SUSPECTING GLAUCOMA

John M. Spalding, OD, FAAO
Orlando, Florida

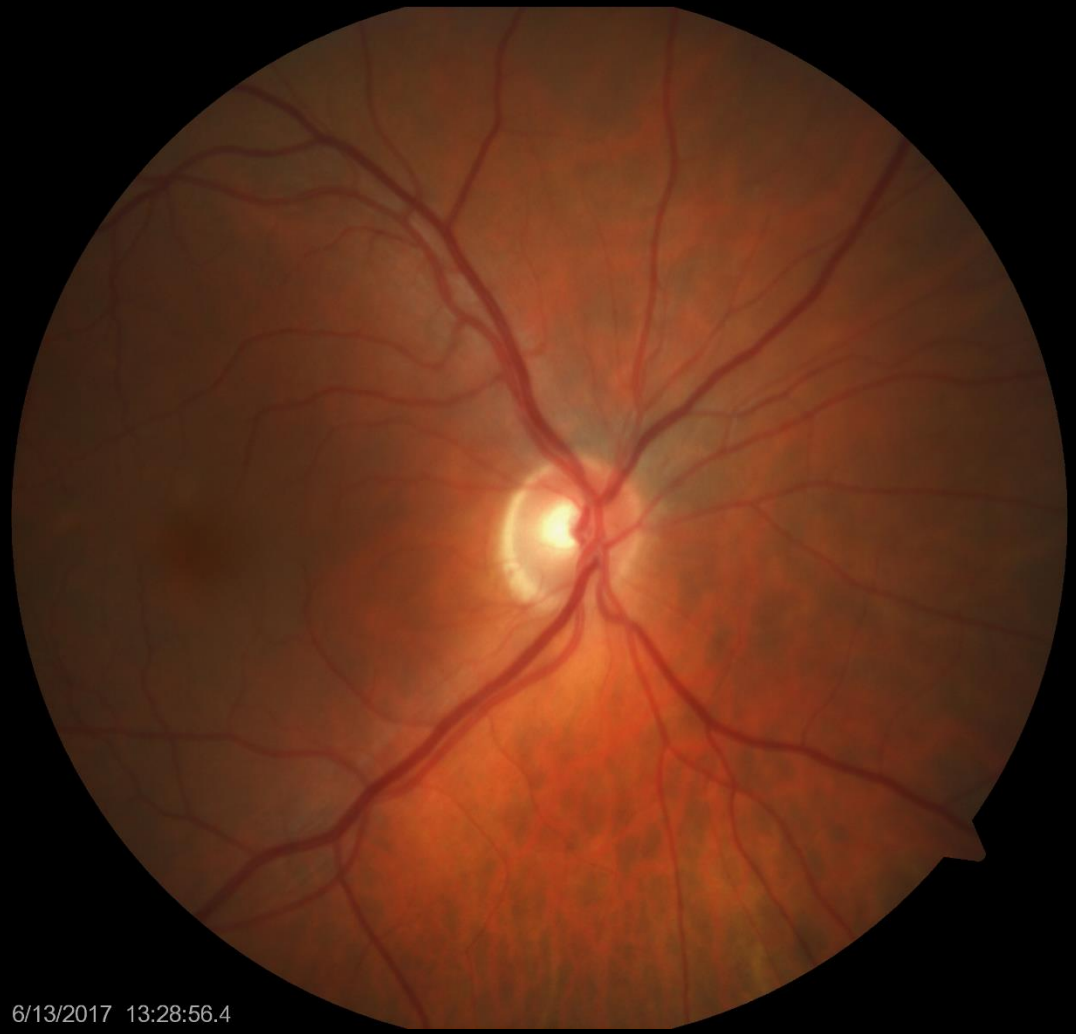
NO FINANCIAL DISCLOSURES.

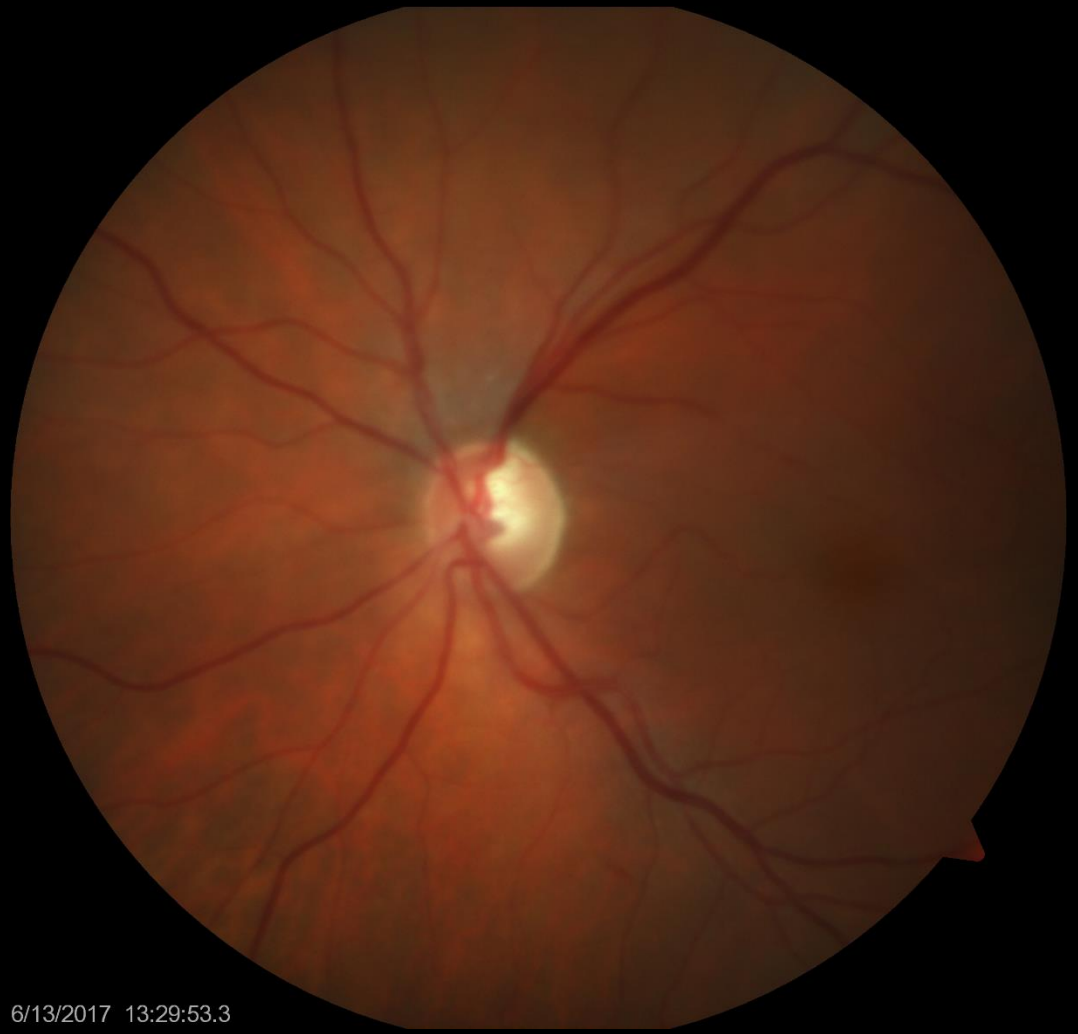
CASE

- 70 / W / F
- FORMER VISUAL FIELD TECH AT LOCAL OPHTHALMOLOGY PRACTICE
- CC: decreased near vision after ce/iol ou, no distance problems without rx, no comfort problems
- OC HX:
  - LEE 1yr privately, no records, ce/iol x 1yr
- OC MEDS:
  - none
- MED HX:
  - h/o melanoma L shoulder (s/p surgery)
- ALLERGIES:
  - none
- FAM HX:
  - -DM, -glaucoma, -blind
- SOC HX:
  - -etoh, +tobacco

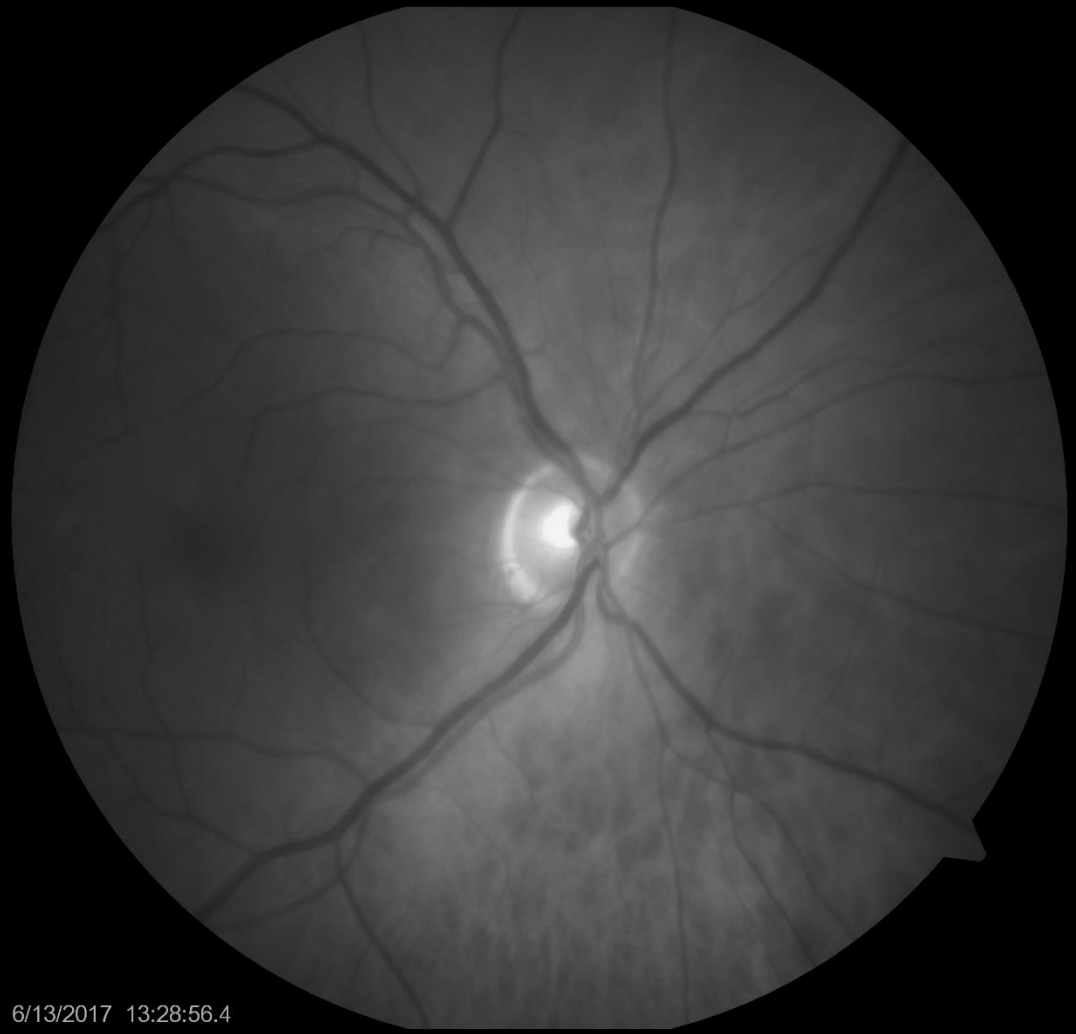
- BVA:
  - 20/20 OD +50-025x022
  - 20/20 OS +075-025x007
- FROM, Normal Pupils, NO APD
- CF: FTFC OD, FTFC OS
- SLE:
  - OU dermatochalasis
- IOP: 18/18 @ 1235p
- PACHYM: 582/555
- GONIO: open to CBB 360, no PAS/recess/NV, tr pig
- DFE: see photos

