patients with mild to moderate glaucoma and cataracts.
- OAG, or other types like exfoliation and pigment dispersion cases
- MIGS may be less effective in lowering IOP than traditional glaucoma surgeries,

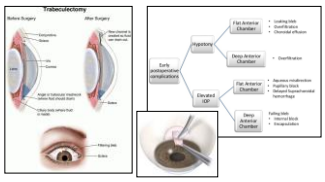
129

WHEN AND HOW

- MIGS do fill a gap in the treatment of patients who would benefit from lower IOP but do not warrant the risk of traditional surgery.
- Decrease medication use
- Combined with cataract
- Narrow angles ? Hence cataract surgery

130

WHY MIGS?

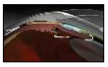


131

MIGS TREATMENTS

- Increase Trabecular Outflow
  - iStent and iStent inject
  - Trabectome
  - Kahook Blade
  - Hydrus Microstent
- Increase Uveoscleral Outflow
  - Cypass (withdrawn)
  - iStent Supra (not approved)





132

MIGS TREATMENTS

- Reduce Aqueous Production
  - Endoscopic photocoagulation ECP
- Subconjunctival Filtration
  - Xen Gel Stent
- Ab Externo
  - Inn Focus (not appr
  - Ahmed Shunt



133

PHYSIOLOGICAL CONSIDERATIONS

134

RESISTANCE TO OUTFLOW AND CHANNELS

- The highest point of resistance in the conventional outflow pathway is believed to be in the **juxtacanalicular component** of the trabecular meshwork
- Distal components of conventional outflow also offer resistance.

Location

- The nasal quadrant is the most common site for Schlemm canal surgery due to

1. its easy access through clear corneal temporal incisions.
2. This site also coincides with the area of the highest concentration of collector channels.

135

STRESS TESTS FOR SUCCESS

- Provocative testing can assist in identifying the location of unobstructed collector channels and aqueous veins.

1. Blood reflux with provocative gonioscopy
2. Episcleral vein filling with fluorescein tracer can be helpful in identifying unobstructed collector channels.

The level of blood reflux and vein filling correlates with post-operative IOP.

- High-resolution imaging using SD OCT can provide a noninvasive method used spectral domain ocular coherence tomography (OCT) to noninvasively assess Schlemm's canal and collector channels and the intrascleral venous plexus

136

OTHER MODIFICATIONS

- Other modifications to increase conventional outflow

1. The number of inserted devices,
2. the length of a device
3. the width of a trabecular meshwork incision

137

IS CATARACT SURGERY A "GLAUCOMA TREATMENT"?

- Lowers IOP – Normals, POAG, OHT, Angle closure
- Opens and deepens Anterior Chamber
- Trabecular meshwork changes dues to phaco energy?
- Trabecular aspiration
- IOP is indeed declined… not as much as one would expect
- IOP high then the drop in pressure is high
- If anatomically narrow or blocked then the phaco indeed helps
- The change is IOP is not permanent …IOP goes back to normal levels in 2 years

138

TRABECULAR OUTFLOW DEVICES

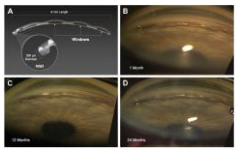
139

ISTENT INJECT

- Apical head (230 microns in width) connected to a narrow thorax that is attached to a wider flange.
- The head is inserted directly into the canal without the necessity to adjust the angle for implantation.
- It resides within the canal and contains 4 inlets for fluid passage.
- The 23-gauge stainless steel injector contains **2 stents for implantation**

140

HYDRUS MICROSTENT



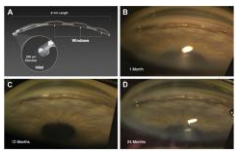
- The Hydrus device is Crescent-shaped scaffold that is open posteriorly
- "intracanalicular scaffold" for Schlemm's canal and a bypass of the TM
- nickel-titanium alloy (nitinol)
- Contains three windows along its 8mm length.
- With or without phacoemulsification
- One quadrant of Schlemm's

Ophthalmology 2019;126:29-37

141

HYDRUS MICROSTENT

- The device is implanted through the trabecular meshwork using a manual inserter.
- The device is designed for ab interno placement through the TM into the Schlemm's canal.
- The inlet segment of the device resides in the AC, while the remaining length of the stent dilates and scaffolds a quadrant of the Schlemm's.
- Preclinical studies suggest that Schlemm's canal scaffolding over a quadrant provides access to multiple collector channels.