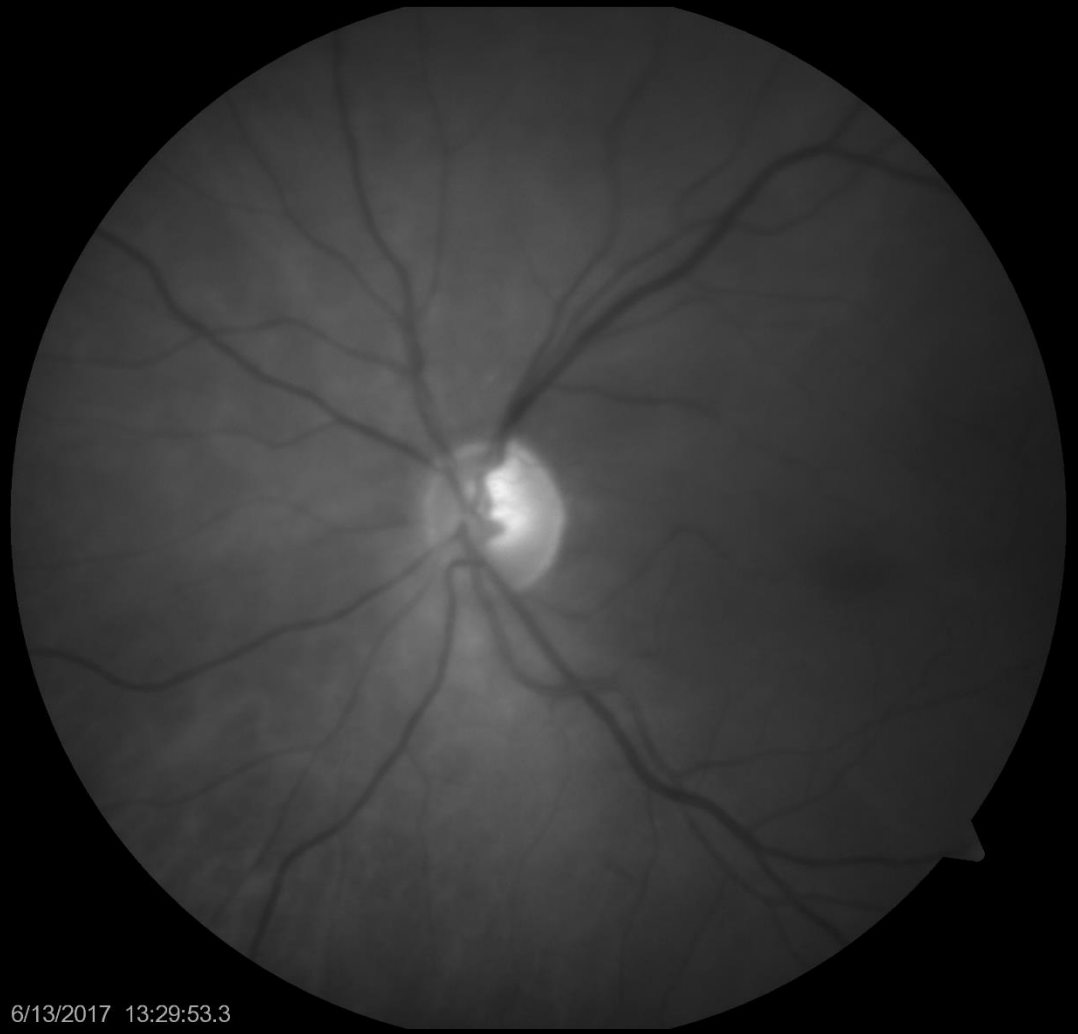
DFE



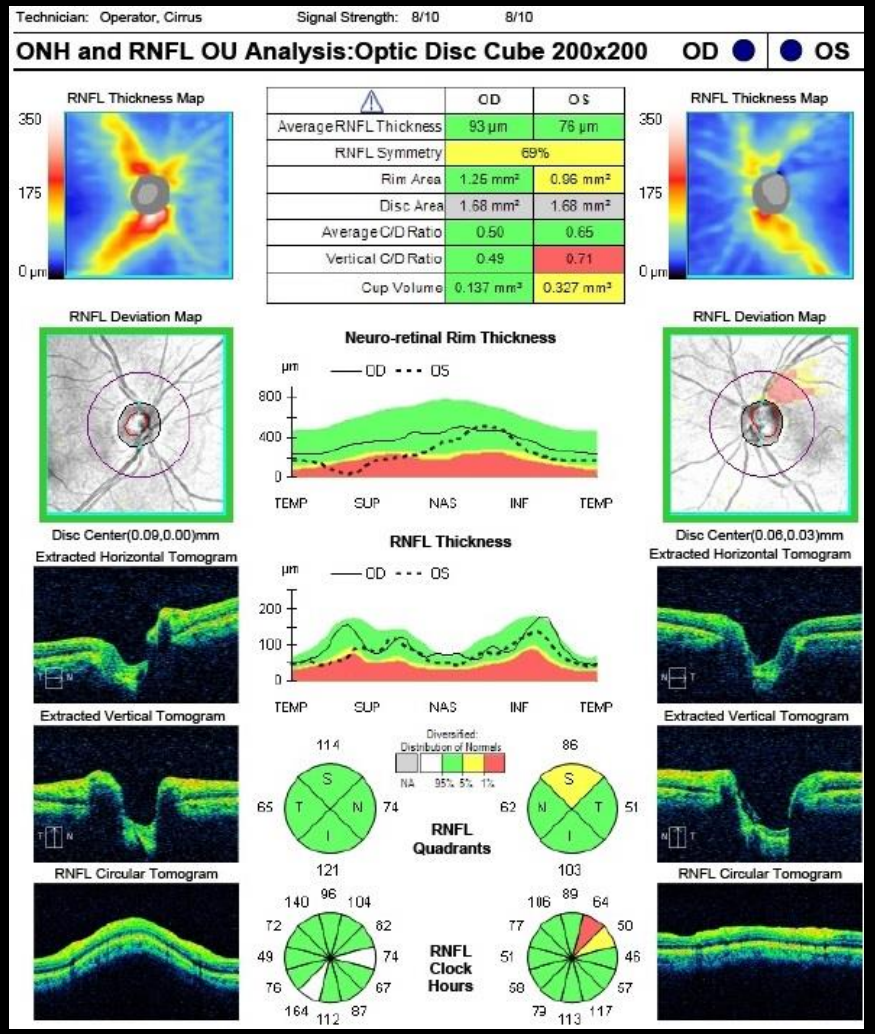


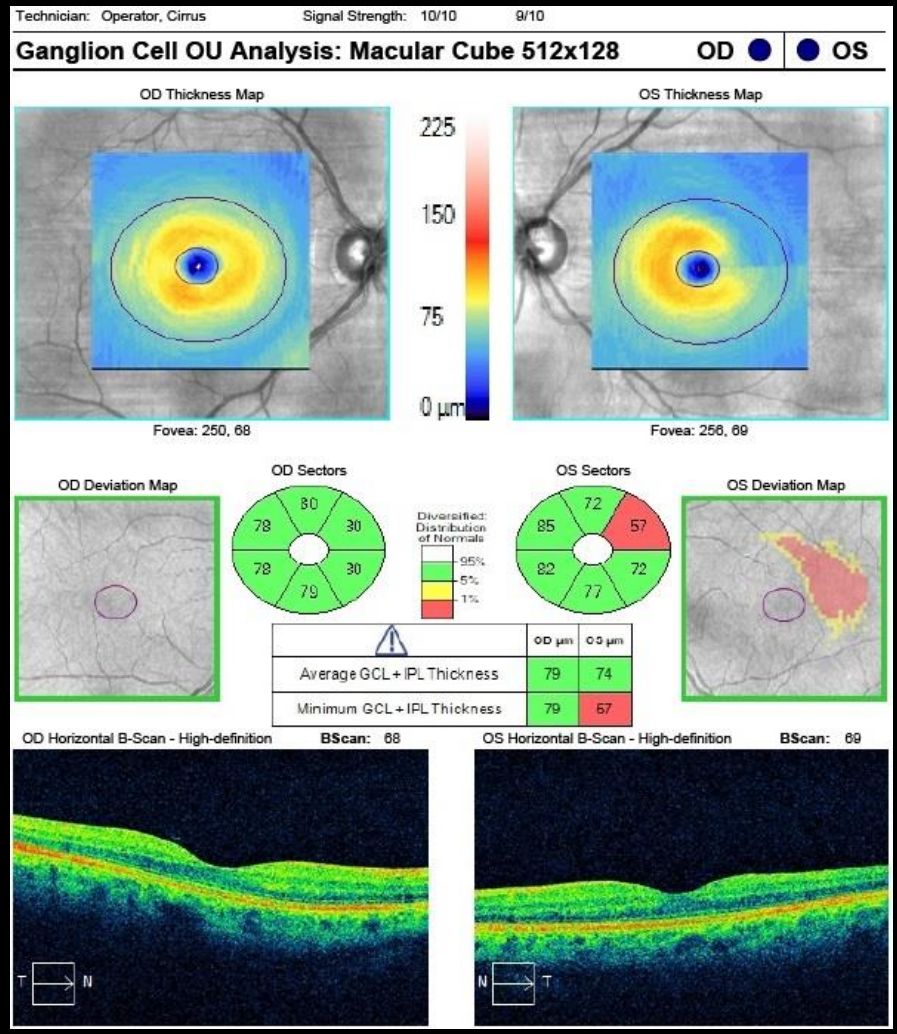
RNFL



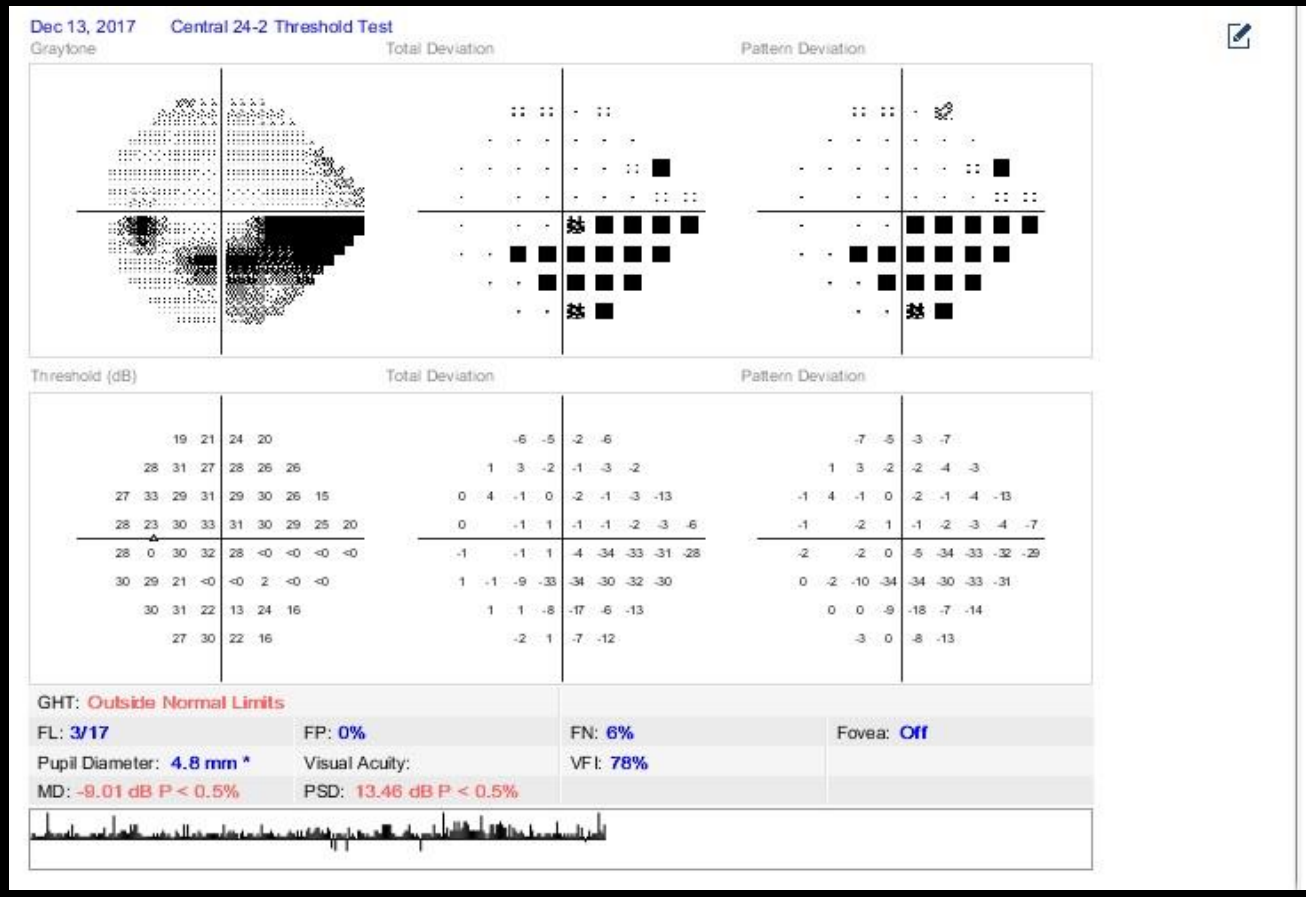


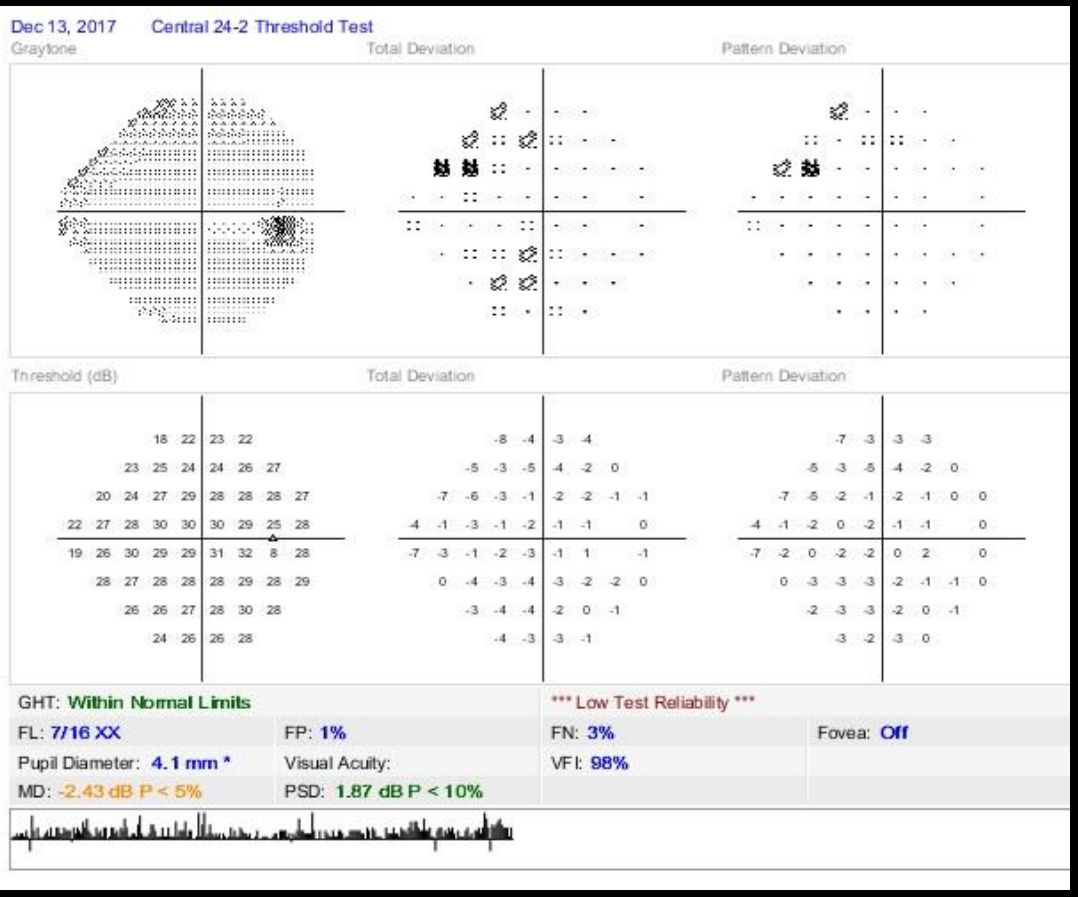
CIRRUS
RNFL / GCC



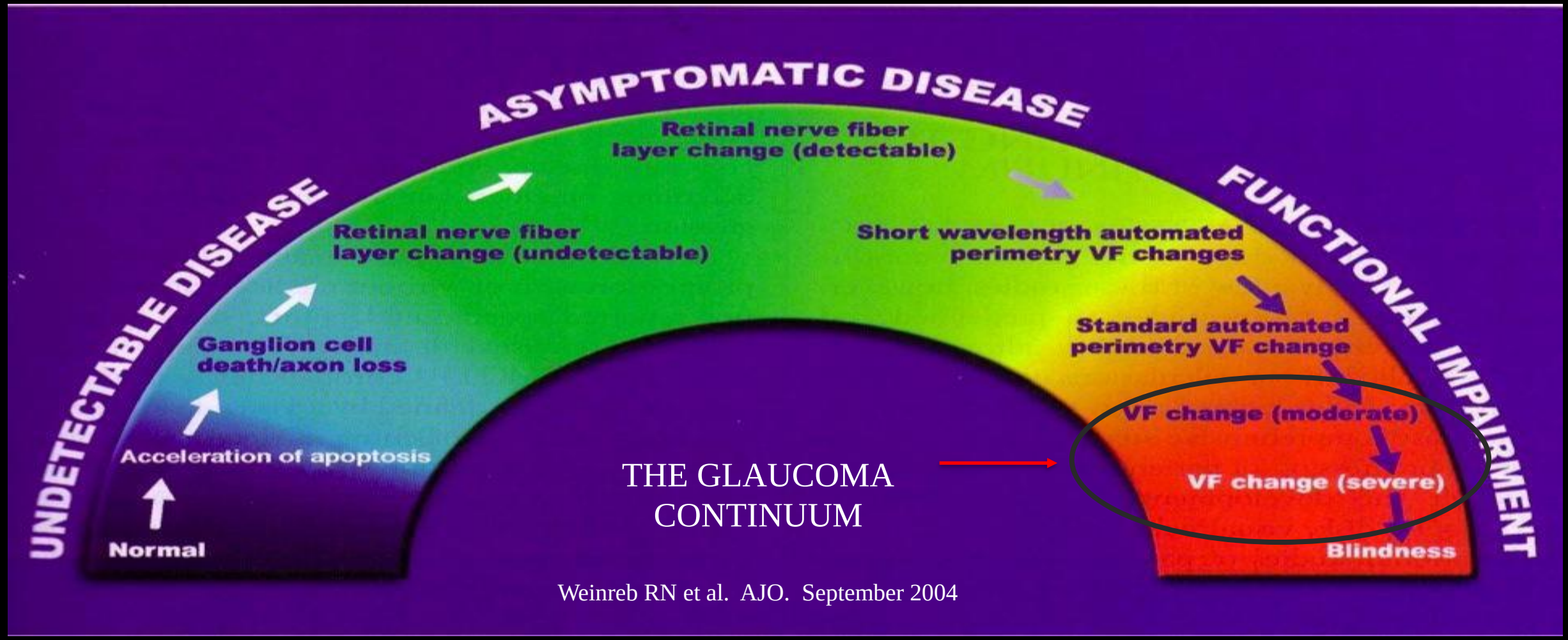


VF 24-2 SITA STD



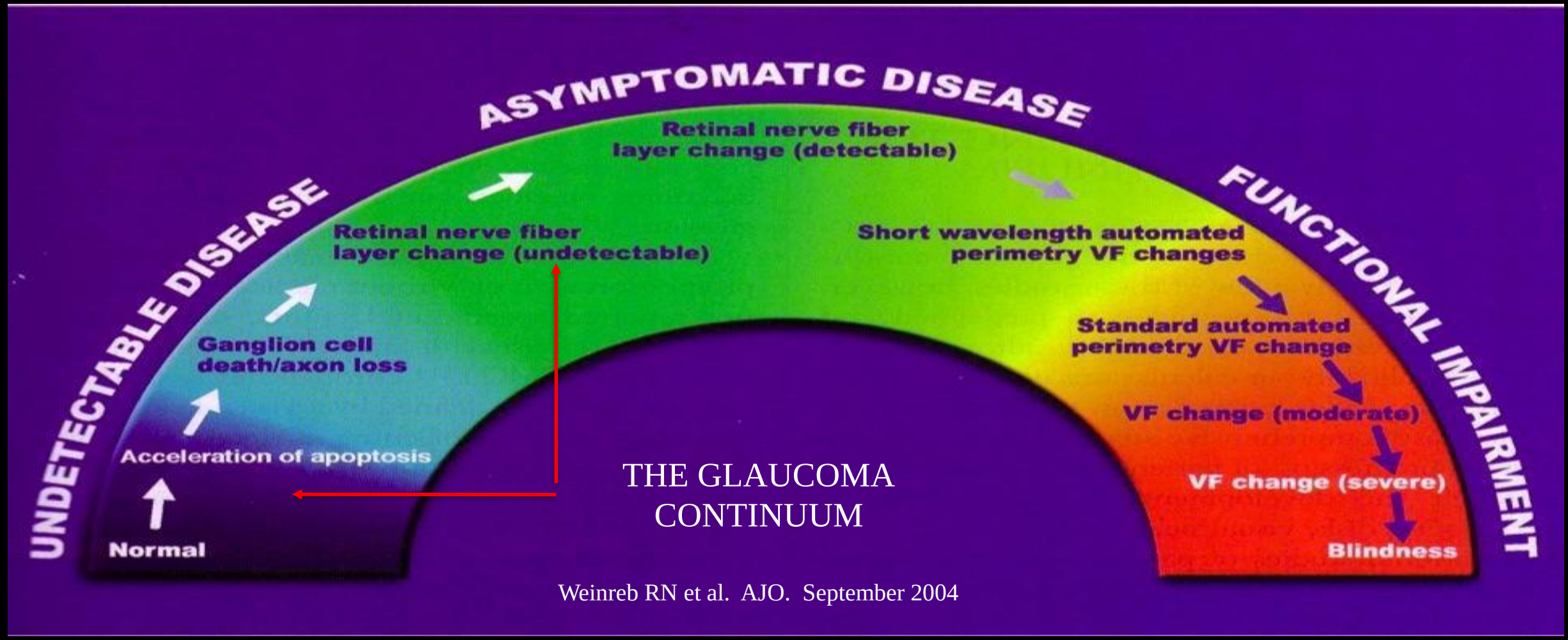


WHERE SHE IS NOW WITHIN THE GLAUCOMA CONTINUUM



Weinreb RN et al. AJO. September 2004

HOWEVER, AT SOME POINT….
SHE WAS A GLAUCOMA SUSPECT

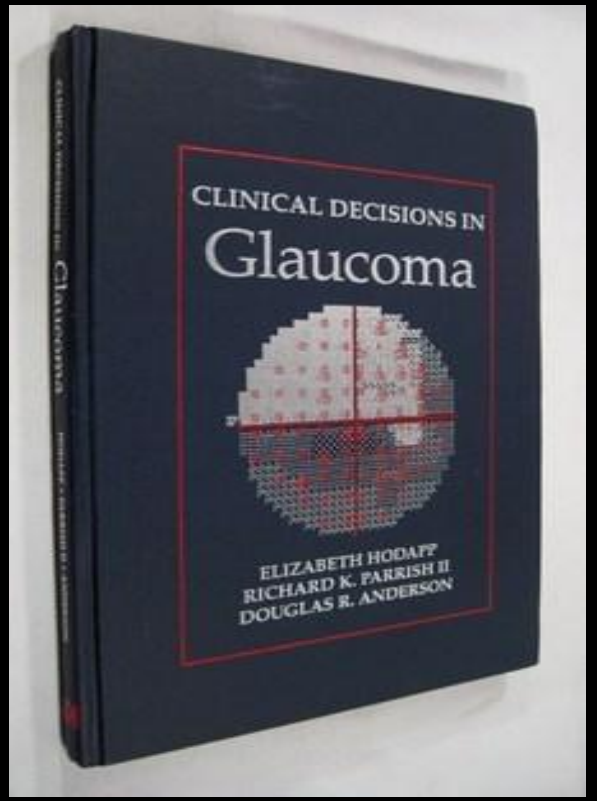


QUESTION

HOW CAN WE DETECT THESE PATIENTS EARLIER?

SUSPECT EVERYONE

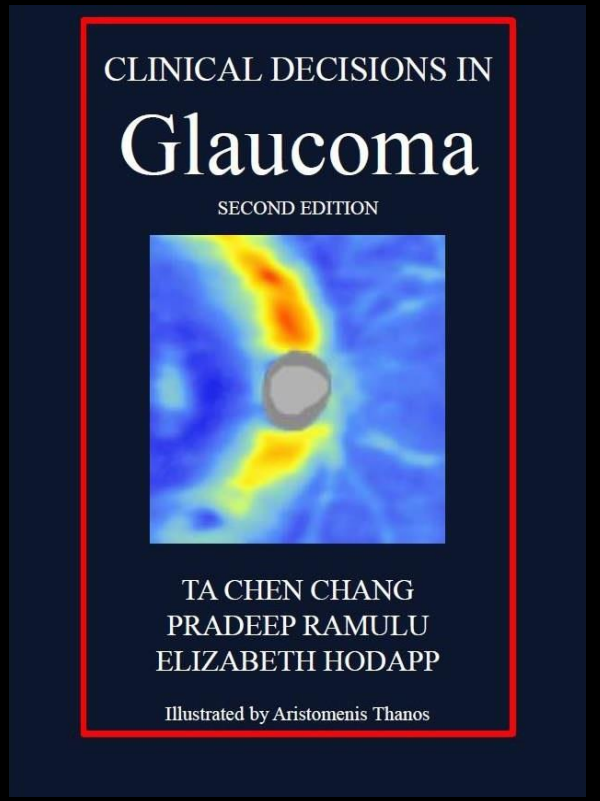
"…WE RECOMMEND THAT EVERY COMPLETE OCULAR EXAMINATION BE PERFORMED WITH THE POSSIBILITY OF GLAUCOMA FIRMLY IN MIND…"



Drs. Hodapp, Parrish and Anderson
Clinical Decisions in Glaucoma
1993, Mosby

and again in

Drs. Chang, Ramulu and Hodapp
Clinical Decisions in Glaucoma
2nd Edition, 2016



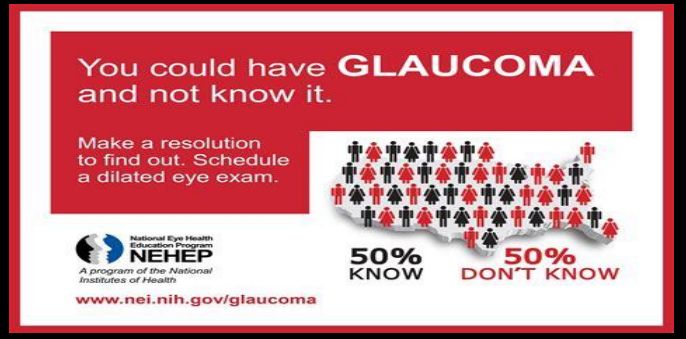
QUESTION

THAT SEEMS EXCESSIVE BUT IS IT?

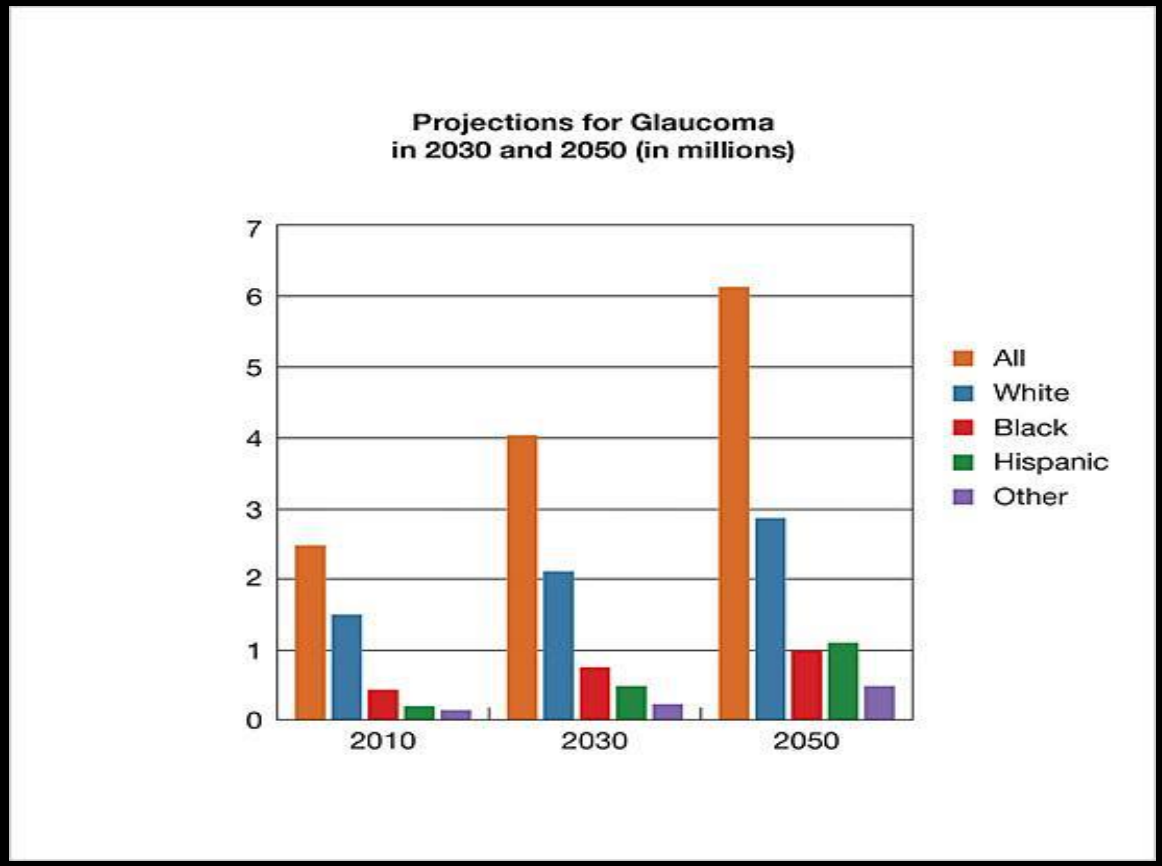
STATISTICS

- WORLDWIDE
  - 76 MILLION WITH GLAUCOMA (ACG /OAG) AS OF 2020 PPP
    - UP FROM PRIOR 45 MILLION AS OF 2015 PPP
  - ACG / OAG SECOND LEADING CAUSE OF BLINDNESS
  - PREVALENCE OF POAG
    - > 40 YO 3.05 % IN 2013
      - UP FROM PRIOR 2%
    - 52.7 MILLION IN 2020
    - EXPECT 79.8 MILLION IN 2040

- UNITED STATES
  - 3.36 MILLION WITH OAG 2020
    - EXPECTED TO BE 7 MILLION IN 30 YEARS
  - 50% WITH ONH DAMAGE ARE *UNAWARE*



WHAT DOES THE FUTURE HOLD FOR THE UNITED STATES?



7/17/19
https://www.nei.nih.gov

YOUR PATIENT POPULATION MAY DIFFER

TABLE IV. Frequency of Nonrefractive Ocular Diagnoses

Diagnosis	Frequency	Percent
Glaucoma	168	25.5
Suspect	133	20.2
Primary Open Angle	27	4.1
Angle Closure	4	0.6
Pseudoexfoliation	1	0.2
Traumatic	3	0.5
Diabetes	91	13.8
No Retinopathy	68	10.3
Nonproliferative	16	2.4
Macular Edema	2	0.3
Proliferative	5	0.8
AMD	31	4.7
Nonexudative	21	3.2
Drusen	8	1.2
Exudative	2	0.3
Other	139	21
Blepharitis	43	6.5
Cataract	39	5.9
Retinal Vascular Disease	22	3.3
Severe Dry Eye	14	2.1
Optic Neuropathy	11	1.7
Peripheral Retinal Disease (Lattice, Retinal Break, Detachment)	10	1.5

VETERAN EYE DISEASE AFTER ELIGIBILITY REFORM:
PREVALENCE AND CHARACTERISTICS
(ATLANTA)

Military Medicine, 178, 7:811, 2013

TABLE 2. Ocular Diagnoses in Veterans in the Veterans Affairs Capitol Health Care Network from Fiscal Year 2007 to Fiscal Year 2011

	Fiscal Year						
Variable	2007 (N = 130,709)	2007 (N = 130,709)	2007 (N = 130,709)	2007 (N = 130,709)	2007 (N = 130,709)	β	*P* Value
Disease category, n (%)							
Disorders of refraction and accommodation	11,067 (8.5)	12,046 (9.2)	14,150 (10.3)	16,078 (11.4)	18,854 (13.1)	1.13	<.01
Glaucoma	8815 (6.7)	9003 (6.9)	9494 (6.9)	9921 (7.0)	10,431 (7.4)	0.14	.03
Ophthalmic complications of diabetes	2896 (2.2)	3180 (2.4)	3065 (2.2)	2952 (2.1)	2908 (2.0)	−0.07	.148
Cataract	9215 (7.1)	8827 (6.7)	11,292 (8.2)	12,050 (8.5)	13,529 (9.6)	0.68	.02
Any ophthalmic diagnosis	26,804 (20.5)	27,552 (21.1)	29,677 (21.5)	31,460 (22.2)	33,611 (23.3)	0.67	<.01

TRENDS IN PREVALENCE OF DIAGNOSED OCULAR DISEASE AND
UTILIZATION OF EYE CARE SERVICES IN AMERICAN VETERANS
(MD, DC, AND PARTS OF VA, WV, PA)

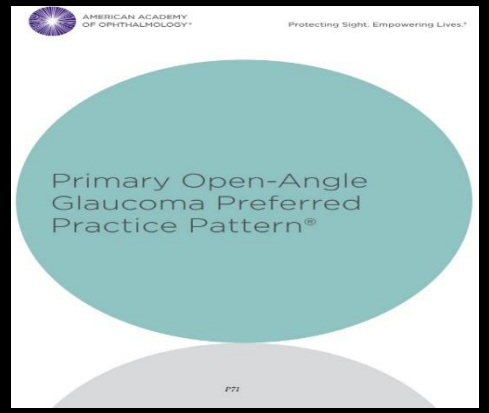
Am J Ophthalmol. 2017 Jan;173:70-75

QUESTION

WHAT'S THE DIFFERENCE BETWEEN HAVING GLAUCOMA AND BEING A SUSPECT?

PRIMARY OPEN-ANGLE GLAUCOMA

"A CHRONIC, PROGRESSIVE OPTIC NEUROPATHY IN ADULTS IN WHICH THERE IS A CHARACTERISTIC ACQUIRED ATROPHY OF THE OPTIC NERVE AND LOSS OF RETINAL GANGLION CELLS AND THEIR AXONS. THIS CONDITION IS ASSOCIATED WITH AN OPEN ANTERIOR CHAMBER ANGLE BY GONIOSCOPY."



AMERICAN ACADEMY OF OPHTHALMOLOGY

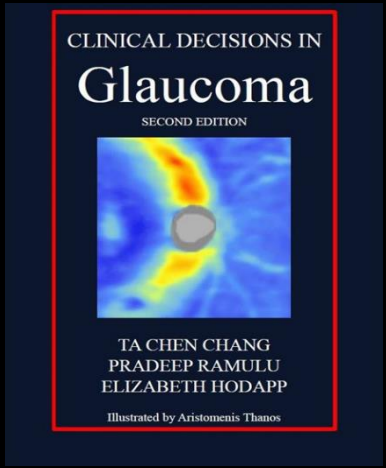
Preferred Practice Pattern

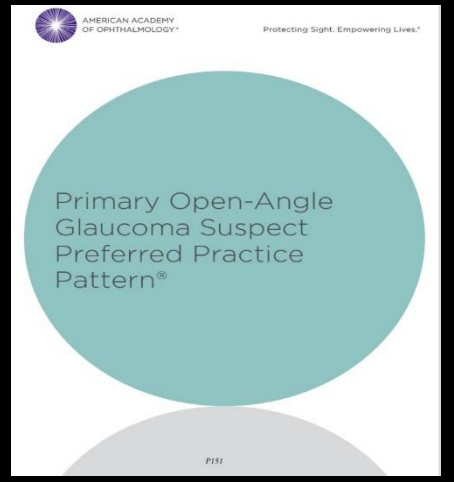
2020

GLAUCOMA SUSPECT

- “SOMEONE WHO, FOR ONE OR MORE REASONS, IS AT HIGHER THAN USUAL RISK OF DEVELOPING GLAUCOMATOUS OPTIC NERVE DAMAGE AND VISUAL DEFICIENCY AND THEREFORE WARRANTS CAREFUL FOLLOW-UP.”

- “AN INDIVIDUAL WITH **CLINICAL FINDINGS** AND / OR A CONSTELLATION OF **RISK FACTORS** THAT INDICATE AN INCREASED LIKELIHOOD OF DEVELOPING PRIMARY OPEN-ANGLE GLAUCOMA.”





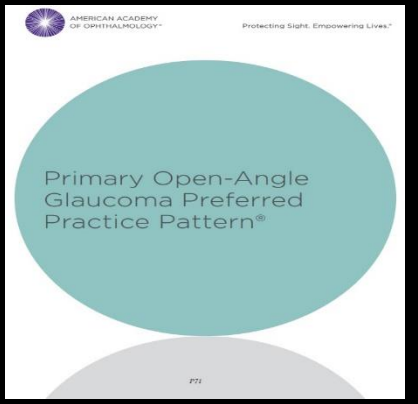
RISK FACTORS ASSOCIATED WITH OPEN-ANGLE GLAUCOMA

- IN NUMEROUS STUDIES
  - ELEVATED IOP
  - OLDER AGE
  - FAMILY HISTORY OF GLAUCOMA
  - AFRICAN RACE OR LATINO / HISPANIC ETHNICITY
  - THIN CENTRAL CORNEA
  - LOW OCULAR PERFUSION PRESSURE
  - TYPE 2 DIABETES MELLITUS
  - MYOPIA
  - LOWER SYSTOLIC AND DIASTOLIC BLOOD PRESSURE
  - HYPOTHYROIDISM*
  - MALE*
  - ---
  - DISC HEMORRHAGE
  - LARGER CUP-TO-DISC RATIO
  - HIGHER PSD ON THRESHOLD VISUAL FIELD

- OTHER FACTORS
  - MIGRAINES
  - SLEEP APNEA*
  - PERIPHERAL VASOSPASM
  - CARDIOVASCULAR DISEASE
  - LOW CORNEAL HYSTERESIS*
  - SYSTEMIC HTN
  - TRANSLAMINAR PRESSURE GRADIENT (ICP VS IOP)
  - GENETIC FACTORS

AMERICAN ACADEMY OF OPHTHALMOLOGY
Preferred Practice Pattern

** = NEW AS OF 2020*



AGE

- PREVALENCE OF GLAUCOMA
  - INCREASES WITH AGE
  - FRAMINGHAM EYE STUDY
    - PREVALENCE OF POAG
      - 52-85 YO = 1.65%
      - IF YOU ADD VF TESTING = 2.1%

- OVERALL PREVALENCE
  - 4-10X HIGHER IN OLDER AGE GROUPS COMPARED TO THOSE IN 40S
  - 2004 DATA
    - 2% OF POPULATION > 40 YO HAD POAG
  - 2013 DATA
    - 3%

TABLE 1 PREVALENCE (%) OF DEFINITE OPEN-ANGLE GLAUCOMA

Study		Age-Specific Prevalence Age Groups (yrs)					
		40–49	50–59	60–69	70–79	80+	Total
Baltimore Eye Study[16]		1.3	4.2	6.2	8.9	12.9	5.0
Barbados Eye Study[17]		1.4	4.1	6.7	14.8	23.2	6.8
Los Angeles Latino Eye Study[14]		1.3	2.9	7.4	14.7	21.8	4.7
Proyecto Vision Evaluation Research[18]		0.5	0.6	1.7	5.7	12.6	2.0
Baltimore Eye Study[16]		0.2	0.3	1.5	3.3	1.94	1.4
Blue Mountains Eye Study[19]		0.4*		1.3	4.7	11.4	3.0
Visual Impairment Project[20]		0.5	1.5	4.5	8.6	9.9	3.4
Beaver Dam Eye Study[21]							2.1
Roscommon[22]			0.7	1.8	3.2	3.1	1.9

RACE

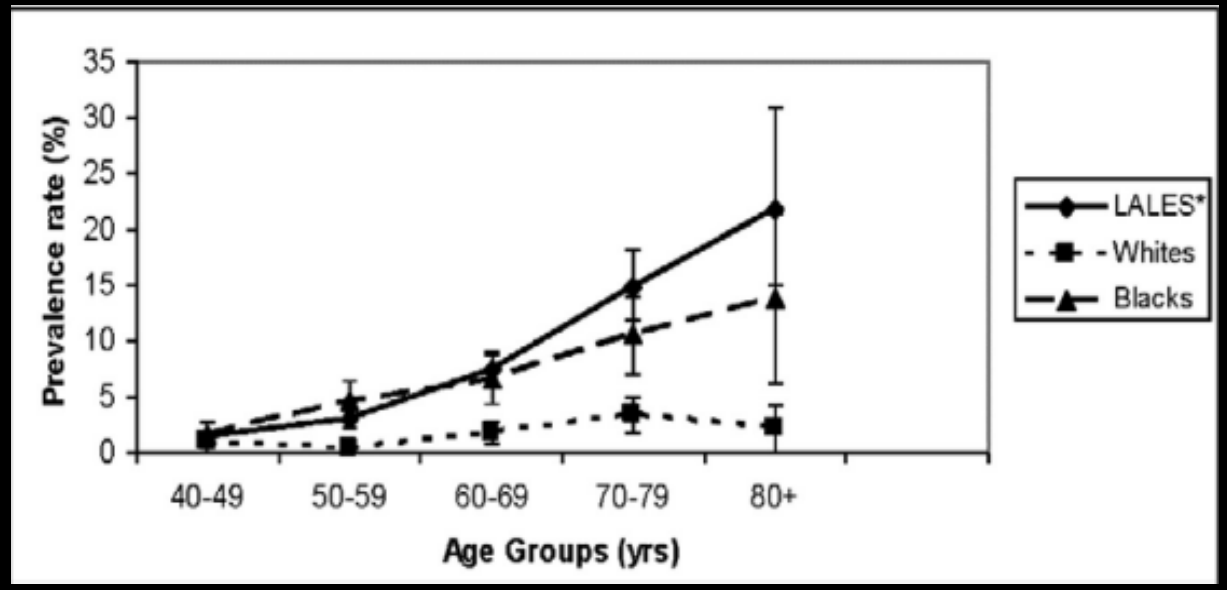
- AFRICAN AMERICANS
  - DEVELOP DISEASE EARLIER
  - DO NOT RESPOND AS WELL TO TREATMENT
  - MORE LIKELY TO REQUIRE SURGERY
  - HIGHER PREVALENCE OF BLINDNESS
  - BALTIMORE EYE SURVEY
    - PREVALENCE OF GLAUCOMA
      - AA WERE 4.3X CAUCASIANS
- AFRO-CARIBBEAN
  - BARBADOS EYE STUDY
    - HIGHER THAN AA > 60 YO

TABLE 1 PREVALENCE (%) OF DEFINITE OPEN-ANGLE GLAUCOMA

Study	Ethnoracial Group	Age-Specific Prevalence					
		Age Groups (yrs)					
		40–49	50–59	60–69	70–79	80+	Total
Baltimore Eye Study[16]	African American	1.3	4.2	6.2	8.9	12.9	5.0
Barbados Eye Study[17]	Afro-Caribbean	1.4	4.1	6.7	14.8	23.2	6.8
Los Angeles Latino Eye Study[14]	Latino	1.3	2.9	7.4	14.7	21.8	4.7
Proyecto Vision Evaluation Research[18]	Latino	0.5	0.6	1.7	5.7	12.6	2.0
Baltimore Eye Study[16]	NHW	0.2	0.3	1.5	3.3	1.94	1.4
Blue Mountains Eye Study[19]	NHW	0.4*		1.3	4.7	11.4	3.0
Visual Impairment Project[20]	NHW	0.5	1.5	4.5	8.6	9.9	3.4
Beaver Dam Eye Study[21]	NHW						2.1
Roscommon[22]	NHW		0.7	1.8	3.2	3.1	1.9

RACE

- LATINO / HISPANIC ETHNICITY
  - PREVALENCE
    - INCREASES WITH AGE
    - > 40 YO 1.7% > 80 YO 7.4%
  - STARTING AT AGE 60
    - ≥ AFRICAN AMERICANS
- OTHER RACES
  - JAPANESE
    - HIGHER PREVALENCE OF NORMAL TENSION GLAUCOMA
  - CHINESE, VIETNAMESE, PAKISTANI, INUIT
    - HIGHER PREVALENCE OF ANGLE CLOSURE GLAUCOMA



SEX

- NEW AS OF 2020 PPP
- META-ANALYSIS
  - POAG PREVALENCE
    - IN POPULATION BASED SURVEYS
  - 81 ARTICLES FROM 1966-2014
  - 5266 / 216,214 CASES
  - RESULTS
    - MEN HAVE 33% HIGHER RISK THAN WOMEN
- MECHANISM THEORIES
  - BIOLOGICAL DIFFERENCES IN NERVE FIBER LAYER THICKNESS
  - PROTECTIVE EFFECT OF FEMALE HORMONES ON GANGLION CELL LOSS
  - CARDIOVASCULAR DISEASE DIFFERENCES

Table 2 ORs of primary open angle glaucoma (POAG) for a decade increase in age, trends over time and study design factors

Factor	Study populations	Unadjusted OR* (95% CrI)	All surveys Adjusted OR† (95% CrI)	Surveys conducted since 2000 Adjusted OR† (95% CrI)
Effect per decade increase in age by racial group				
White	29	1.99 (1.86, 2.13)	1.99 (1.86, 2.12)	1.97 (1.50, 2.64)
Black	13	1.60 (1.52, 1.67)	1.59 (1.52, 1.67)	1.47 (1.38, 1.57)
East Asian	15	1.48 (1.39, 1.57)	1.48 (1.39, 1.57)	1.45 (1.34, 1.57)
South Asian	16	1.69 (1.58, 1.82)	1.69 (1.58, 1.81)	1.70 (1.57, 1.83)
South-East Asian	5	1.56 (1.31, 1.87)	1.56 (1.31, 1.88)	1.46 (1.22, 1.75)
Hispanic or Latino	2	2.31 (2.12, 2.52)	2.31 (2.12, 2.52)	2.24 (2.03, 2.48)
Other/mixed	8	1.88 (1.44, 2.47)	1.90 (1.45, 2.52)	1.42 (0.85, 2.32)
Year of survey				
1960–1979	7	0.45 (0.24, 0.89)		
1980–1989	15	0.75 (0.46, 1.22)		
1990–1999	28	0.81 (0.54, 1.22)		
2000+	38	1.00		
Study design factors: visual field (VF)/intraocular pressure (IOP)				
VF on all	37	1.00	1.00	
VF on all and IOP criterion	5	0.55 (0.26, 1.18)	0.64 (0.35, 1.14)	
IOP criterion and VF on subset	35	0.58 (0.40, 0.86)	0.78 (0.56, 0.99)	
Other	11	0.90 (0.52, 1.53)	1.23 (0.77, 1.76)	
Study design factors				
(In surveys conducted since 2000)				
Follows ISGEO and VF on all	10	1.00		1.00
Follows ISGEO and VF on subset	14	0.70 (0.37, 1.34)		0.69 (0.44, 1.10)
Does not follow ISGEO	14	1.03 (0.53, 1.91)		0.79 (0.48, 1.33)
Sex‡				
Female	54	1.00	1.00	
Male	54	1.33 (1.24, 1.42)	1.30 (1.22, 1.41)	

Kapetanakis VV, Chan MP, Foster PJ, et al. Global variations and time trends in the prevalence of primary open angle glaucoma (POAG): A systematic review and meta-analysis. *Br J Ophthalmol*. 2016;100:86-93.

DIABETES

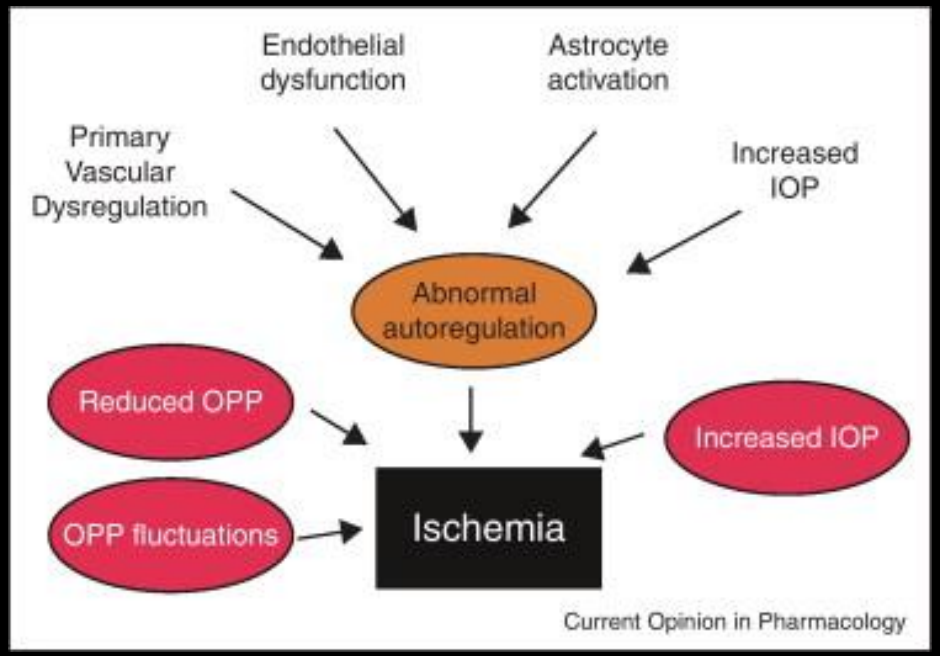
- CONFLICTING REPORTS
  - SOME STUDIES FIND NO RELATIONSHIP
  - OTHERS SAY DM IS PROTECTIVE
  - OTHERS SAY DM IS RISK FACTOR FOR POAG

  - POPULATION BASED STUDIES
    - HIGHER ODDS OF DM WITH POAG
      - 40% HIGHER ODDS IN HISPANICS
      - 2X HIGHER IN NONHISPANIC WHITES
      - LONGER DURATION OF TYPE 2 = HIGHER RISK OF HAVING POAG
    - META-ANALYSIS OF 47 STUDIES
      - INCREASED RISK OF GLAUCOMA AND MAY BE ASSOCIATED WITH ELEVATED IOP

- MECHANISM THEORY
  - MICROVASCULAR CHANGES MAY MAKE ONH MORE SUSCEPTIBLE TO DAMAGE IN THOSE WITH TYPE 2 DM

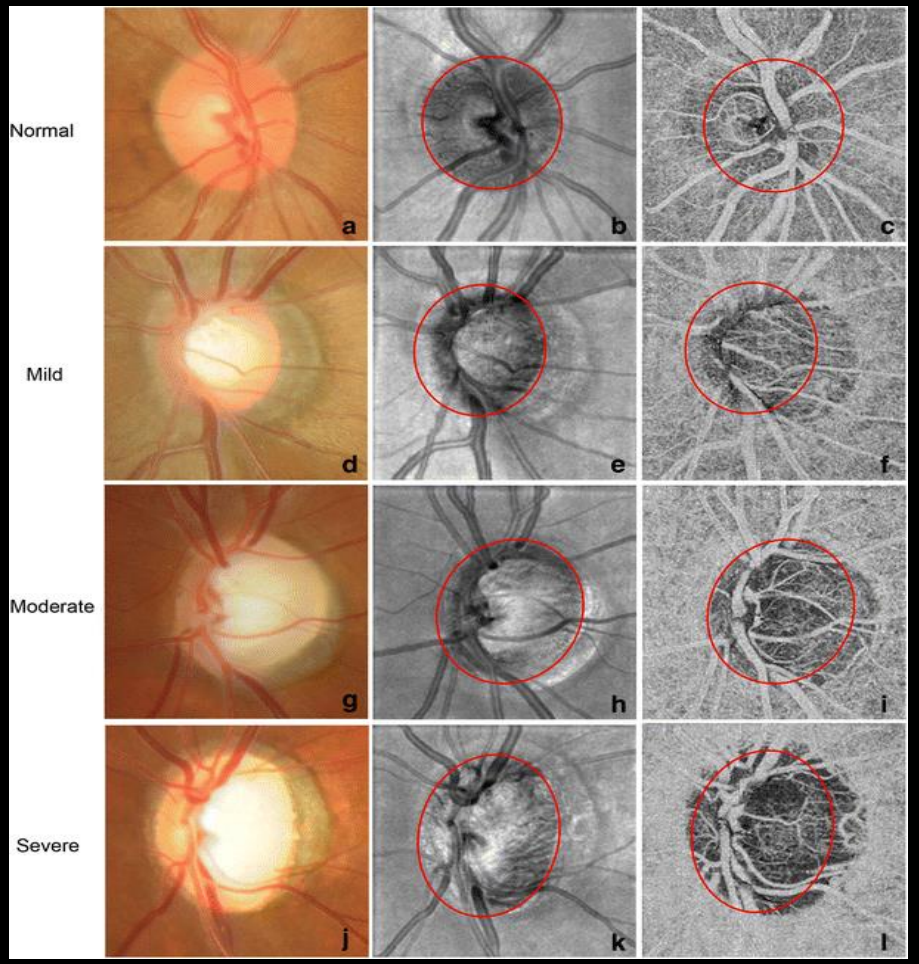
OCULAR PERFUSION PRESSURE and BP

- OCULAR PERFUSION PRESSURE
  - DIFFERENCE BETWEEN BP AND IOP
    - SYSTOLE OR DIASTOLE
- MECHANISM THEORY
  - REDUCED PERFUSION AND/OR VASCULAR DYSREGULATION AND THE SUBSEQUENT ISCHEMIA OF THE ONH CONTRIBUTE TO GLAUCOMA DAMAGE
- HOW TO CALCULATE IT
  - MEAN OPP = 2/3 MAP - IOP
    - MEAN ARTERIAL PRESSURE (MAP) = DBP + [1/3 X (SBP-DBP)]
  - IT IS NOT EXACT
- SHOULD WE BE CALCULATING IT?
  - PROBABLY NOT
    - JUST REMEMBER….THINGS OTHER THAN IOP IMPACT GLAUCOMA
  - CHECK BLOOD PRESSURE
  - LOW BP WITH HIGH IOP = AT RISK (LOWER OPP)
    - RISK OF REDUCTION IN VOLUME OF BLOOD TO ONH
    - EYE AT RISK DUE TO IMPAIRED AUTO-REGULATION
    - RISK OF ISCHEMIA, OXIDATIVE STRESS



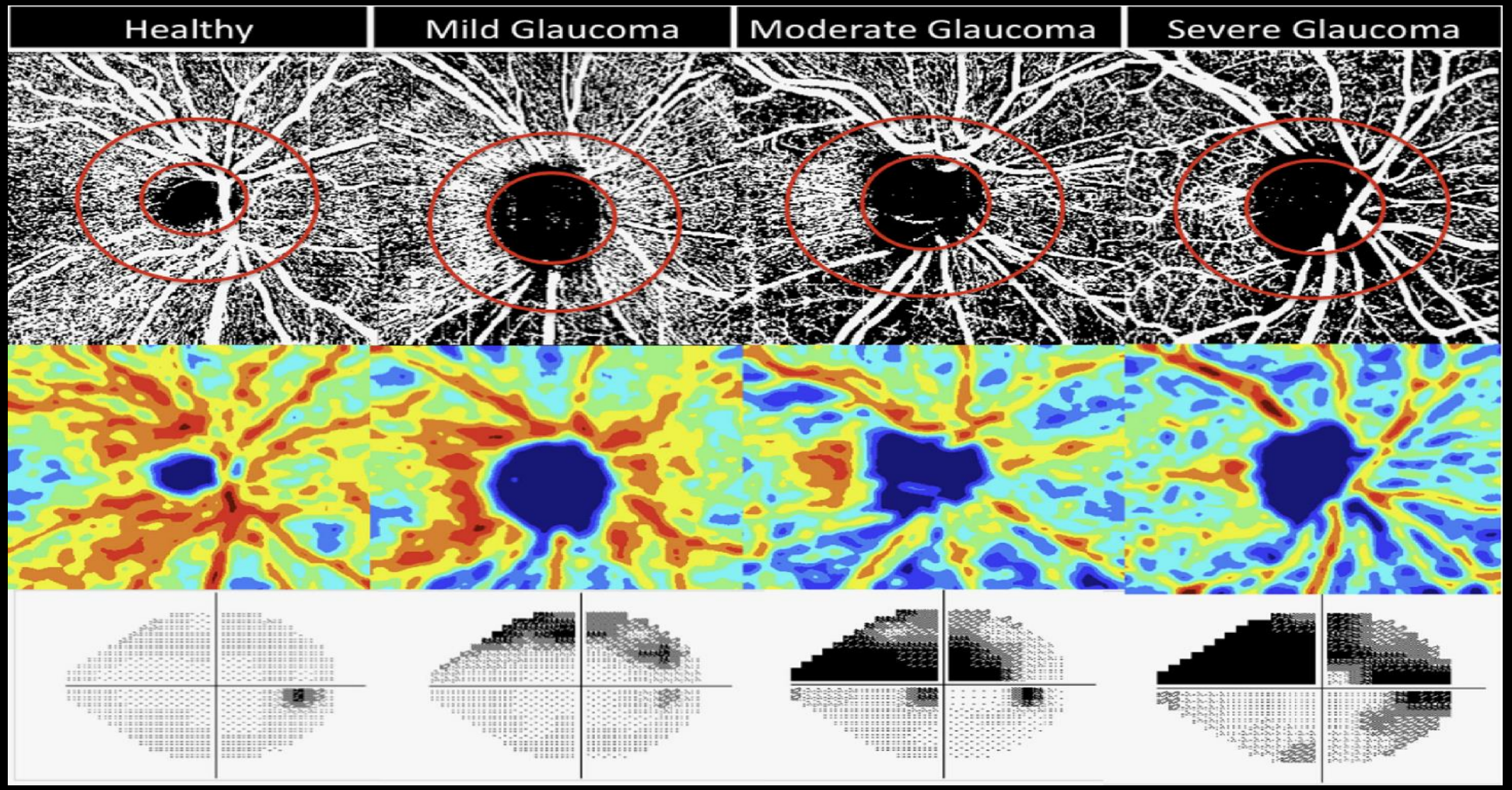
CHERECHEANU AP ET AL. CURRENT OPINION IN PHARMACOLOGY. FEB 2013. PP 36-42.

OCT-A and ONH PERFUSION



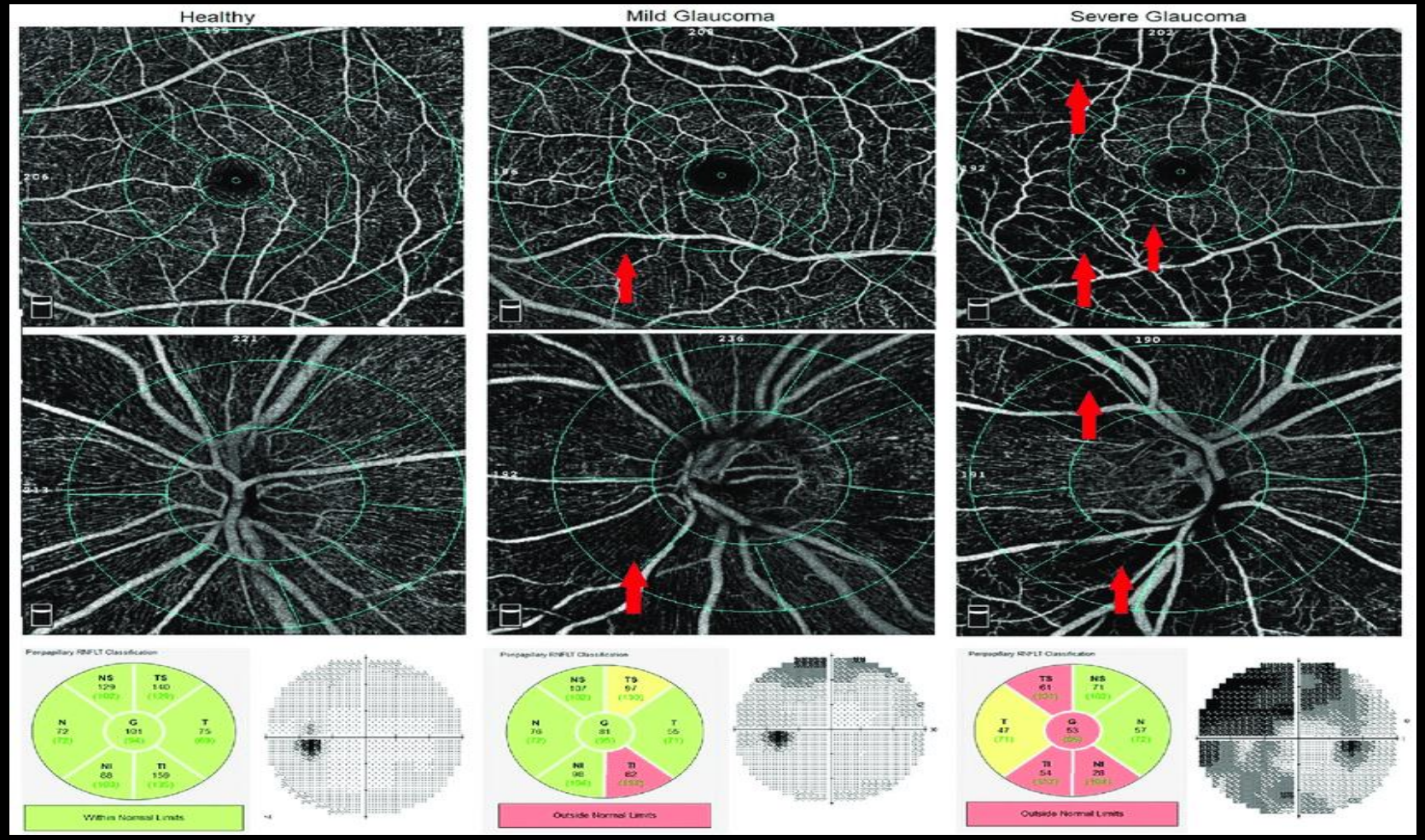
Graefes Arch Clin Exp Ophthalmol 253, 1557–1564 (2015)

OCT-A and ONH PERFUSION



Asia-Pacific Journal of Ophthalmology, 8, 115–125. (2019)

OCT-A and ONH / MACULA PERFUSION



July 2020. PLoS ONE

HYPOTHYROIDISM

- NEW AS OF 2020 PPP
- MECHANISM THEORIES
  - DECREASED CELLULAR METABOLISM
  - INCREASED SUSCEPTIBILITY TO GANGLION CELL LOSS
  - ALTERATIONS IN MUCOPOLYSACCHARIDES IN TM THAT INCREASES IOP

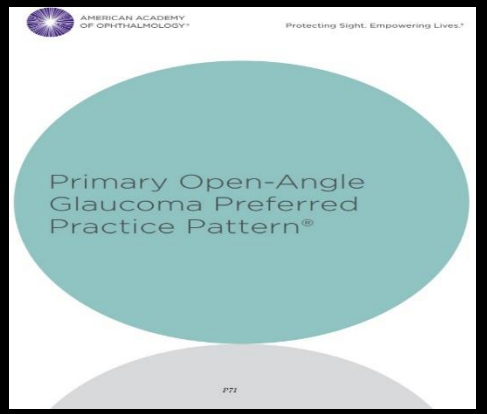
FAMILY HISTORY

- ROTTERDAM EYE STUDY
  - ALL SIBLINGS OF GLAUCOMA CASES AND CONTROLS EVALUATED
    - ODDS OF POAG WERE 9.2X HIGHER IF FIRST DEGREE RELATIVE WITH POAG
      - FIRST DEGREE = SIBLING OR PARENT

- BALTIMORE EYE SURVEY AND LALES
  - ODDS OF POAG 1.92 AND 2.85 IF FIRST DEGREE RELATIVE
  - ODDS OF 3.7 AND 3.47 IF SIBLING WITH GLAUCOMA
  - 5X HIGHER IF TWO OR MORE SIBLINGS

THE EYE EXAM AND… OPPORTUNITIES TO SUSPECT GLAUCOMA

- VA
- PUPILS
- SLIT-LAMP
- IOP
- CENTRAL CORNEAL THICKNESS
- GONIOSCOPY



- DILATED FUNDUS EVALUATION
- MAGNIFIED, STEREOSCOPIC EVAL OF
  - ONH
  - RNFL
- DOCUMENTATION OF ONH
  - STEREOPHOTOGRAPHY