Ophthalmology 2019;126:29-37

142

HYDRUS

- Indication with cataract surgery in OAG
- Contraindicated in angle closure, traumatic, malignant, ac anomalies
- Monitor the patient postoperatively for proper maintenance of intraocular pressure.
- The safety and effectiveness not established in young patients <21 years
- Significant prior trauma,
- Chronic inflammations, secondary glaucoma, prior incisional surgery, ALT

eyes with abnormal anterior segment, eyes with chronic inflammation

- The safety and effectiveness of use of more than a single Hydrus Microstent has not been established.

143

TRABECTOME

- The Trabectome removes a strip of trabecular meshwork and inner wall of Schlemm's canal using high frequency electrocautery.
- Up to 180 degree
- The 19.5-gauge handpiece incorporates an insulated footplate that enters Schlemm's canal through the trabecular meshwork.
- An irrigation port keeps the anterior chamber formed and dissipates heat, and an aspiration port is adjacent to the cautery electrode

144

TRAB 360 (SIGHTSCIENCES)

- TRAB 360 is a disposable, non-powered device used to perform an ab interno 360° trabeculotomy.
- The TRAB 360 device consists of a cannula, from which a flexible nylon-like trabeculotome is advanced into Schlemm's canal for 180 degrees
- After the trabeculotomy is created, the trabeculotome can be retracted once and then advanced into the remainder of Schlemm's canal in the opposite direction for up to a total of 360 degrees.

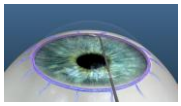
145

EXCIMER LASER TRABECULOSTOMY

- Excimer laser trabeculostomy (ELT) creates small holes in the trabecular meshwork and inner wall of Schlemm's canal
- Energy from a quartz fiberoptic probe connected to a xenon chloride pulsed excimer laser.
- Eight to 10 laser punctures are spaced over 90-degree, with visible whitening of the trabecular meshwork and bubble formation

146

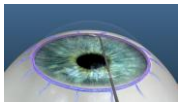
AB INTERNO CANALOPLASTY



- Ab interno canaloplasty (ABiC) increases aqueous outflow through cannulation of Schlemm's canal with an illuminated microcatheter (iTrack, Ellex)
- An ophthalmic viscosurgical device is injected to viscodilate Schlemm's canal and the proximal collector channels.
- It has been theorized that viscodilation may also create microperforations within the TM to aid in aqueous outflow.

147

AB INTERNO CANALOPLASTY



- As the viscoelastic is injected, blanching of episcleral vessels, which is indicative of a patent collecting system, serves as an indirect indicator of success.
- Indications for ABiC include mild to moderate OAG when maximal medical management and laser trabeculoplasty have failed.
- Ab Externo approach is also possible

148

CONTRAINDICATIONS

- Required anticoagulation, bleeding diatheses, angle closure, obscured angle structures, severe endothelial compromise, or intraocular lens instability.
- Relative contraindications include previous corneal transplant and an inability to elevate patient's head 30° during the first postoperative week.

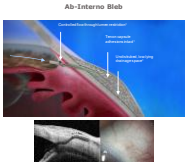
149

SUB CONJUNCTIVAL FILTRATION

150

XEN GEL STENT

- A glaucoma implant designed to reduce intraocular pressure in eyes suffering from refractory glaucoma
- 6-mm length, 45-micron inner diameter—about the length of an eyelash
- Composed of gelatin, cross-linked with glutaraldehyde
- Creates a permanent channel through the sclera allowing flow of aqueous humor from the anterior chamber into the subconjunctival space



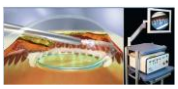
151

AQUEOUS PRODUCTION SUPPRESSION

152

ENDOCYCLOPHOTOCOAGULATION (ECP)

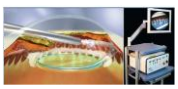
- ECP consists of cyclodestruction of the ciliary body epithelium to reduce aqueous production and therefore IOP.
- The ECP probe is reusable device, which includes a laser source, camera, and light source.
- The probe directed towards the anterior ciliary processes delivers continuous energy (810 nm wavelength) for successful photocoagulation.
- Localized shrinkage and whitening of the processes



153

ENDOCYCLOPHOTOCOAGULATION (ECP)

- Through a single corneal incision, approximately 240 to 300 degrees of the ciliary processes can be treated, but more incisions are needed for a 360-degree treatment.
- As expected, the greater the amount of processes treated, the greater the reduction in IOP and need for glaucoma medications.



154

SUMMARY

- Minimal trauma, high efficacy, high safety profile, and rapid recovery.
- There is an increasing interest and availability of MIGS procedures.
- Important to have good science and long-term follow-up data.
- MIGS devices may offer benefits to our patients with glaucoma
  - through IOP reduction
  - reduced need for glaucoma medications
  - high safety profile.
- MIGS are here to stay for the foreseeable future and its role increasing.

155

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156