  OR
  - COMPUTER BASED ANALYSIS
- VISUAL FIELD BY AUTOMATED PERIMETRY

AAO Preferred Practice Pattern, POAG Suspect, 2020

REFRACTIVE ERROR

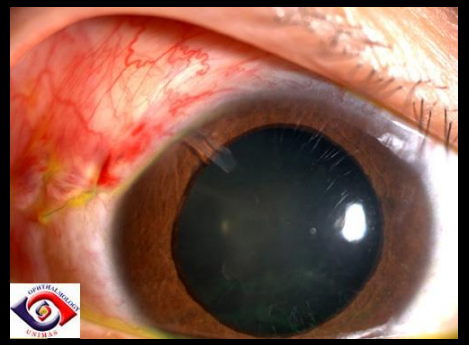
- MYOPIA
  - 1999 BLUE MOUNTAINS STUDY (AUSTRALIA)
    - 3654 PATIENTS
    - GLAUCOMA DIAGNOSED BASED ON VISUAL FIELDS, OPTIC DISC CUPPING, RIM THINNING
    - GLAUCOMA PRESENT IN
      - 1.5% NO MYOPIA. 4.2% OF LOW MYOPIA (1-3D). 4.4% MODERATE-HIGH MYOPIA (>3D)
    - CONCLUSIONS
      - 2-3X GREATER RISK IF MYOPIC, INDEPENDENT OF OTHER GLAUCOMA RISK FACTORS AND IOP
  - LALES
    - LONGER AXIAL LENGTH HAS HIGHER PREVALENCE OF POAG
  - POSSIBLE MECHANISM
    - WEAKER SCLERAL SUPPORT AT ONH = GREATER SUSCEPTIBILITY OF OPTIC NERVE TO DAMAGE
- HYPEROPIA
  - RISK OF ANGLES BEING NARROW
    - CONSIDER GONIOSCOPY

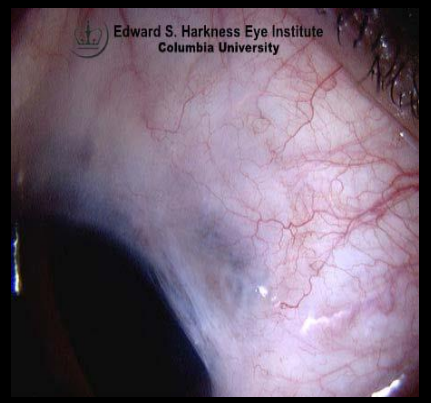
PRELIMINARY TESTING

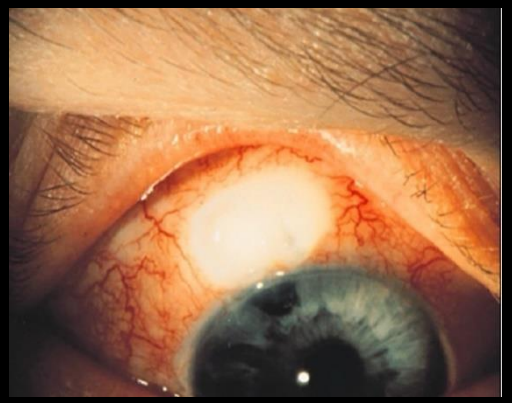
- VISUAL STATUS
  - POSSIBLY NORMAL OR
    - 20/20 OR REDUCED DUE TO SEVERE GLAUCOMA
      - OR AMBLYOPIA OR OTHER DISEASE
- LENSOMETRY / AUTOREFRACTION
  - POSSIBLY EMMETROPIA OR
    - AXIAL MYOPES
      - SUSCEPTIBLE TO ONH DAMAGE
    - HYPEROPES
      - RISK OF NARROW ANGLES
- PUPILS
  - POSSIBLY NORMAL OR
    - APD POSSIBLE IF ASYMMETRIC GLAUCOMA
      - OR OTHER DISEASE
    - MID-DILATED IF ACUTE ANGLE CLOSURE
    - SURGICAL
      - LOOK FOR BLEB
- CONFRONTATION FIELDS
  - POSSIBLY NORMAL OR
    - CONSTRICTED
      - INF NASAL OR 360 DEGREES
      - GLAUCOMA OR OTHER DISEASE

SLIT LAMP EXAMINATION

- CONJUNCTIVA / SCLERA
  - POSSIBLY NORMAL OR…
    - HYPEREMIA
      - POSSIBLE SIGN OF INFLAMMATION
        - ? UVEITIC
      - ON PROSTAGLANDIN OR OTHER
    - SCARRING
      - ? H/O FAILED SURGERY
    - OTHER INDICATORS
      - TUBE PLATE
      - SUTURES
      - FILTRATION BLEB

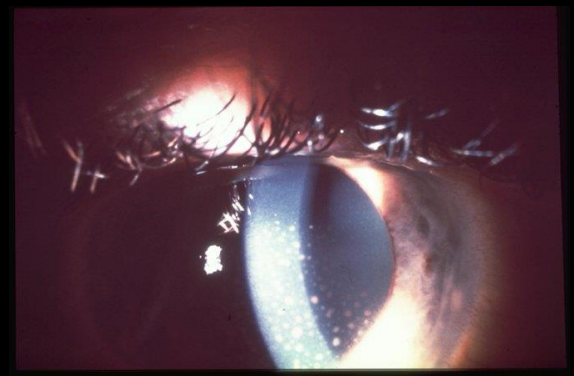


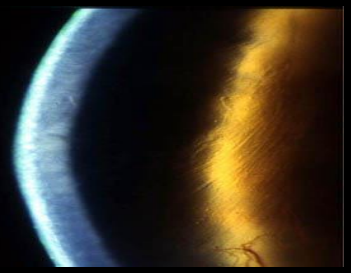


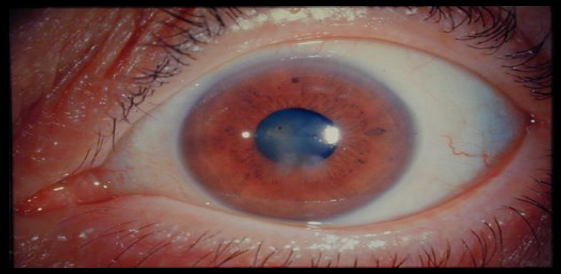


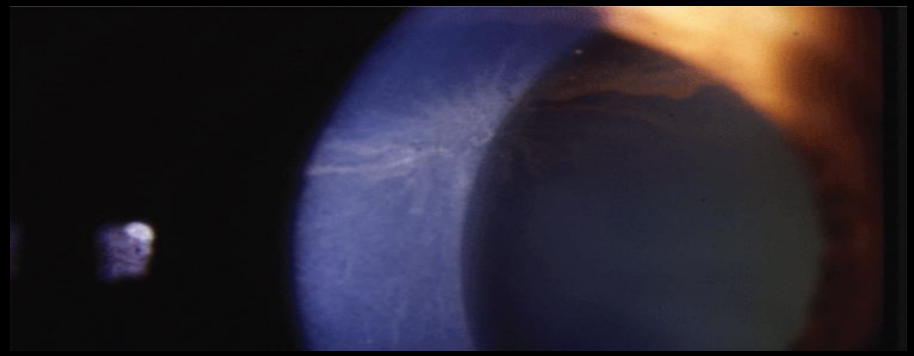
SLIT LAMP EXAMINATION

- CORNEA
  - POSSIBLY NORMAL OR…
    - SCARRING
    - PIGMENT
      - KRUKENBERG SPINDLE
    - KERATIC PRECIPITATES
    - EDEMA
      - IF PRESSURE HIGH
    - GUTTATA
      - MAY THROW OFF IOP READING
    - WHORL KERATOPATHY
      - MAY BE ON RHO-KINASE INHIBITOR



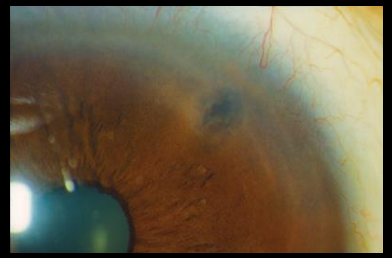


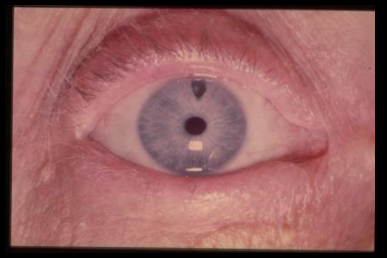


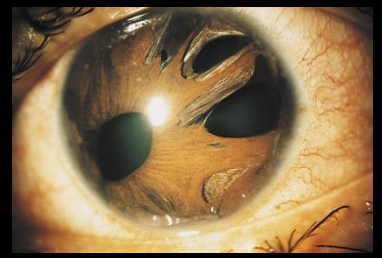


SLIT LAMP EXAMINATION

- IRIS
  - NORMAL OR…
    - TRANSILLUMINATION DEFECTS
    - WHITE FLAKES AT PUPILLARY BORDER
    - SPHINCTER TEARS
    - HETEROCHROMIA
    - KOEPPE OR BUSACCA NODULES
    - IRIDECTOMY / IRIDOTOMY
    - NEOVASCULARIZATION
      - RARE IF ASYMPTOMATIC
    - DEVELOPMENTAL ABNORMALITIES
      - ICE SYNDROMES (UNILATERAL)
      - AXENFELD-REIGER'S (BILATERAL)

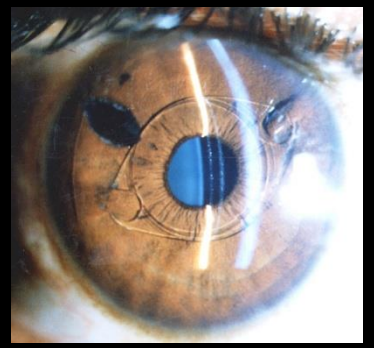


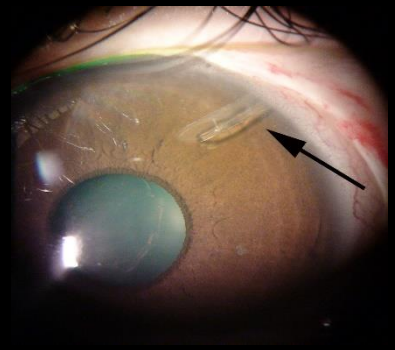


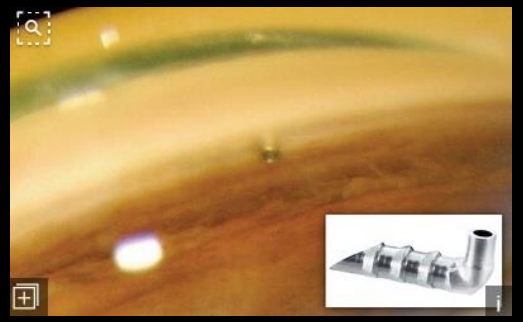


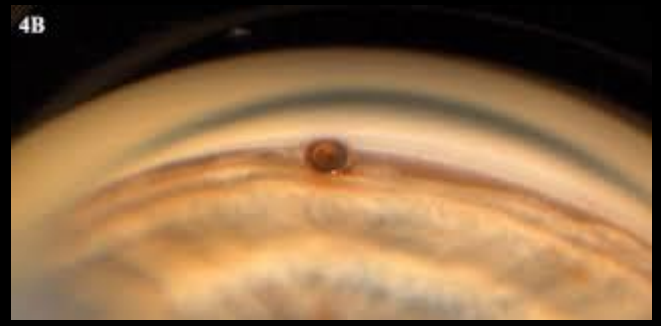
SLIT LAMP EXAMINATION

- ANTERIOR CHAMBER
  - NORMAL OR…
    - CELLS AND / OR FLARE
      - ACTIVE INFLAMMATION
    - SYNECHIAE
      - PRIOR INFLAMMATION
    - TUBES / EXPRESS SHUNT
    - ACIOL
      - COMPLICATED CATARACT
      - COMBINED PROCEDURE
    - MIGS ?
      - WILL NEED GONIO LENS VIEW THEM
  - ESTIMATE DEPTH
    - < GRADE 2, DO GONIOSCOPY

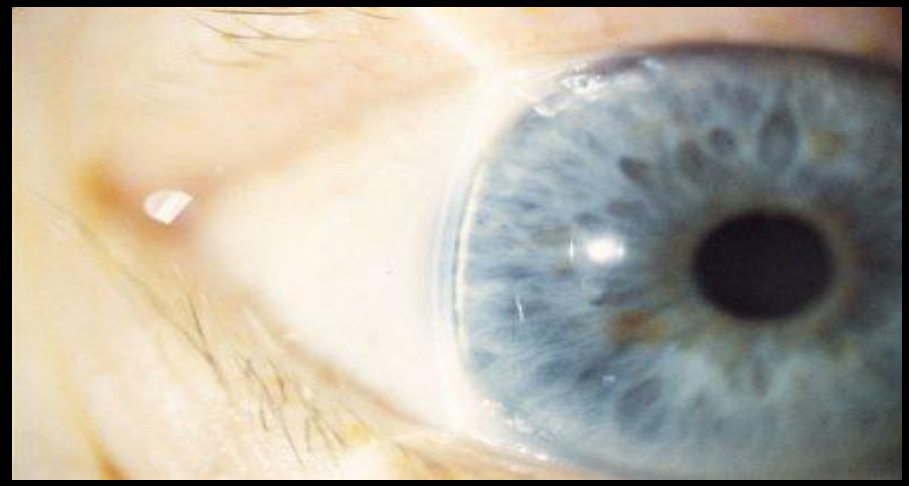


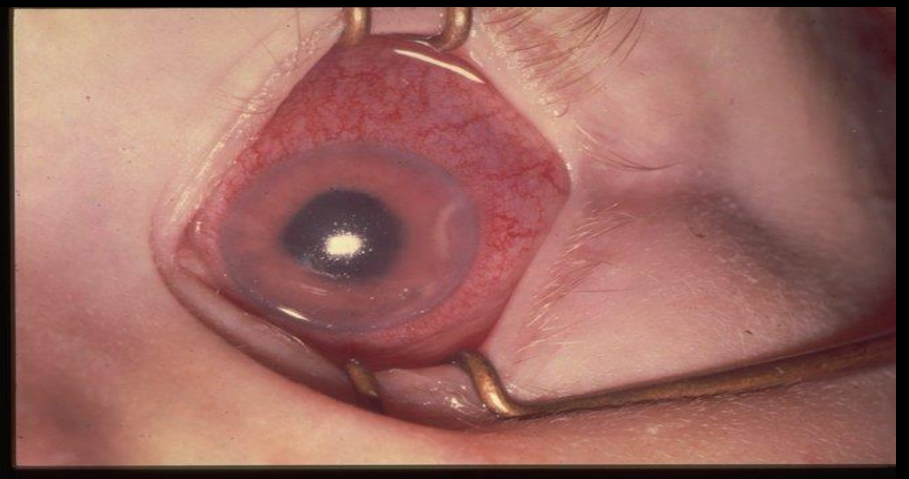






ESTIMATE ANGLE DEPTH



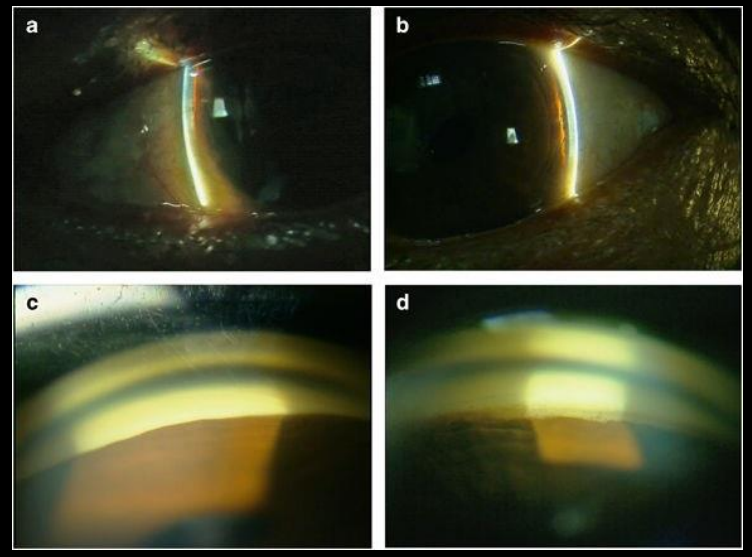


GONIOSCOPY

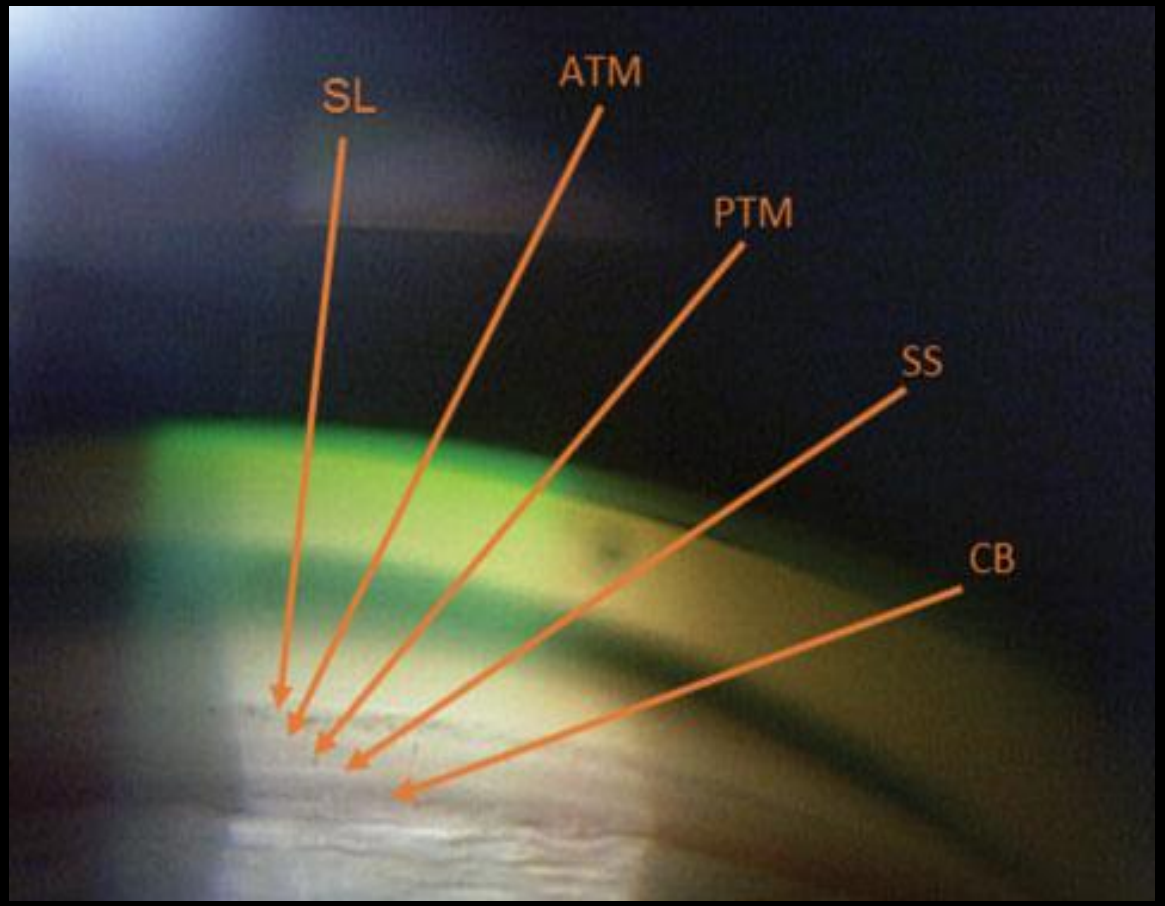
- WHY DO IT?
  - IS IT SAFE TO DILATE?
    - DONE IF < GRADE 2 ON VAN HERICK
    - CONSIDER ON ALL > +2.50
  - DIFFERENTIATE
    - OPEN VS ANGLE CLOSURE GLAUCOMA
      - IF NARROW, MAY INFLUENCE TREATMENT OPTIONS
    - POAG VS SECONDARY OAG
      - IF SECONDARY, MAY INFLUENCE TREATMENT OPTIONS
  - MONITOR FOR CHANGE
  - ANGLE CLOSURE SUSPECT
    - IF < 180 DEGREES OF VISIBLE TM (POSTERIOR/PIGMENTED)

TABLE 1
Original van Herick grading scale

Van Herick's grading	Ratio of gap to limbal corneal section
Grade 1	<1:4
Grade 2	1:4
Grade 3	1:2
Grade 4	1:1 (or >1:1)

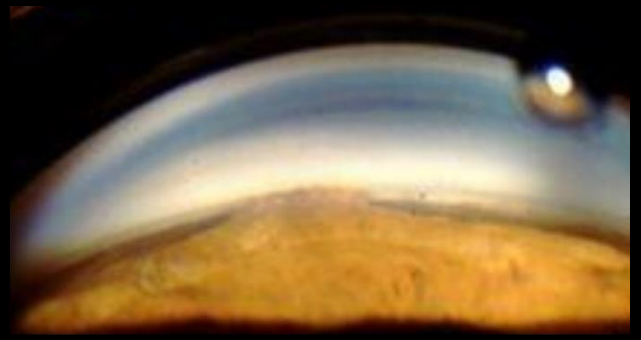


NORMAL VS ABNORMAL GONIOSCOPY

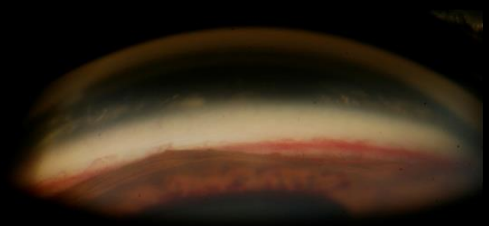


Cymbor, M. Review of Optometry. October 15, 2016

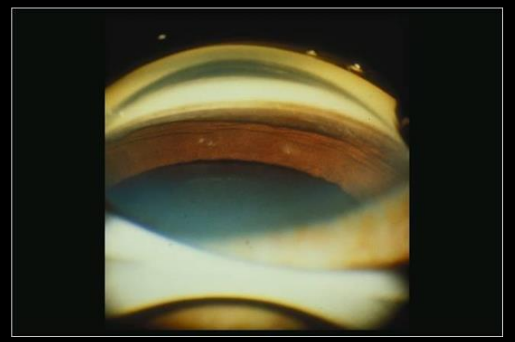
PIGMENT DISPERSION



PAS



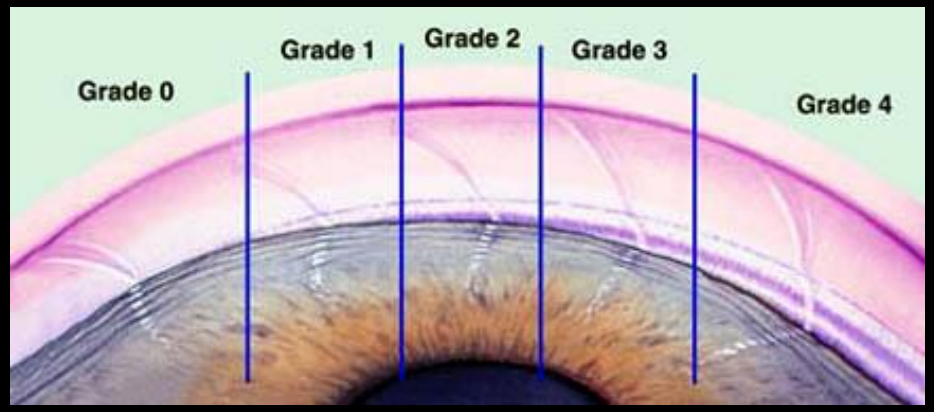
NVA

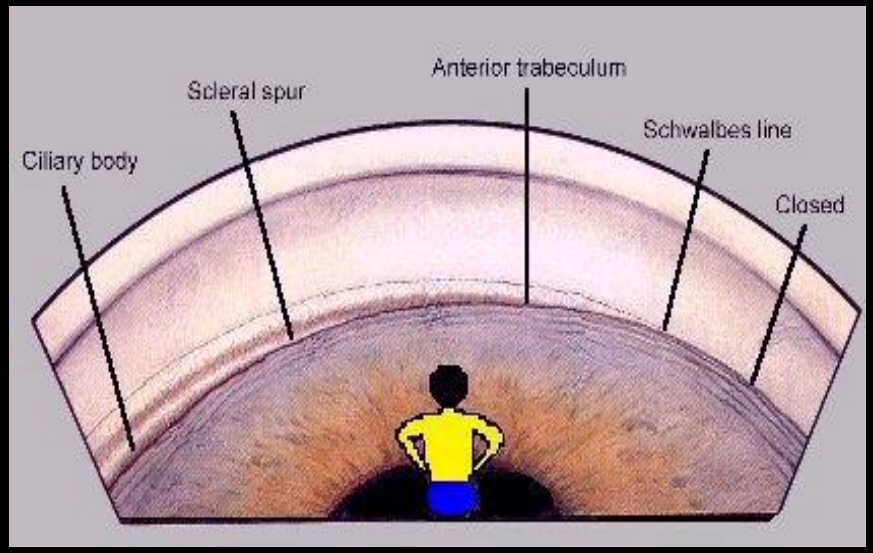


ANGLE RECESSION

GONIOSCOPY DOCUMENTATION

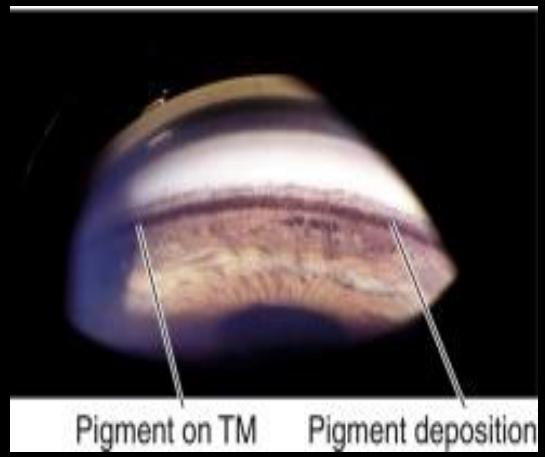
- SEVERAL GRADING SYSTEMS CAN BE USED
  - SHAFFER, SPAETH, SCHEIE (1957)
- 4-MIRROR IS PREFERRED
  - LESS INVASIVE, CAN COMPRESS
- WHAT TO LOOK FOR
  - MENTALLY NOTE
    - OPEN, SUSPICIOUSLY NARROW
    - ASYMMETRIC DIFFERENCES
  - <u>SIMPLE METHOD…RECORD THE DEPTH</u>
    - MOST POSTERIOR STRUCTURE VISUALIZED IN ALL QUADRANTS OD AND OS
    - IF NARROW, DOES ANGLE OPEN WITH COMPRESSION?
  - <u>RECORD PRESENCE / ABSENCE OF</u>
    - PIGMENT, PAS, RECESSION, NV

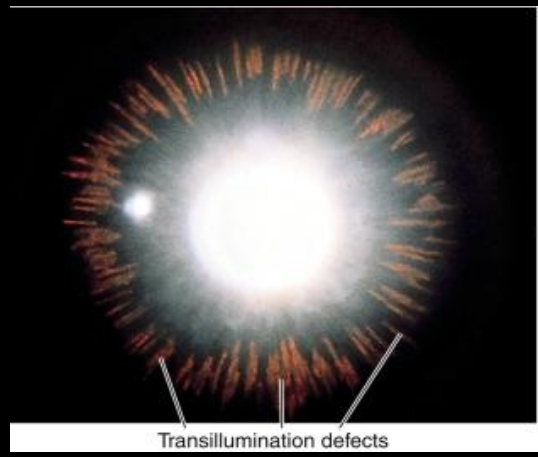


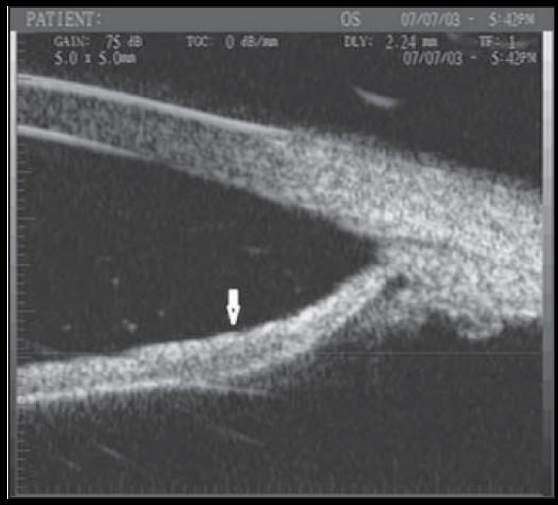


PDS / PIGMENTARY GLAUCOMA

- KRUKENBERG SPINDLE AND/OR IRIS TRANSILLUMINATION DEFECTS (SPOKE-LIKE, MID-PERIPHERAL)
- DARKLY PIGMENTED POSTERIOR TM ON GONIO
- MIDPERIPHERAL POSTERIOR IRIS BOWING
- TRANSIENT EPISODES OF BLURRED VISON OR SEEING HALOS AROUND LIGHTS AFTER EXERCISE
- MODERATELY MYOPIC MEN < AGE 50
- MAPPED TO CHROMOSOME 7q35-q36 (GPDS1 GENE)
- IOP MAY SPIKE
  - MECHANISM
    - OBSTRUCTION OF TRABECULAR MESHWORK BY PIGMENT AND PIGMENT-LADEN MACROPHAGES
- GLAUCOMA MAY DEVELOP IN 25-50% WITH PDS

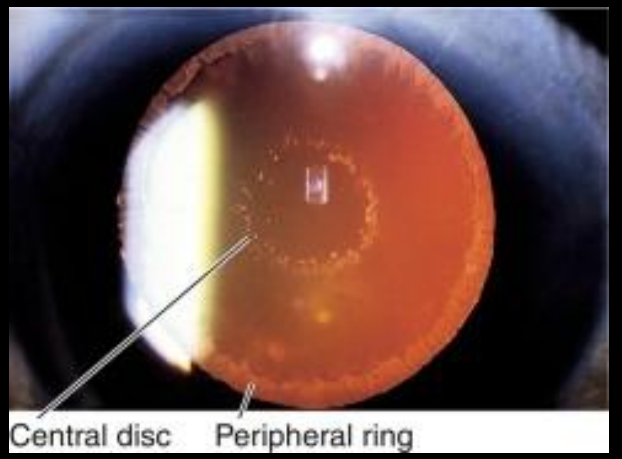


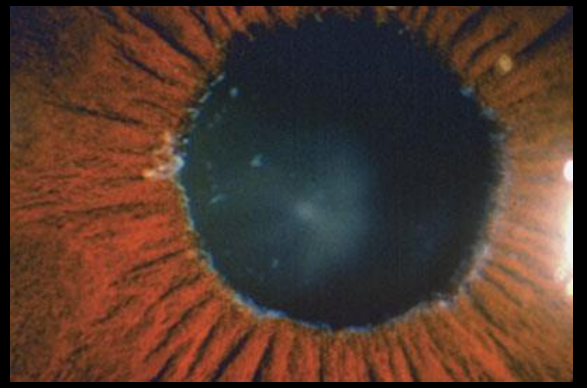




PSEUDOEXFOLIATION / GLAUCOMA

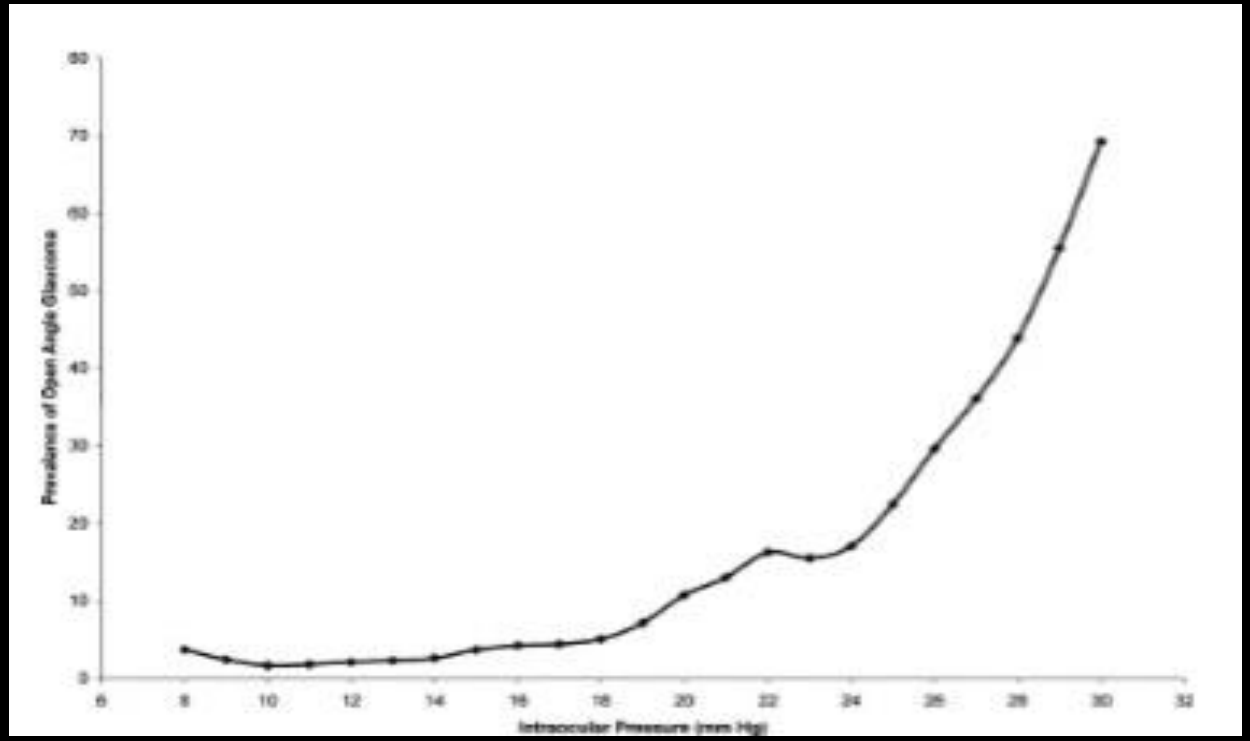
- GRAY-WHITE MATERIAL DEPOSITION ON PUPIL MARGIN, ANTERIOR LENS CAPSULE OR CORNEAL ENDOTHELIUM
  - ALSO FOUND IN SKIN, HEART, LUNGS
- LOSS OF PUPILLARY RUFF, TI DEFECTS
- PIGMENTED TM AND SAMPAOLESI'S LINE
- WHITE MATERIAL ON ZONULES
- BILATERAL > UNILATERAL, ASYMMETRIC
- RARELY < AGE 65
- IOP MAY SPIKE
  - MECHANISM
    - FROM ACCUMULATION OF MATERIAL IN ANGLE OR LENTICULAR PUPILLARY BLOCK FROM ZONULAR LAXITY AND MOVEMENT OF LENS
- 60% MAY DEVELOP OC HTN OR GLAUCOMA





INTRAOCULAR PRESSURE

- A RISK FACTOR ONLY
  - NOT PART OF THE DEFINITION
- PREVALENCE OF GLAUCOMA INCREASES WITH LEVEL OF IOP
- THE HIGHER THE IOP, THE GREATER THE RISK AND SEVERITY OF GLAUCOMA
- RISK OF DEVELOPING GLAUCOMA
  - IOP > 21 mmHg 16X RISK VS < 16 mmHg
- DEVELOPING VF DEFECT OVER 5 YEARS
  - 6.7% IF IOP > 20 mmHg
  - 1.5% IF IOP < 20 mmHg



the Los Angeles Latino Eye Study. Am J Ophthalmol 2008;146:743.

INTRAOCULAR PRESSURE

- WORRIED ABOUT THE IOP > 21mmHg?
  - THAT NUMBER IS ARBITRARY
    - 2 STANDARD DEVIATIONS ABOVE THE MEAN IN THE EUROPEAN POPULATION
- WHAT IF THE IOP IS NOT “HIGH”?
  - IT DOES NOT MATTER
    - BALTIMORE EYE SURVEY
      - 55% NEWLY DIAGNOSED POAG HAD INITIAL IOP < 22 mmHg
      - 24% STILL HAD IOP < 22 mmHg ON TWO READINGS
      - 16% EVEN HAD IOP < 22 mmHg ON THREE READINGS

INTRAOCULAR PRESSURE

- IF IOP IS NOT ELEVATED
  - NO GUARANTEE OF NORMALCY
- IF IOP IS ELEVATED (≥ 22 mmHg) = FURTHER TESTING IS RECOMMENDED
  - GOAL IS TO FIND THE CAUSE
  - POAG IS A DIAGNOSIS OF EXCLUSION
  - THE CAUSE MAY INFLUENCE TREATMENT OPTIONS
- IF IOP IS ASYMMETRIC
  - NORMALS RARELY DIFFER BY 2 mmHg
  - POAG MAY HAVE MODERATE ASYMMETRY
  - IF WIDELY DISPARATE, CONSIDER UNILATERAL PROCESS (SECONDARY CAUSE)
    - PSEUDOEXFOLIATION, TRAUMA, ETC.

INTRAOCULAR PRESSURE

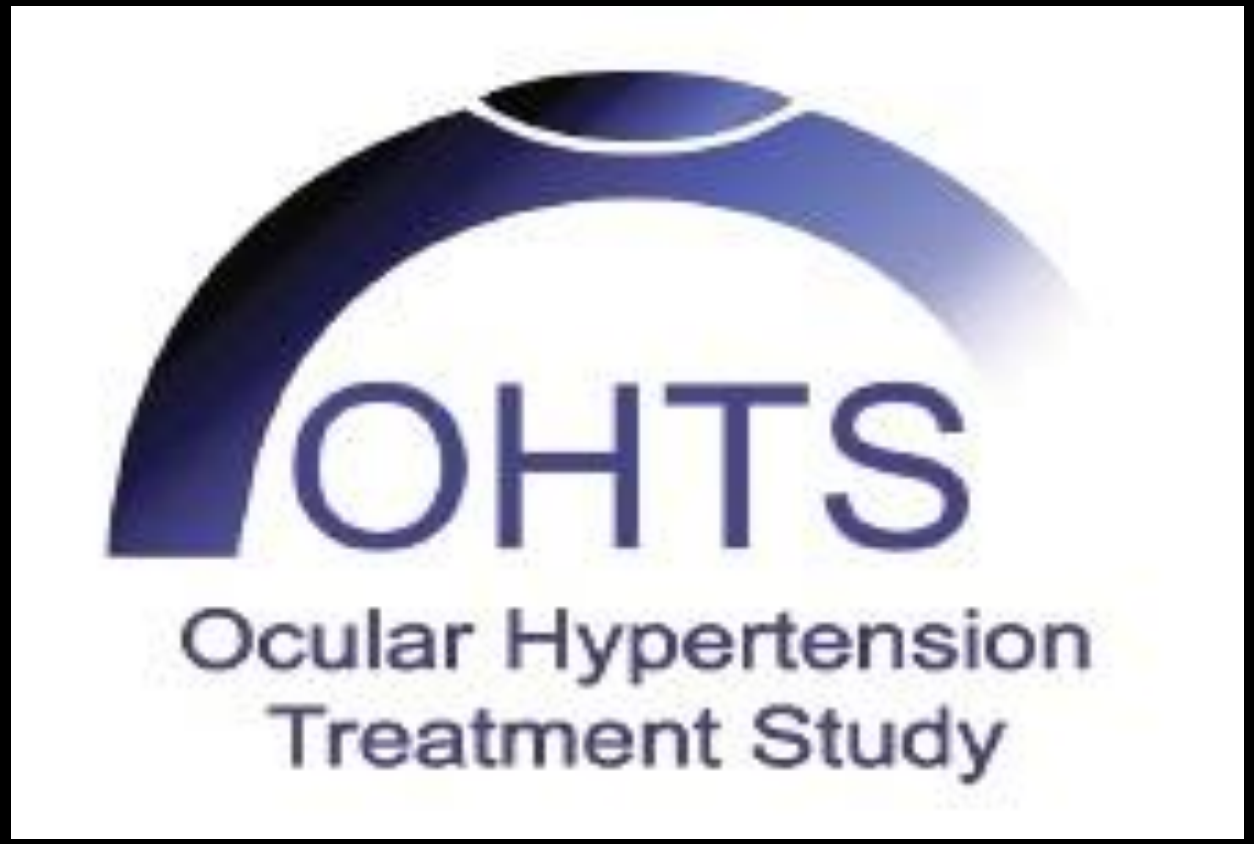
- HOW MANY IOP READINGS SHOULD I GET?
  - AT LEAST 3 READINGS, ON DIFFERENT DAYS, AT DIFFERENT TIMES OF THE DAY
- WHAT DEVICE SHOULD I USE?
  - APPLANATION PREFERRED FOR MANAGEMENT
  - OTHER OPTIONS
    - ICARE, ORA, DCT, ETC.
  - NCT / TONOPEN / ACCEPTABLE FOR SCREENING
    - NOT AS ACCURATE / REPEATABLE FOR HIGH AND LOW IOP
  - BE CONSISTENT
  - TRAIN TECHNICIANS WELL, REPEAT AS NEEDED
- RECORD TIME TESTED
  - CONSIDER MODIFIED DIURNAL TESTING

INTRAOCULAR PRESSURE

- BUT…
  - SUSCEPTIBILITY OF OPTIC NERVE DAMAGE VARIES
  - 3-6 MILLION PEOPLE HAVE OCULAR HYPERTENSION WITHOUT GLAUCOMATOUS DAMAGE

IOP

- FROM THE OHTS
  - 1300 PATIENTS
  - RESULTS
    - IOP RELATED INFO
      - LOWERING IOP DELAYS OR PREVENTS DEVELOPMENT OF GLAUCOMA IN PATIENTS WITH ELEVATED IOP
      - MAJORITY OF OCULAR HTN PATIENTS DO NOT DEVELOP GLAUCOMA
      - ALL PATIENTS WITH OCULAR HTN DO NOT NEED TREATMENT
      - TREAT THOSE AT GREATEST RISK



Gordon, MO, et al. *Arch Ophthalmol. 2002;120:714-720*

IOP AND CENTRAL CORNEAL THICKNESS

- FROM THE OHTS
  - 1300 PATIENTS
  - RESULTS
    - CCT RELATED INFO
      - INFLUENCES GOLDMANN TONOMETRY
      - A RISK FACTOR FOR DEVELOPING POAG
        - THICKNESS < 555 um 3X RISK COMPARED TO > 588
      - RISK FACTOR FOR PROGRESSION?
        - NOT ALL STUDIES AGREE
        - STILL TO BE DETERMINED

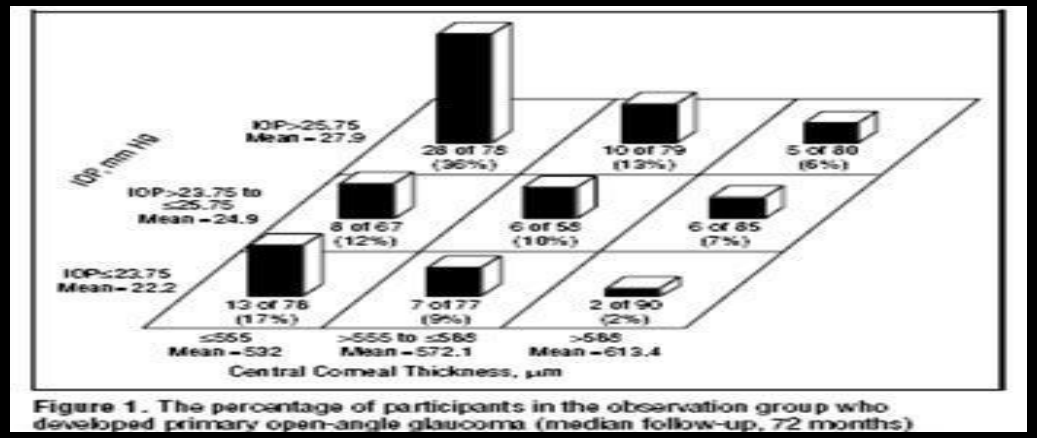


Figure 1. The percentage of participants in the observation group who developed primary open-angle glaucoma (median follow-up, 72 months)

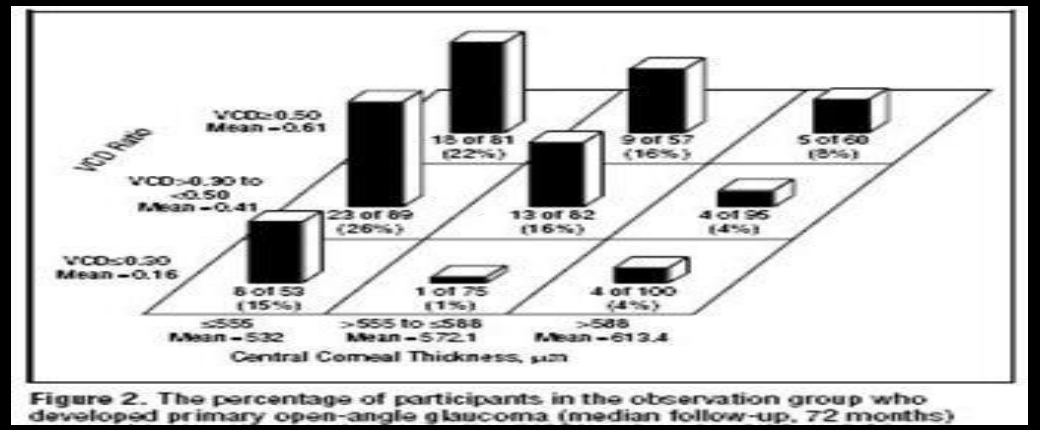


Figure 2. The percentage of participants in the observation group who developed primary open-angle glaucoma (median follow-up, 72 months)

Gordon, MO, et al. *Arch Ophthalmol. 2002;120:714-720*

CENTRAL CORNEAL THICKNESS

- RACIAL VARIATIONS ARE PRESENT
  - AFRICAN AMERICAN 534 um
  - LATINO 546 um
  - CAUCASIAN 556 um
- SAY NO TO NOMOGRAMS
- THINK: THIN / NORMAL / THICK
  - THIN = AT RISK

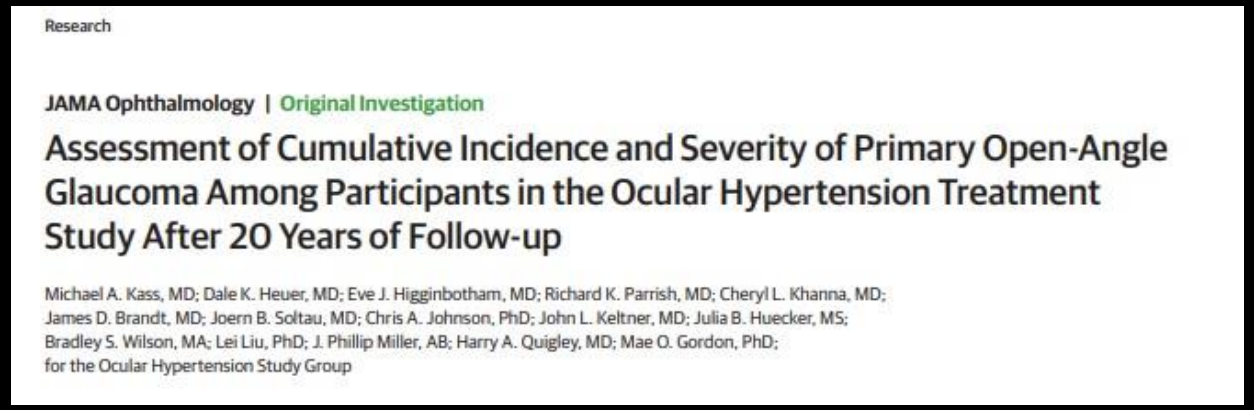
"THE IMPLICATION THAT IOP CAN BE CORRECTED WITH AN ARITHMETIC, LINEAR CORRECTION FACTOR OF SOME mmHg / um CLEARLY REPRESENTS AN OVERSIMPLIFICATION OF WHAT IS UNDOUBTEDLY A COMPLEX AND NONLINEAR RELATIONSHIP BETWEEN CORNEAL THICKNESS AND TRUE IOP"

BRANDT JD, ET AL

OHTS, OPHTHALMOLOGY 2001; 108: 1779-1788

OHTS AT 20YRS*
(MORE DATA TO COME)

- ORIGINAL STUDY
  - 2/94 TO 12/08, 1636 PATIENTS IN 22 CLINICS
  - MEAN AGE 55.4 YO
    - DOES EARLY TREATMENT REDUCE THE INCIDENT OF POAG IN PATIENTS WITH OHT?
    - DO BASELINE DEMOGRAPHIC AND CLINICAL FACTORS PREDICT WHICH PATIENTS WITH OHT ARE AT LOW/MEDIUM/HIGH RISH OF DEVELOPING POAG?
- NEW REPORT AT 20YRS
  - 971 PATIENTS INCLUDED (515 PATIENTS HAD DIED)
  - MEAN AGE 73.8 YO
  - 56.9% WOMEN, 69.6% WHITE, 24.9 AA
- 20 YR RESULTS
  - INCIDENCE OF POAG IN 1 OR BOTH EYES
    - OBSERVATION GROUP 49.3%
    - TREATMENT GROUP 41.9%
  - 25.2% DEVELOPED VF LOSS



Research

JAMA Ophthalmology | Original Investigation

Assessment of Cumulative Incidence and Severity of Primary Open-Angle Glaucoma Among Participants in the Ocular Hypertension Treatment Study After 20 Years of Follow-up

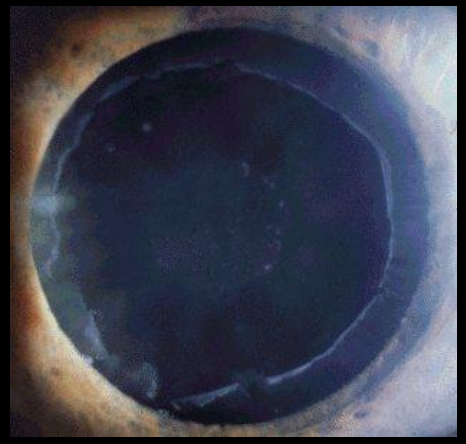
Michael A. Kass, MD; Dale K. Heuer, MD; Eve J. Higginbotham, MD; Richard K. Parrish, MD; Cheryl L. Khanna, MD; James D. Brandt, MD; Joern B. Soltau, MD; Chris A. Johnson, PhD; John L. Keltner, MD; Julia B. Huecker, MS; Bradley S. Wilson, MA; Lei Liu, PhD; J. Phillip Miller, AB; Harry A. Quigley, MD; Mae O. Gordon, PhD; for the Ocular Hypertension Study Group

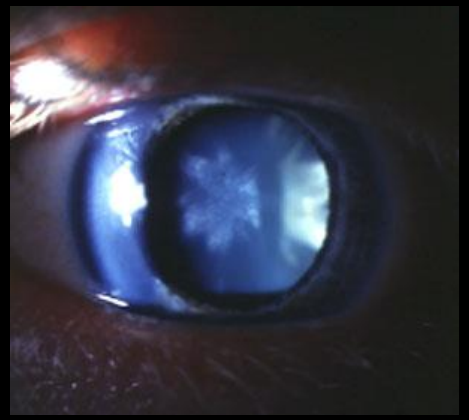
JAMA Ophthalmol. Published online April 15, 2021

* = NEW

SLIT LAMP EXAMINATION

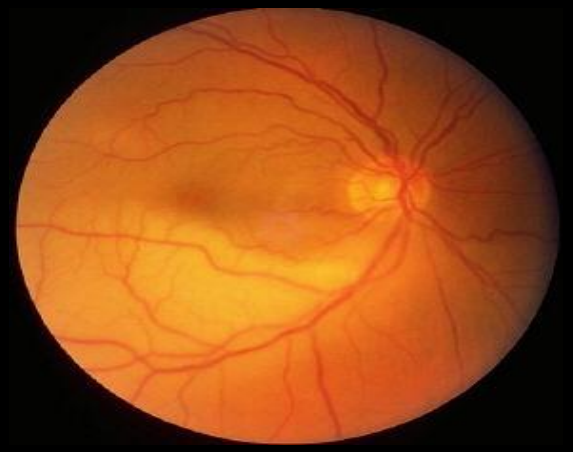
- LENS ASSESSMENT (TYPICALLY ONCE DILATED)
  - NORMAL OR
    - PIGMENT
      - TRAUMA, POSTERIOR SYNECHIAE
    - PSEUDOEXFOLIATION
    - SUBLUXATION
    - CATARACT
      - ROSETTE
      - PHACOLYTIC
      - PHACOMORPHIC
    - PSEUDOPHAKIC
      - UNEVENTFUL?
      - COMPLICATED?
        - ? PSEUDOEXFOLIATION VS OTHER

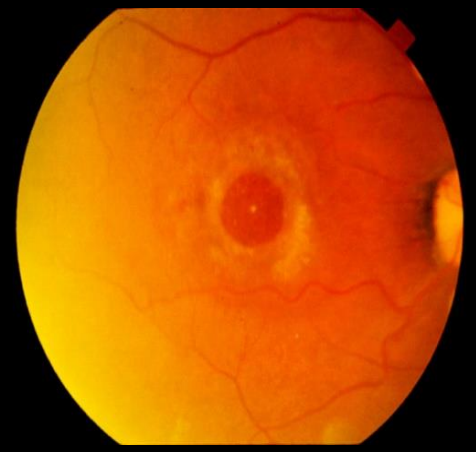


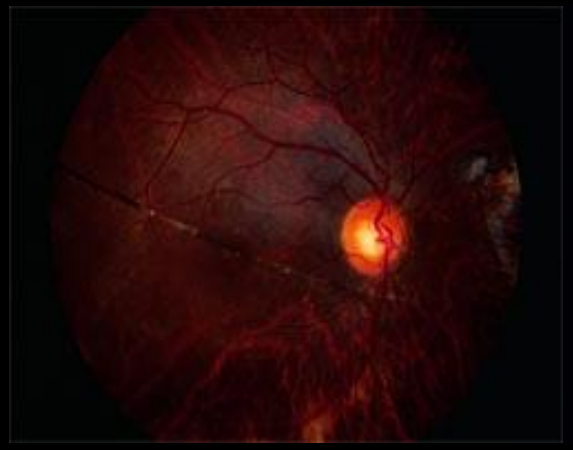


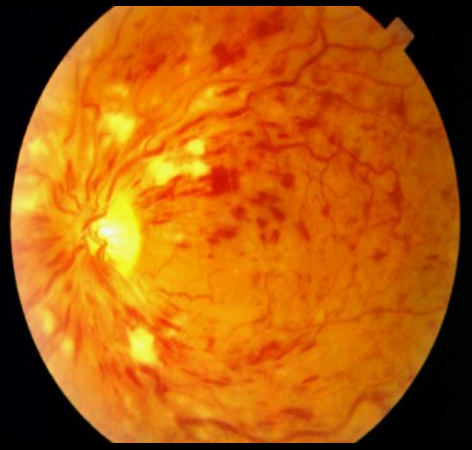
FUNDUS EXAMINATION

- NORMAL OR
  - POSSIBLE REASONS FOR VF DEFECT
    - ARTERY / VEIN OCCLUSION
    - OTHER RETINAL LESIONS
    - OTHER OPTIC NEUROPATHIES
    - S/P PRP
    - CHORIORETINAL SCAR
    - S/P CRYO / SCLERAL BUCKLE, ETC.
  - POSSIBLE SECONDARY GLAUCOMA
    - TRAUMA
      - CHORIORETINAL SCAR
      - CHOROIDAL RUPTURE
      - MACULAR HOLE
      - RETINAL TEAR / RD
    - NVG
      - VASCULAR OCCLUSION
      - OIS
      - SICKLE CELL
      - PDR
      - ETC.



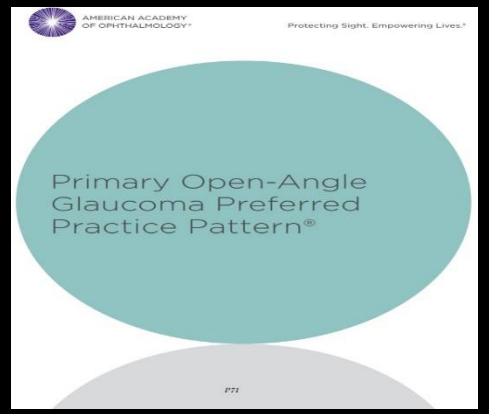




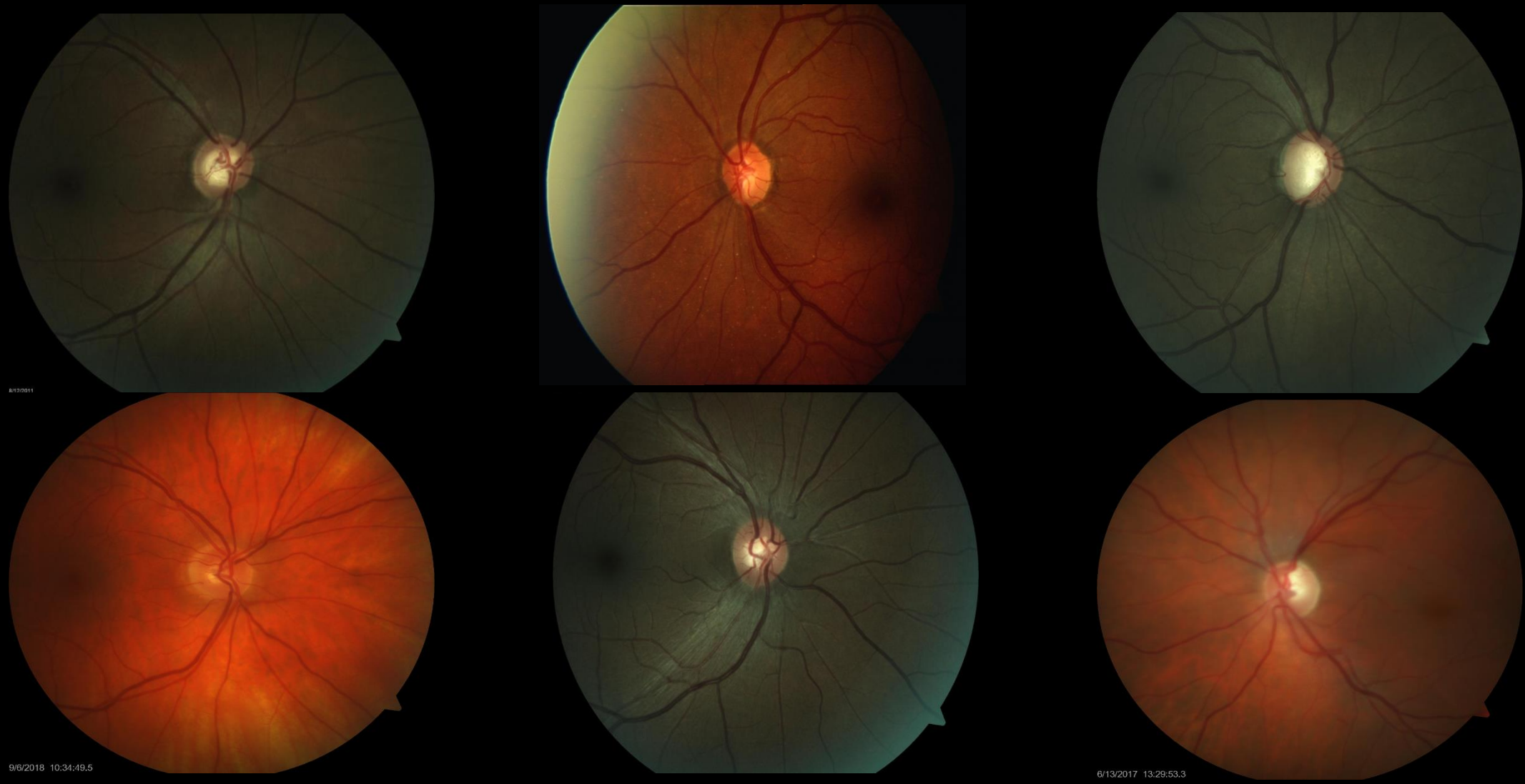


CLINICAL FINDINGS CHARACTERISTIC OF POAG

- OPTIC DISC STRUCTURAL ABNORMALITIES
- RETINAL NERVE FIBER LAYER STRUCTURAL ABNORMALITIES
- RELIABLE AND REPRODUCIBLE VISUAL FIELD ABNORMALITY



WHAT'S THE FIRST THING WE NOTICE WHEN LOOKING AT THE OPTIC NERVE?



THE C/D RATIO

"WHEN A CLINICIAN EXAMINES A PATIENT FOR THE FIRST TIME, THERE IS NO WAY TO DETERMINE WHETHER THE C/D RATIO OBSERVED HAS BEEN STABLE DURING THE PATIENT'S LIFETIME OR HAS ENLARGED AS PART OF THE DISEASE PROCESS, ASSUMING THAT NO PREVIOUS PHOTOGRAPHS OR MEASUREMENTS ARE AVAILABLE FOR COMPARISON"

GORDON MO, ET AL.

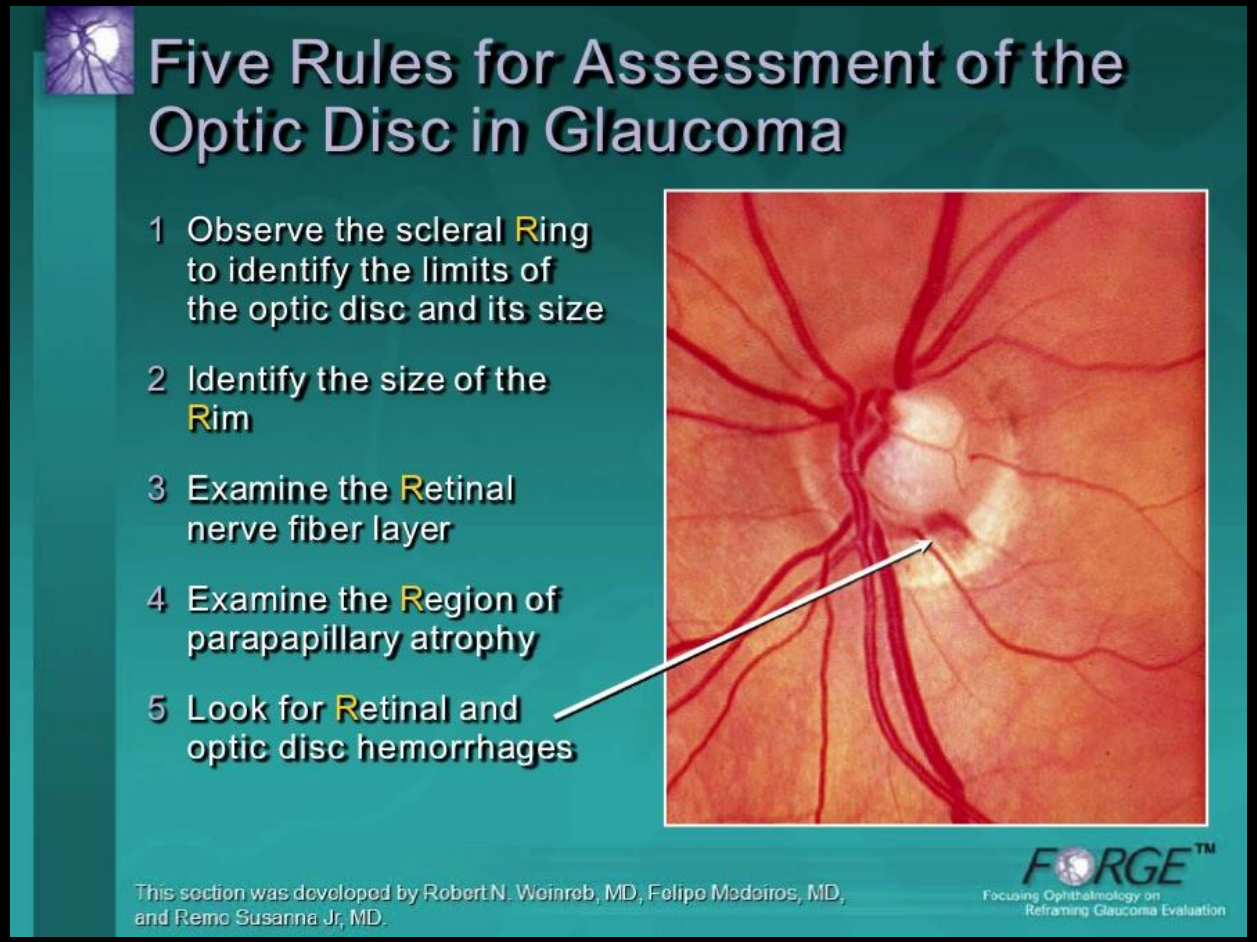
THE OHTS: BASELINE FACTORS THAT PREDICT THE ONSET OF POAG

ARCH OPHTHALMOL 2002; 120: 701-713.

GO BEYOND THE C/D

- WHY?
  - NO LINE SEPARATING NORMAL FROM GLAUCOMA
  - NORMAL VERTICAL C/D RATIO VARIES FROM 0.00-0.85
  - C/D RATIO OF $\geq$ 0.65 OCCURS IN 2.2 - 4% OF NORMALS
  - C/D RATIO IS A FUNCTION OF DISC DIAMETER
- REMEMBER
  - LOOK AT THE CONTOUR OF THE CUP, NOT THE COLOR
- DOCUMENT WHAT YOU SEE, NOT JUST THE C/D
  - DESCRIBE THE ONH

5 RULES OF ONH EVALUATION



REVIEW ARTICLE

Five rules to evaluate the optic disc and retinal nerve fiber layer for glaucoma

Murray Fingeret, O.D.,[a,b] Felipe A. Medeiros, M.D.,[c] Remo Susanna, Jr, M.D.,[d] and Robert N. Weinreb, M.D.[c]

[a]Department of Veterans Affairs, New York Harbor Health Care System, Brooklyn, New York; [b]State University of New York, State College of Optometry, New York, New York; [c]Hamilton Glaucoma Center and the Department of Ophthalmology, University of California, San Diego, California; and [d]Department of Ophthalmology, University of São Paulo, São Paulo, Brazil

A systematic approach for the examination of the optic disc and retinal nerve fiber layer is described that will aid in the detection of glaucoma. This approach encompasses 5 rules: evaluation of optic disc size, neuroretinal rim size and shape, retinal nerve fiber layer, presence of parapapillary atrophy, and presence of retinal or optic disc hemorrhages. A systematic process enhances the ability to detect glaucomatous damage as well as the detection of progression, and facilitates appropriate management.

Key Words: Glaucoma, optic nerve, optic disc, retinal nerve fiber layer, optic disc hemorrhages

The evaluation of the optic nerve and retinal nerve fiber layer (RNFL) is essential to the recognition of glaucomatous damage. An optic nerve or RNFL abnormality is often, but not always, the first sign of glaucomatous damage.[1,2] In the earliest stages of the disease, optic nerve and RNFL damage may be present, while standard automated perimetry is still within normal limits.[3-6] Early glaucomatous damage can be difficult to detect, requiring careful observation of the optic nerve and RNFL. Optic disc photography or optic nerve and RNFL imaging should be performed at the initial visit and yearly thereafter to document the optic nerve and RNFL status. In situations in which stability is in question, photography and imaging may be done at earlier intervals.

Recent studies have found the difficulty clinicians have in following guidelines proposed by professional organizations.[7,8] These guidelines recommend documentation of the optic disc appearance at the time of diagnosis and at periodic intervals during followup. In one study utilizing a chart review, 193 primary open-angle glaucoma (POAG) patients were followed up in 8 private practices in the Los Angeles area for at least 2 years.[8] Almost all patients had a photograph or drawing at the initial examination, but, at the final followup visit, 33.2% had not had an optic nerve drawing or photograph taken within the previous 2 years. Another 37.8% had not had optic disc photography since the initial examination. A more recent chart review evaluated records from 395 POAG patients in 6 managed care plans.[7] Only 53% had optic disc photographs or drawings at the initial examination.

Although several textbooks and articles describe the characteristic signs of glaucomatous damage to the optic disc,

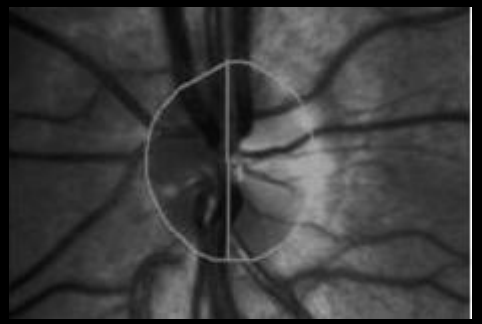
Fingeret M, Medeiros FA, Susanna Jr R, Weinreb RN. Five rules to evaluate the optic disc and retinal nerve fiber layer for glaucoma. Optometry 2005;76:661-8.

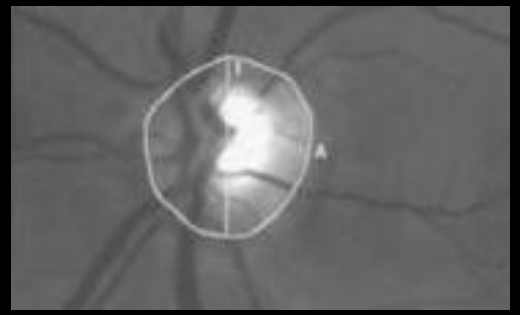
FINGERET M ET AL. OPTOMETRY 2005 pp 661-668.

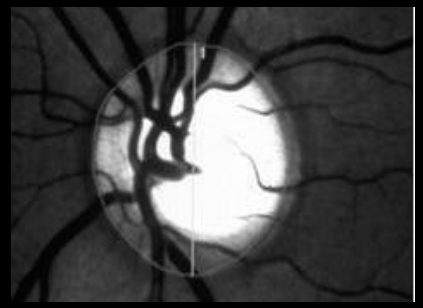
OPTIC NERVE EVALUATION TECHNIQUE

- DILATED PUPIL
- STEREOSCOPIC EVALUATION
- CLEAR 78/90/60/SUPERFIELD LENS AT SLIT-LAMP
- DETERMINE THE SIZE OF THE OPTIC NERVE
  - SMALL
  - MEDIUM
  - LARGE
- WHY?

WHICH ONE OF THESE PATIENTS DO YOU THINK HAS GLAUCOMA?

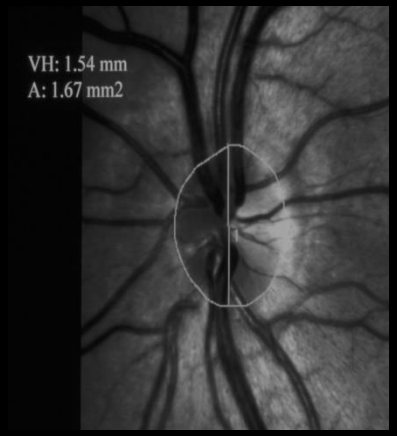


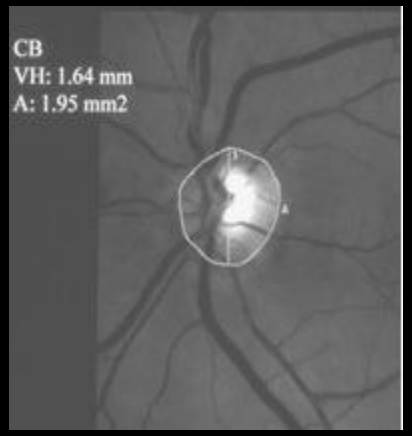


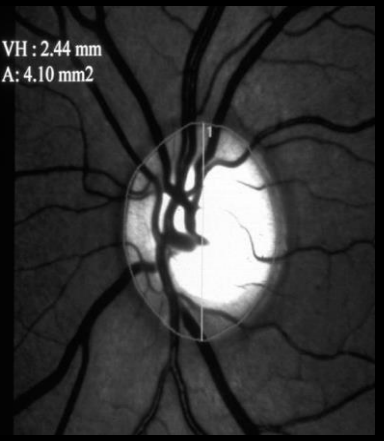


Expected Physiologic Cup Size Based on Measured Vertical Disc Diameter Using a 60 Diopter Lens At The Slit Lamp

	-2std	-1std	Mean	+1std	+2std
Vertical Height (mm)	1.6	1.8	2.0	2.2	2.4
Expected C/D ratio	0.0	0.2	0.4	0.6	0.8







HOW TO MEASURE OPTIC DISC DIAMETER

- USE 60D LENS AT SLIT LAMP OR CORRECTION FACTOR
  - SEE TABLE
- MAKE THIN VERTICAL BEAM, ADJUST BEAM HEIGHT
- READ HEIGHT OFF SCALE
  - > 2.2 mm IS A LARGE DISC
  - < 1.8 mm IS A SMALL DISC
  - THIS IS A ROUGH ESTIMATE
    - REFRACTIVE ERROR / WORKING DISTANCE INFLUENCE READINGS
- OTHER METHODS
  - DIRECT OPHTHAL (GROSS ESTIMATE)
    - SOME DEBATE AS TO IF LARGER THAN SMALLER SPOT OR MIDDLE SPOT?
  - CAMERAS WITH SOFTWARE
  - ADVANCED IMAGING DEVICES
    - HRT
      - DISC AREA, SMALL / AVG / LARGE
    - OCT CIRRUS CALCULATES DISC AREA
      - 1.06-3.38 mm2 (avg 1.83)
      - SMALL <1.63
      - MEDIUM 1.63-1.97
      - LARGE > 1.97

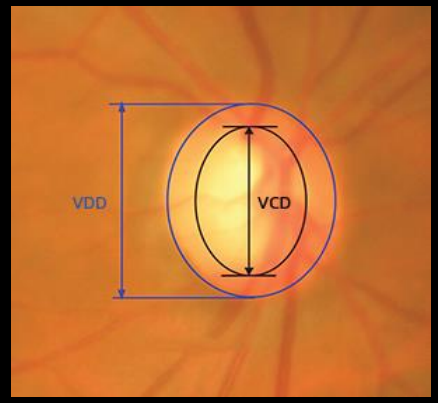


TABLE 3. *Magnification correction factors for the aspheric lenses*

Lens	Present study	Manufacturer's data
Volk		
60 D	0.88	0.92
78 D	1.11	1.15
90 D	1.33	1.39
Nikon		
60 D	1.03	1.02
90 D	1.63	1.54

Lim CS, O'Brien C, Bolton NM. A simple clinical method to measure the optic disk size in glaucoma. J Glaucoma. 1996;5:241–245.

OPTIC NERVE SIZE AWARENESS

- SIZE REALLY SHOULD BE ONE OF THE FIRST THINGS YOU THINK ABOUT
  - IT MAY SAVE YOU A LENGTHY / EXPENSIVE WORK-UP

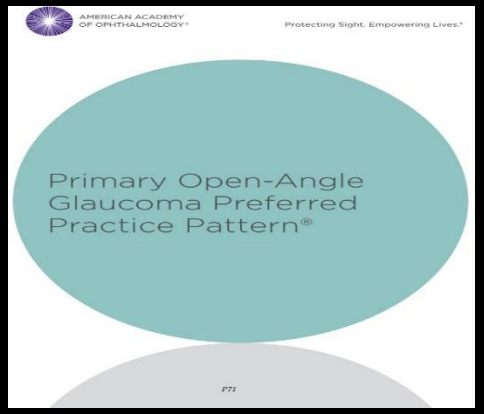
- SMALL SIZED OPTIC NERVES
  - WITH SMALL CUPS = NO GLAUCOMA
  - WITH AVERAGE OR LARGE CUPS = SUSPICIOUS, LOOK FOR OTHER SIGNS

- MEDIUM SIZED OPTIC NERVES
  - WITH SMALL CUPS = NO GLAUCOMA
  - WITH AVERAGE CUPS = NO GLAUCOMA IF NO OTHER SIGNS
  - WITH LARGE CUPS = SUSPICIOUS, LOOK FOR OTHER SIGNS

- LARGE SIZED OPTIC NERVES
  - WITH SMALL CUPS = NO GLAUCOMA
  - WITH AVERAGE CUPS = NO GLAUCOMA IF NO OTHER SIGNS
  - WITH LARGE CUPS = NO GLAUCOMA OR SUSPICIOUS, LOOK FOR OTHER SIGNS

OPTIC DISC STRUCTURAL ABNORMALITIES

- DISC RIM CHANGES AT SUPERIOR OR INFERIOR POLES (ISNT RULE)
  - DIFFUSE THINNING OF RIM
  - FOCAL NARROWING OF RIM
  - NOTCHING OF RIM
- PROGRESSIVE NEURORETINAL RIM NARROWING / INCREASED CUPPING
- HEMORRHAGES AT DISC RIM, PARAPAPILLARY RNFL, LAMINA
- OPTIC DISC NEURAL RIM ASYMMETRY OF THE TWO EYES
  - CONSISTENT WITH LOSS OF NEURAL TISSUE
- LARGE EXTENT OF PARAPAPILLARY ATROPHY



DISC RIM CHANGES AT SUPERIOR OR INFERIOR POLES

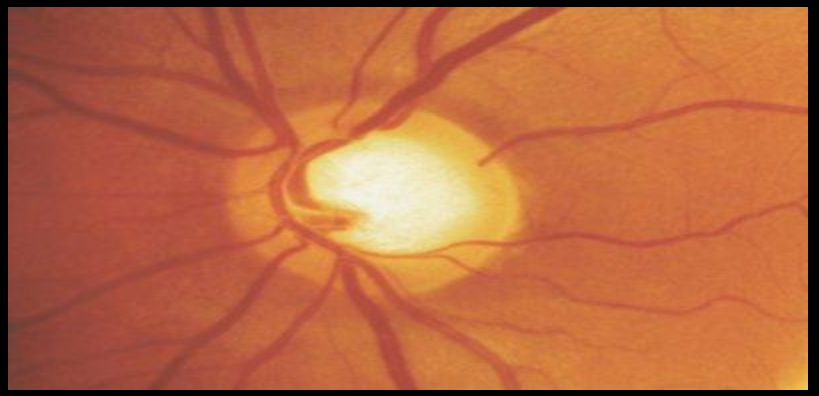
- DIFFUSE
  - CONCENTRIC

  OR
  - LOCALIZED TO ONE POLE
- FOCAL NARROWING OR NOTCHING

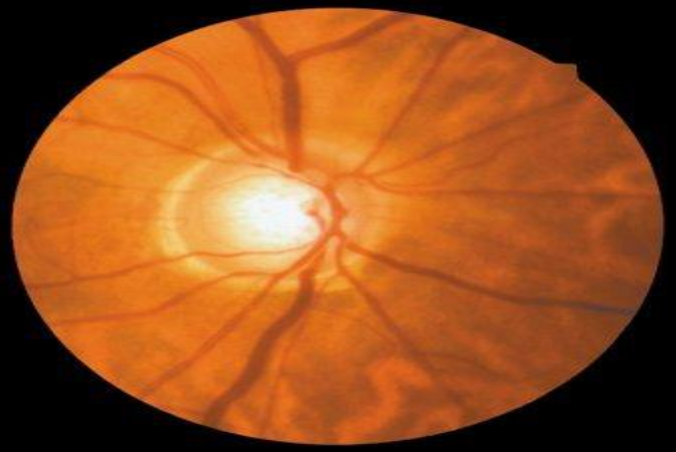
Clinical Decisions in Glaucoma 2nd Edition, 2016

THE ISNT RULE

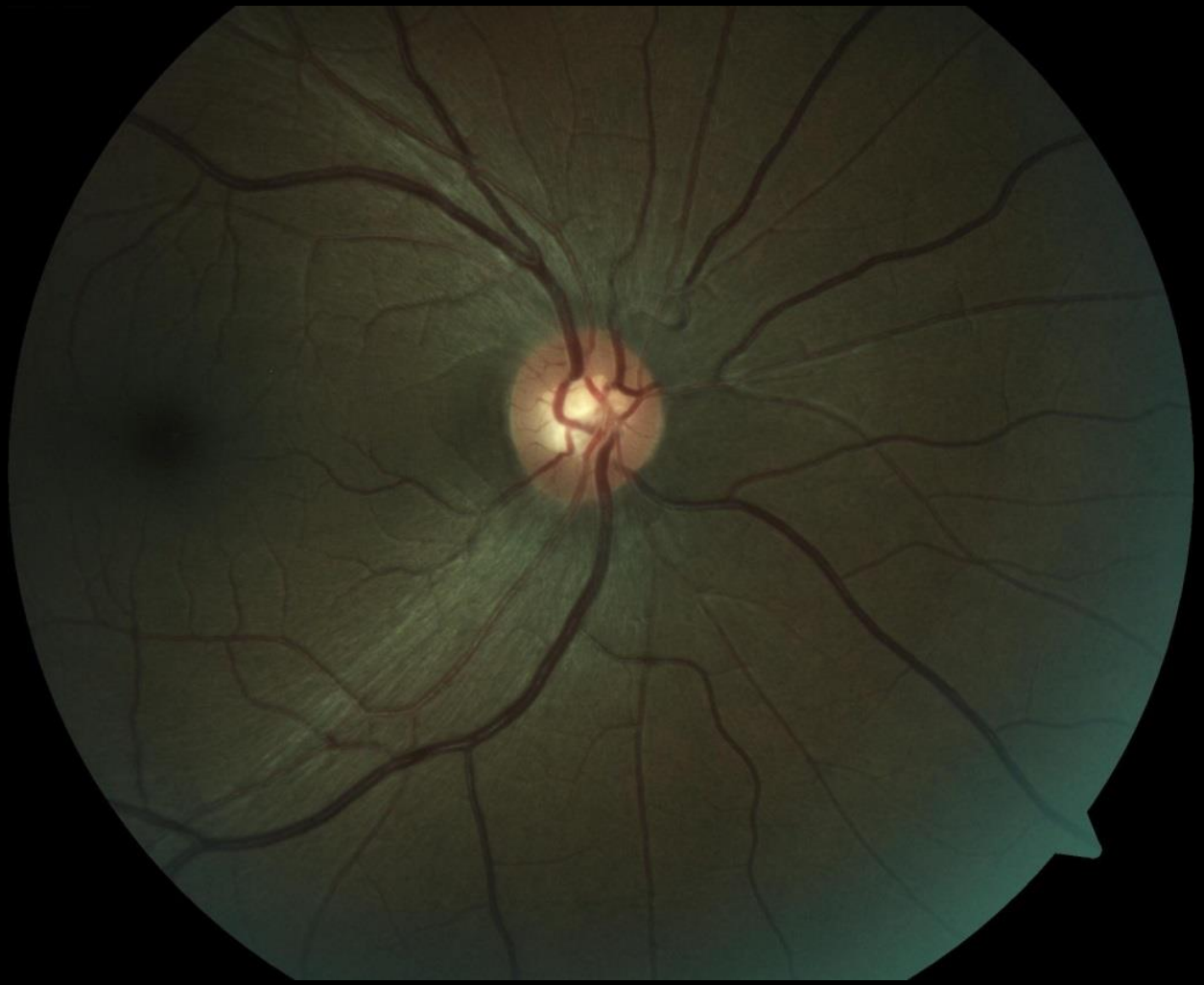
- 1988 FIRST REPORT BY JONAS ET. AL
  - 457 NORMAL EYES
    - INFERIOR RIM > SUPERIOR > NASAL > TEMPORAL
  - GLAUCOMA VIOLATES THE RULE
    - 80% OF THE TIME
      - WHAT ABOUT THE OTHER 20%?
- IT IS NOT FULLPROOF
  - VARIOUS STUDIES AGREE
    - DO NOT PLACE YOUR FULL FAITH IN ISNT RULE

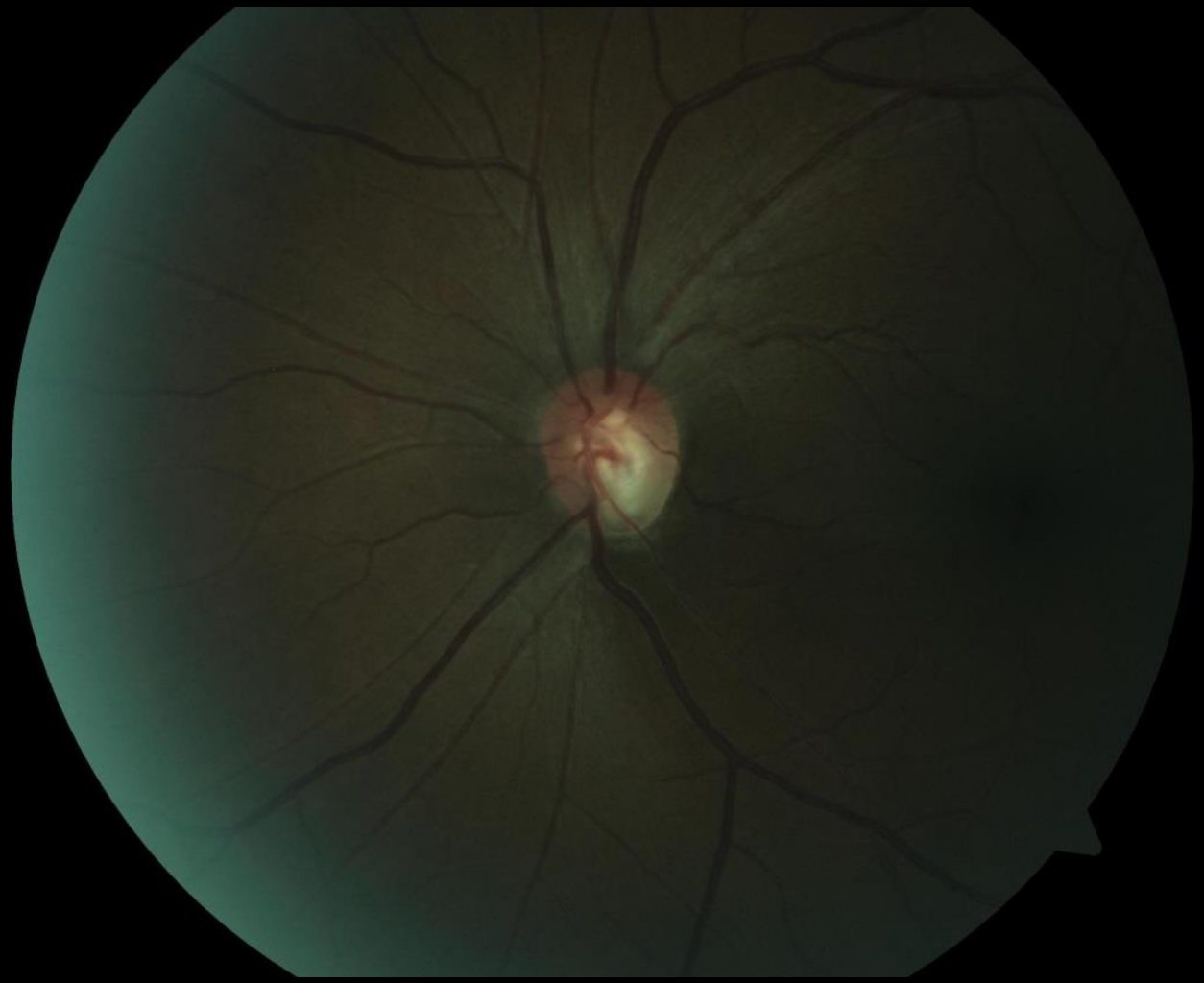


WHICH OF THESE OPTIC NERVES IS NORMAL?



ONE OF THESE
DOES NOT RESPECT THE ISNT RULE





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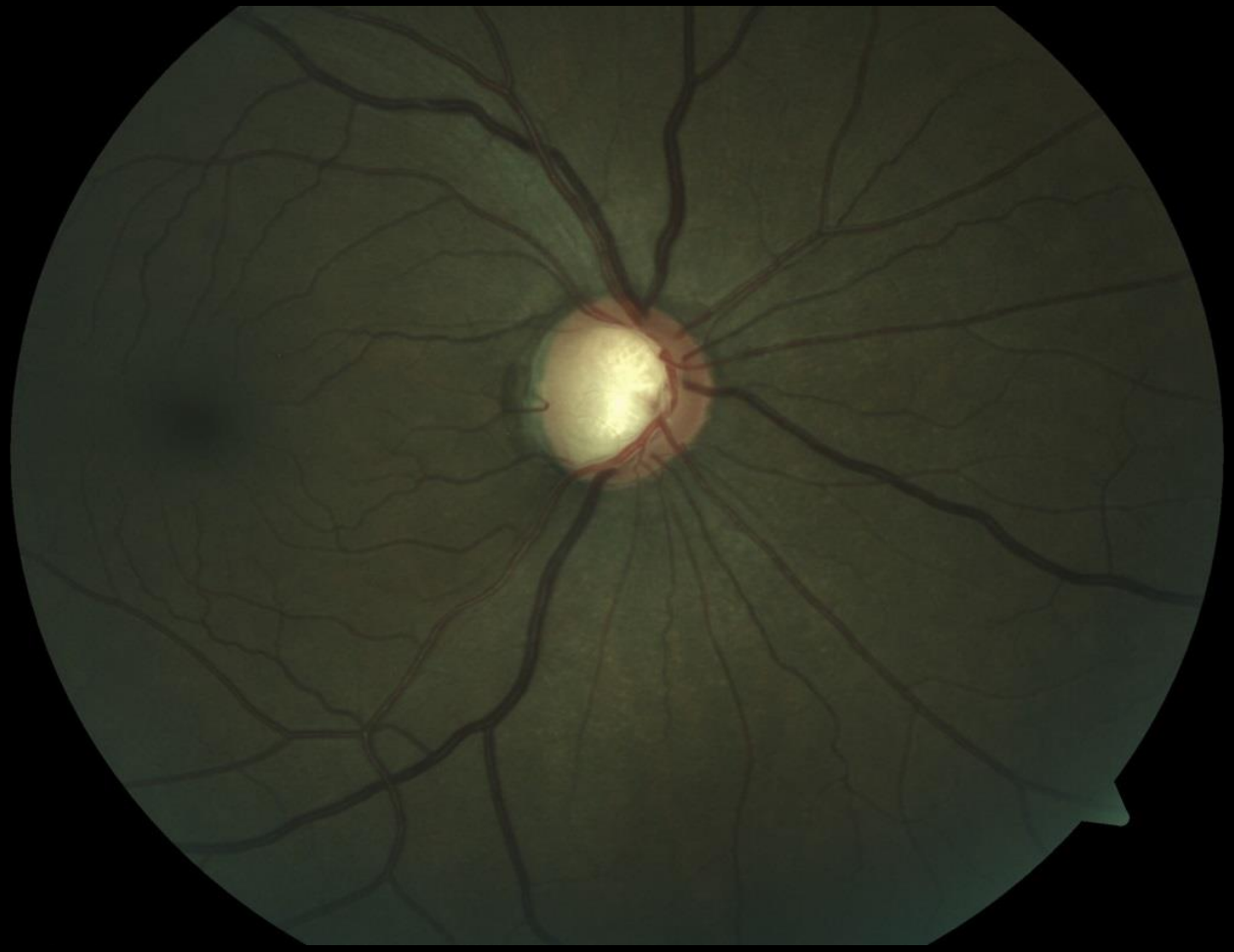
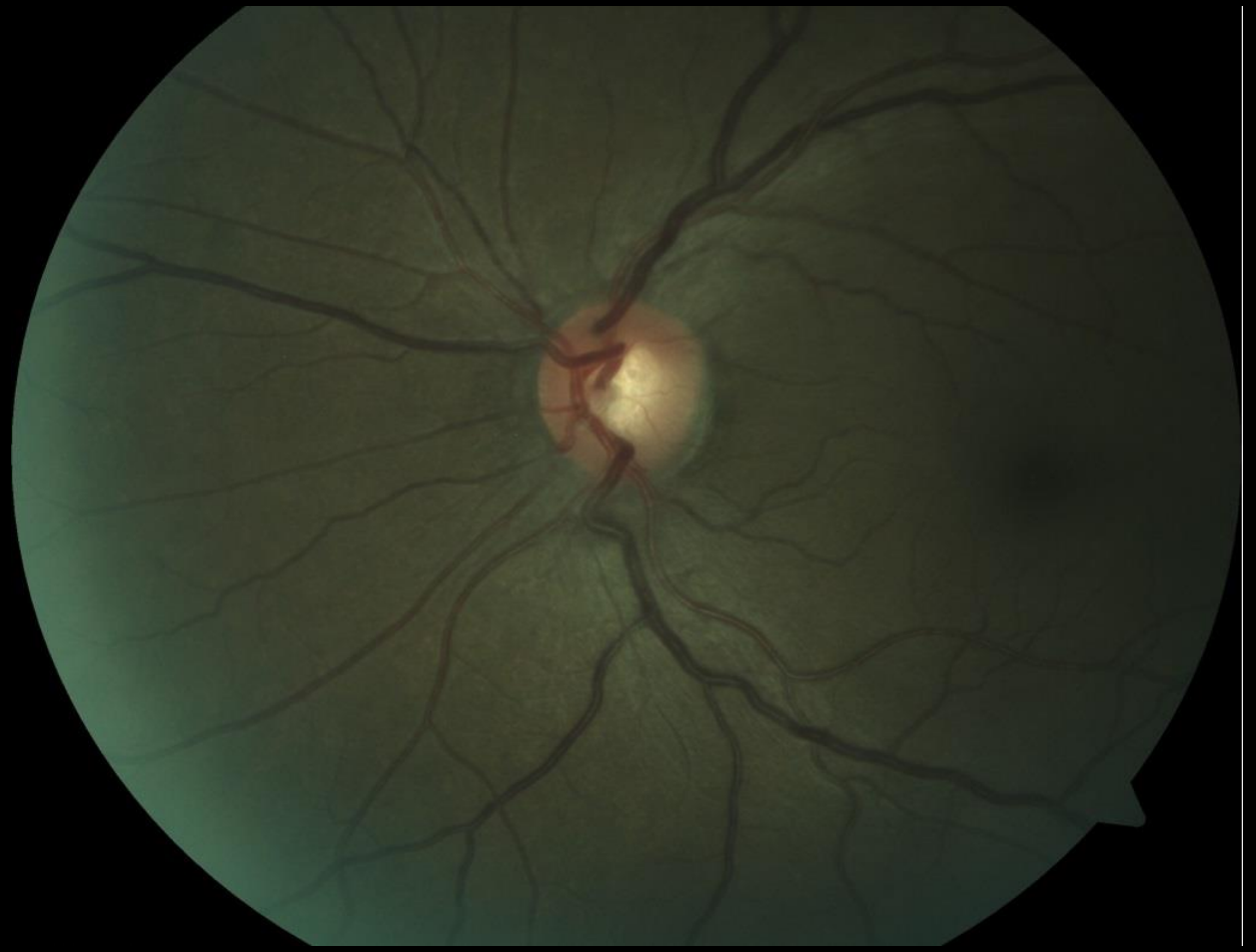
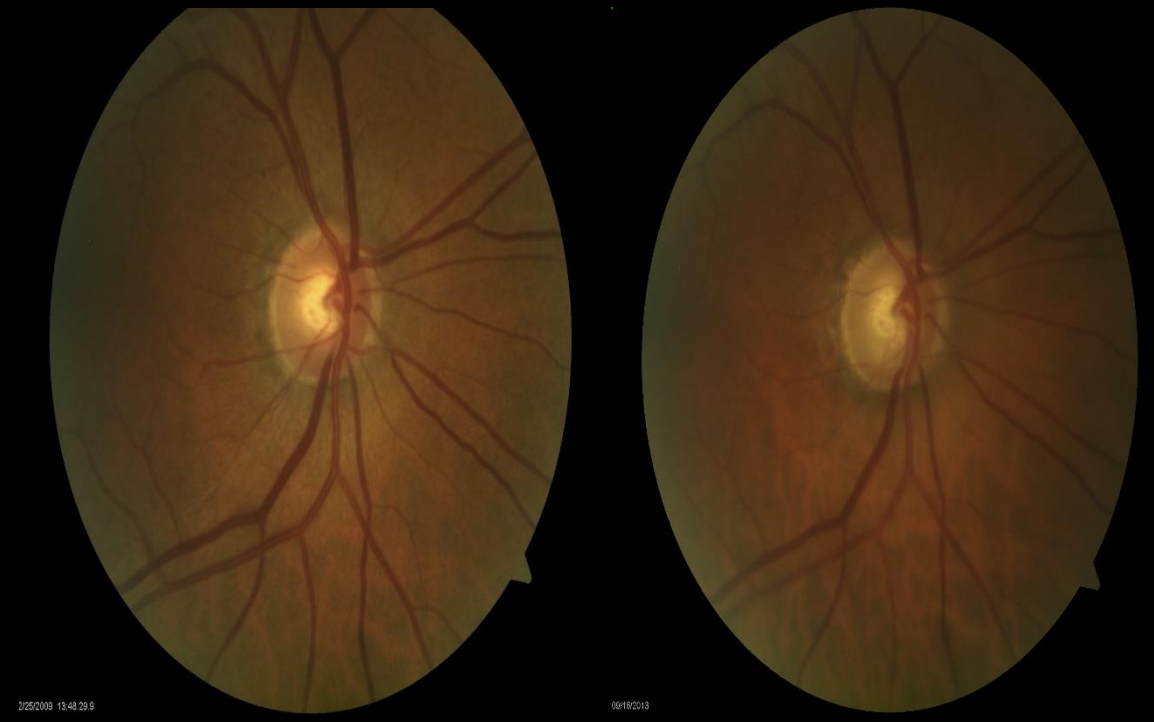




PROGRESSIVE NEURORETINAL RIM NARROWING / INCREASED CUPPING

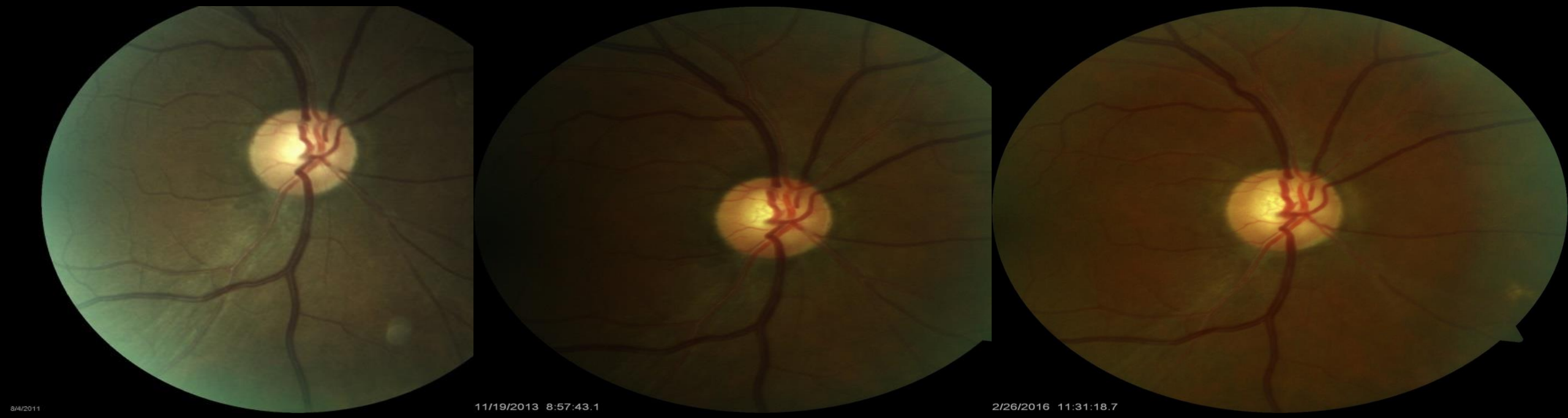
- OPTIONS TO CONSIDER
  - WAS PATIENT BORN THAT WAY
  - IS IT A RECENT CHANGE
  - IS IT A LONG TERM CHANGE
- HOW TO TELL?
  - LOOK FOR CHANGE OVER TIME
  - DRAWING, WRITTEN DESCRIPTIONS
    - NO LONGER GOOD ENOUGH
  - TAKE PICTURES
    - KEEP DOING THESE
    - SUPPLEMENTAL TO OCT
  - BILLING
    - DO PHOTOS ON DFE DAY

    OR
    - DO UNDILATED OCT ON IOP CHECK / VF DAY



2009 VS 2013

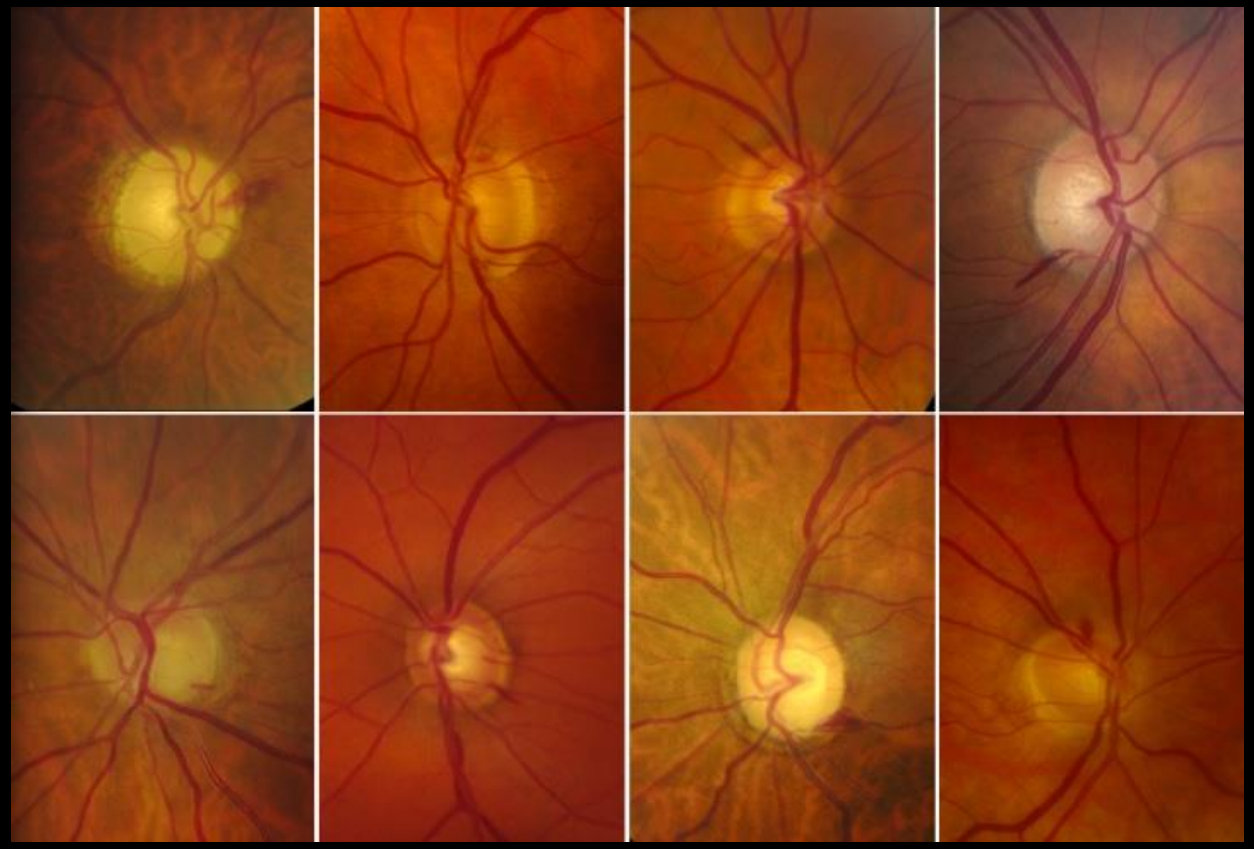
WITHOUT PHOTOS, WOULD YOU BE ABLE TO TELL IF THIS PATIENT CHANGED?



2011 vs 2013 vs 2016

HEMORRHAGES AT DISC RIM, PARAPAPILLARY RNFL, LAMINA

- HISTORY
  - 1889 BJERRUM
    - ASSOCIATION WITH GLAUCOMA
  - 1970 DRANCE AND BEGG
    - ASSOCIATION WITH OPEN-ANGLE GLAUCOMA
- APPEARANCE
  - FLAME OR SPLINTER SHAPED
    - RESULT OF ORIENTATION OF AXONS IN RNFL
    - MAY BE MISTAKEN FOR A BLOOD VESSEL
  - EXTEND RADIALLY FROM THE OPTIC NERVE
- LOCATION
  - PRELAMINAR AREA OF THE OPTIC DISC
  - IN ADJACENT SUPERFICIAL RNFL
  - UPPER AND LOWER POLES
    - INFEROTEMPORALLY MOST COMMON
- DURATION
  - LAST FROM 2 WEEKS TO 8 MONTHS
  - 92% LAST MORE THAN 4 WEEKS



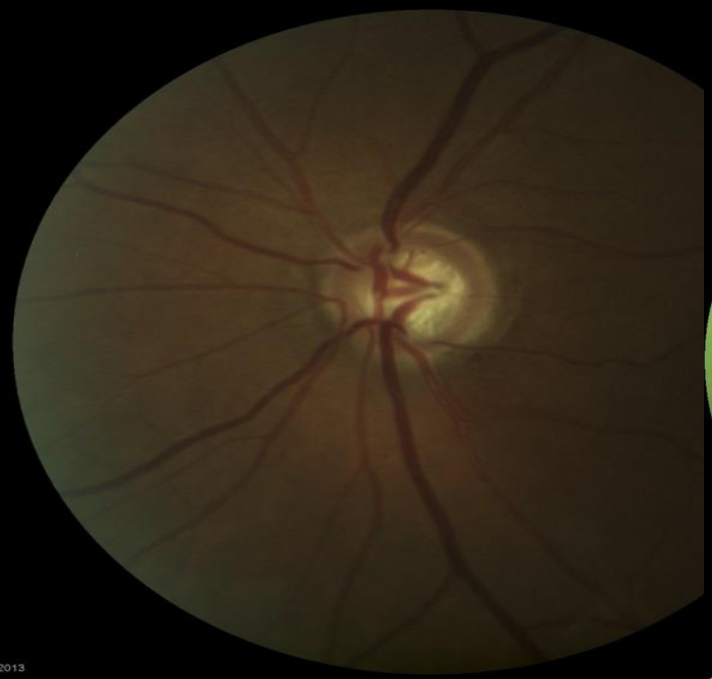
HEMORRHAGES AT DISC RIM, PARAPAPILLARY RNFL, LAMINA

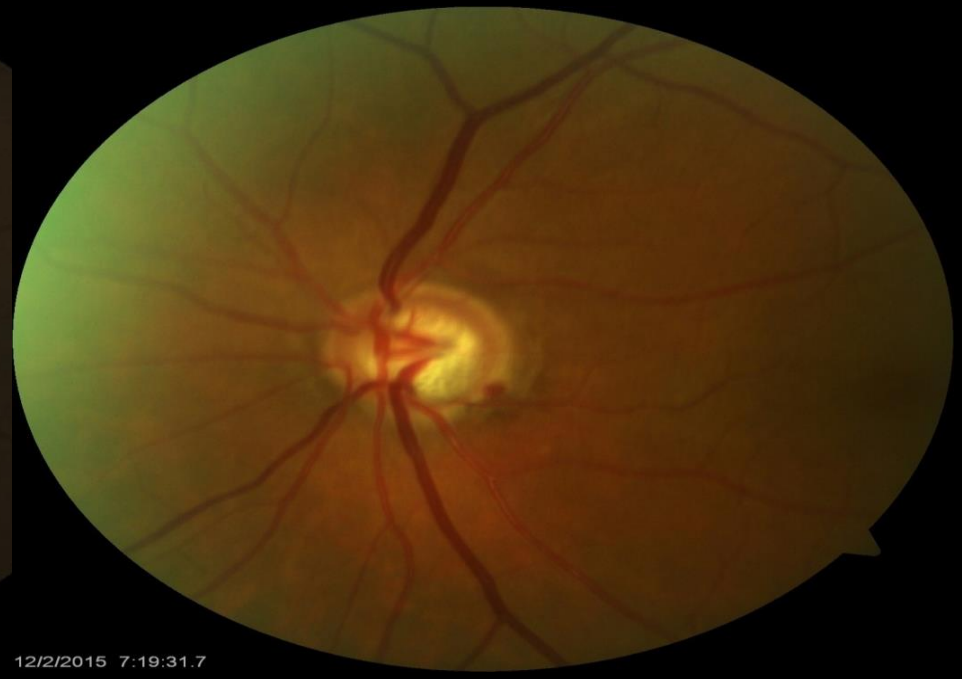
- OHTS
  - POAG INCIDENCE OVER 8 YEARS
    - 13.6% WITH DISC HEME
    - 5.2% WITHOUT DISC HEME
- EMGT
  - 13% OF PATIENTS HAD DISC HEMES AT BASELINE
  - HEMORRHAGES ASSOCIATED WITH PROGRESSION
- ASSOCIATED WITH
  - NFL DEFECT, NOTCH, VF LOSS, LARGER C/D, PARAPAPILLARY ATROPHY
  - PREDICTS SITE OF FUTURE RNFL DEFECTS
- NORMAL TENSION GLAUCOMA
  - RELATIONSHIP BETWEEN LOCATION AND PROGRESSION OF VF LOSS IN 65.4%
- SHOULD BE LOOKED FOR AT EACH VISIT
  - UNDILATED EVALUATION WITH DIRECT OR 90D LENS AT IOP CHECKS

HOW TO DETECT DISC HEMORRHAGES

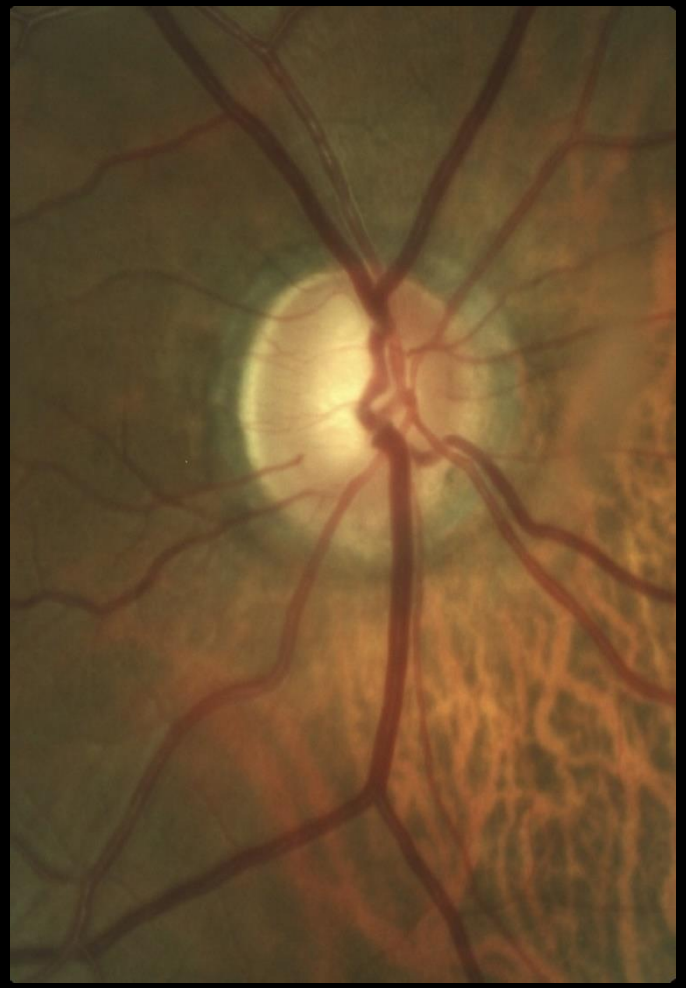
- CLOSE OBSERVATION OF THE OPTIC NERVE
  - LOOK WHERE THERE'S A NOTCH
  - LOOK WHERE THE RIM IS THINNER
  - LOOK WHERE THERE IS A CLINICAL RNFL DEFECT
  - LOOK WHERE THERE IS AN OCT RNFL DEFECT
  - LOOK AT THE OPPOSITE LOCATION OF A VISUAL FIELD DEFECT
- THEY ARE NOT DETECTED BY THE OCT
- DISC PHOTOGRAPHS ARE THE MOST SENSITIVE METHOD
  - TAKE PHOTOS
  - REVIEW THEM

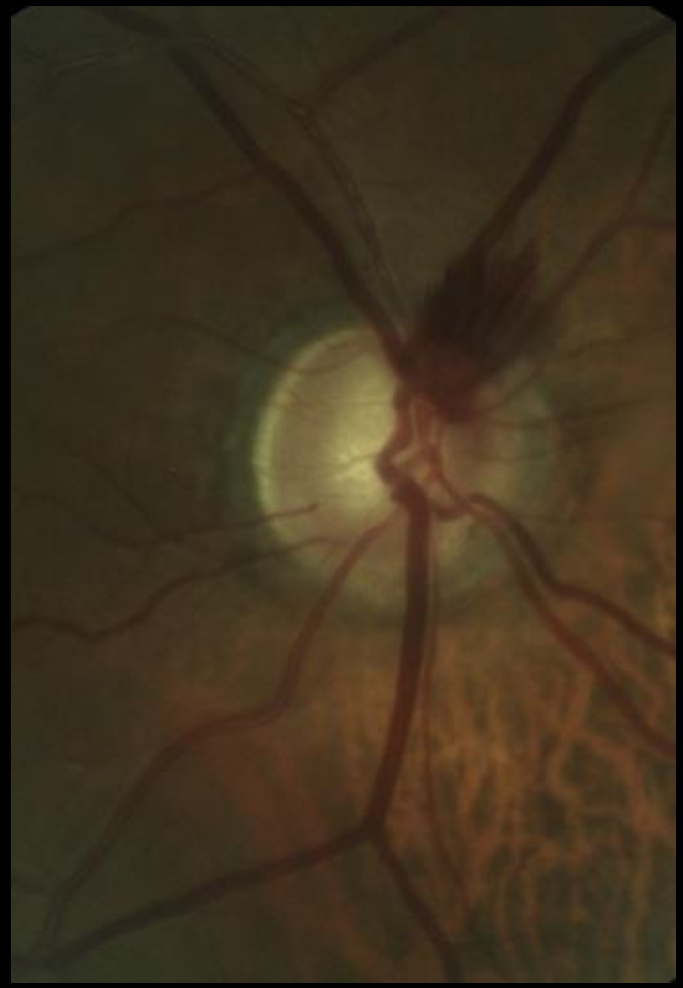
2009 vs 2013 vs 2015





DISC HEMORRHAGE EXAMPLE

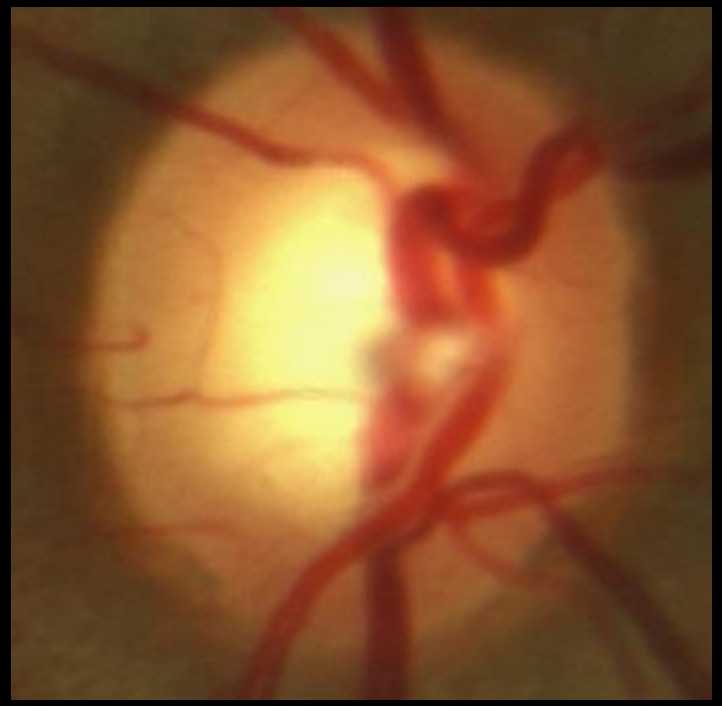


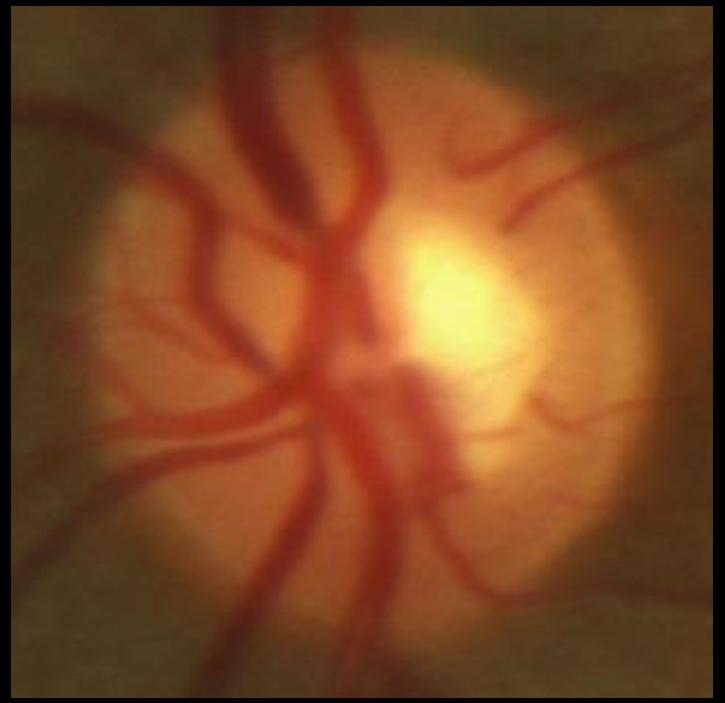


OPTIC DISC NEURAL RIM ASYMMETRY OF THE TWO EYES

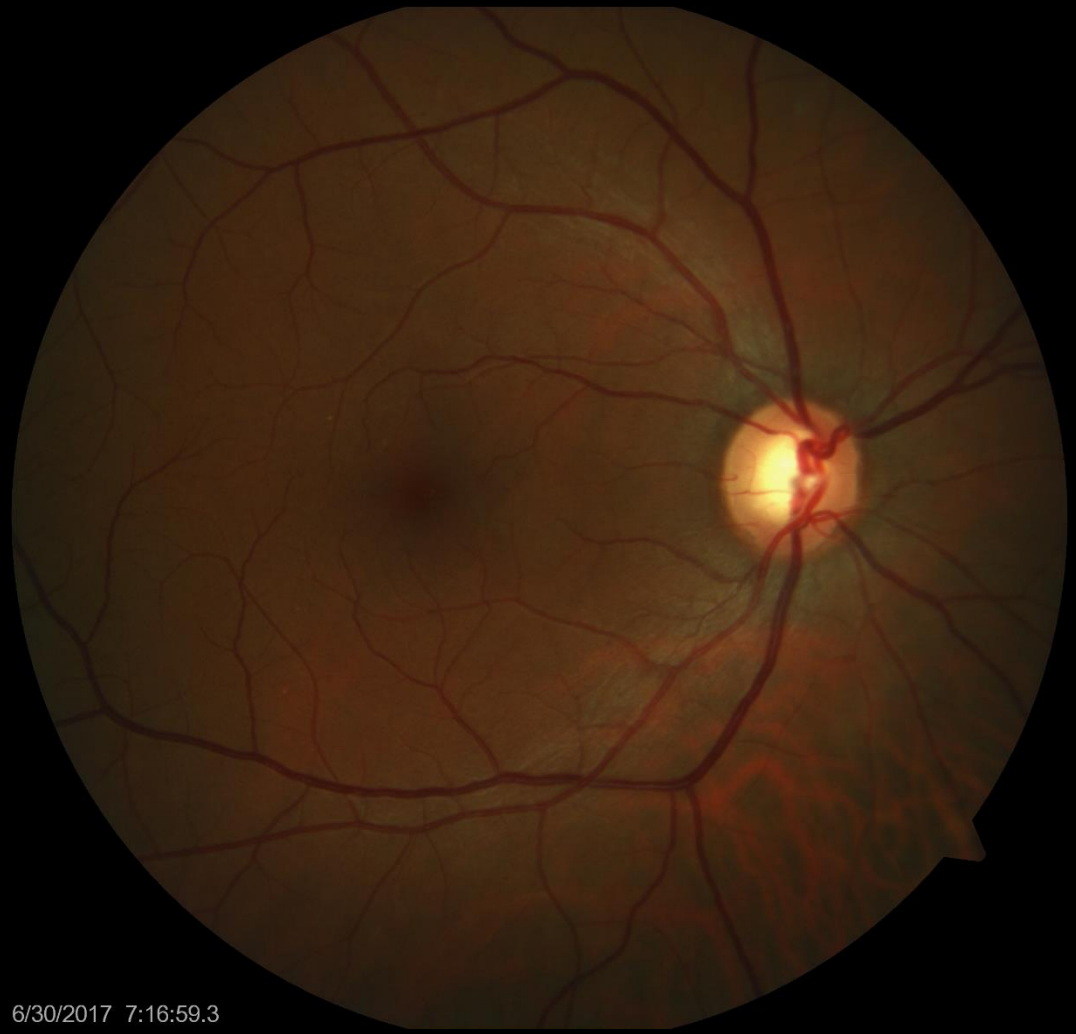
- C/D ASYMMETRY
  - SUGGESTIVE OF GLAUCOMATOUS ONH DAMAGE
    - > 0.2 IN LESS THAN 0.5% OF NORMALS VS 48% IN GLAUCOMA
  - PREDICTOR OF FUTURE GLAUCOMATOUS VF LOSS
  - EVALUATE FOR SECONDARY FORMS OF GLAUCOMA
  - EYE WITH THE LARGER CUP TYPICALLY HAS THE HIGHER IOP
  - CAUTION
    - EVALUATE FOR UNEQUAL DISC SIZES

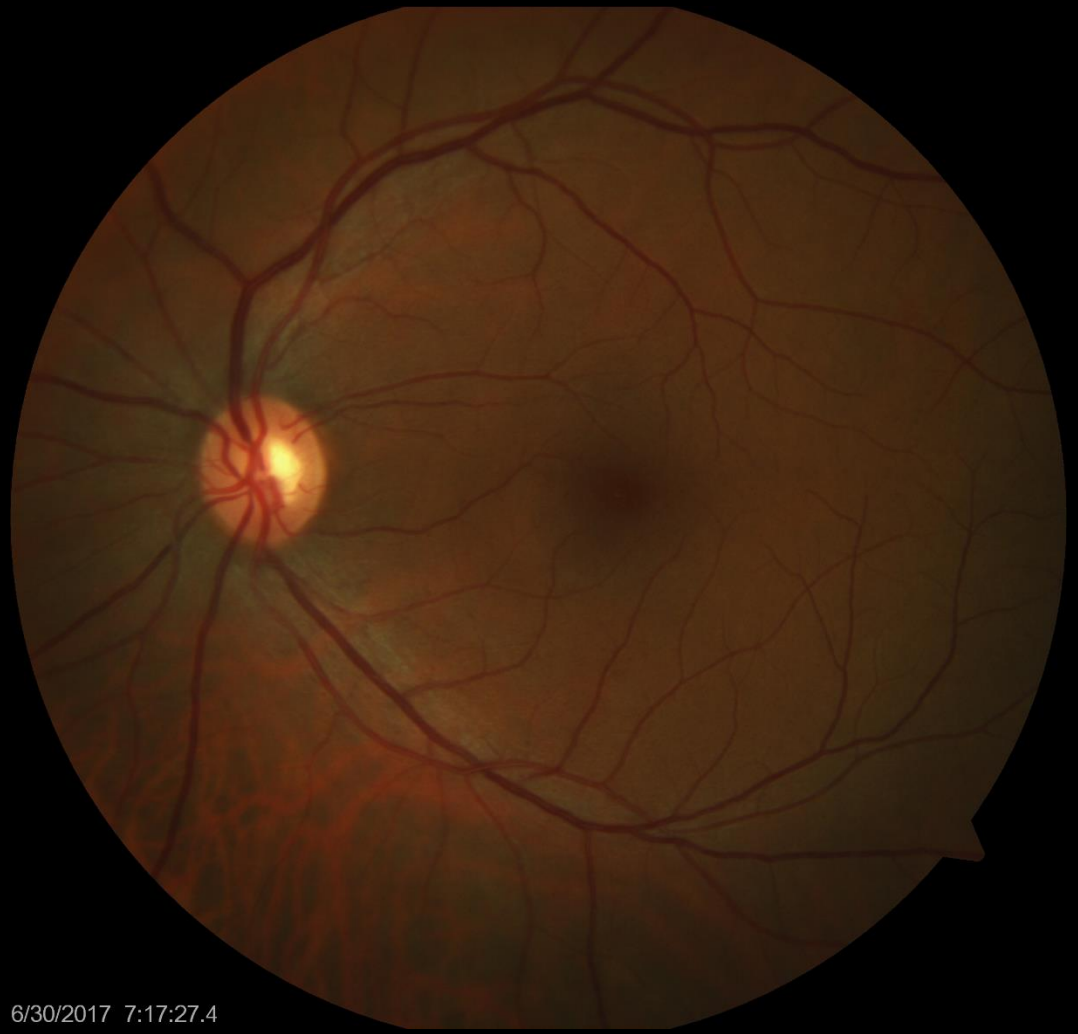
C/D ASYMMETRY



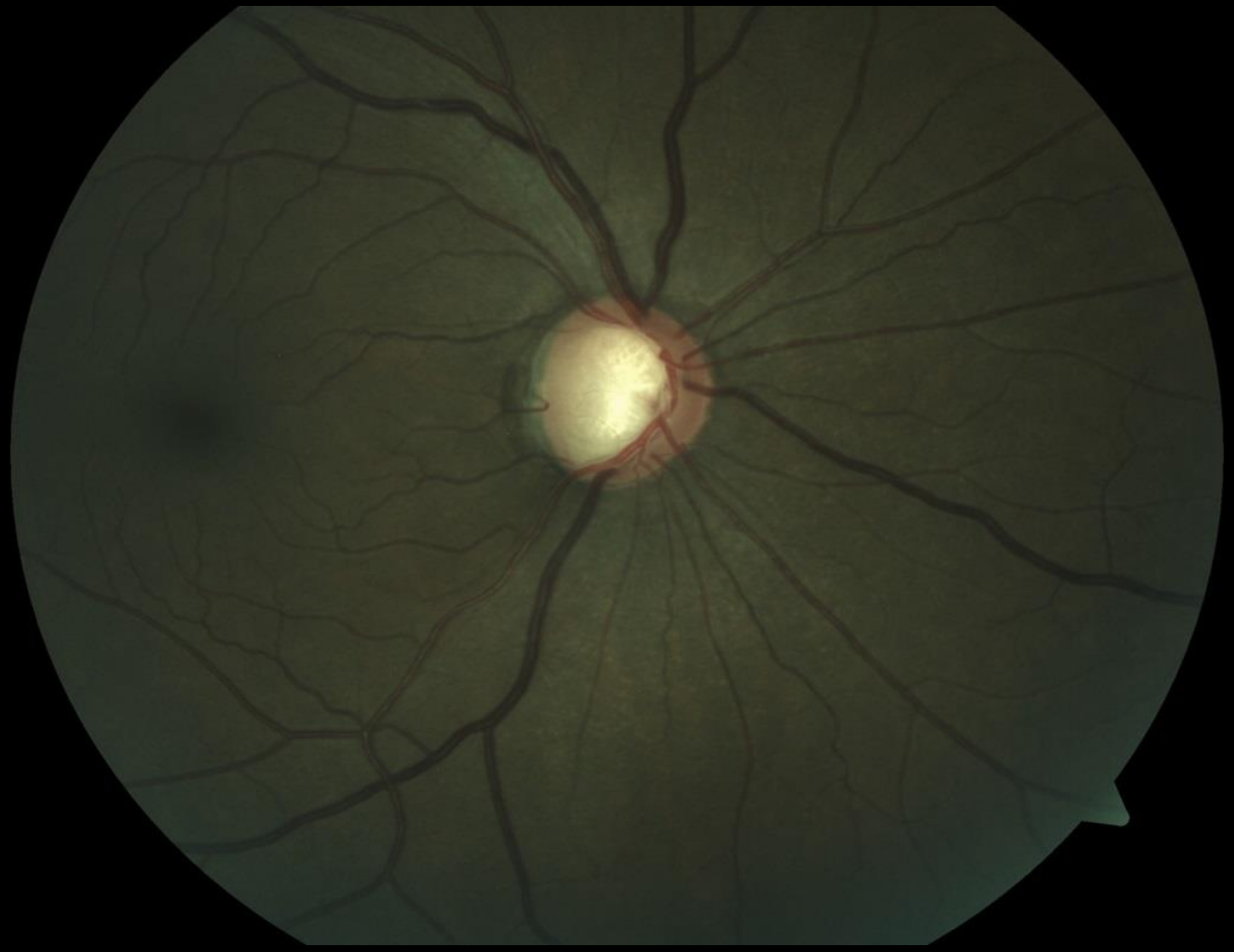


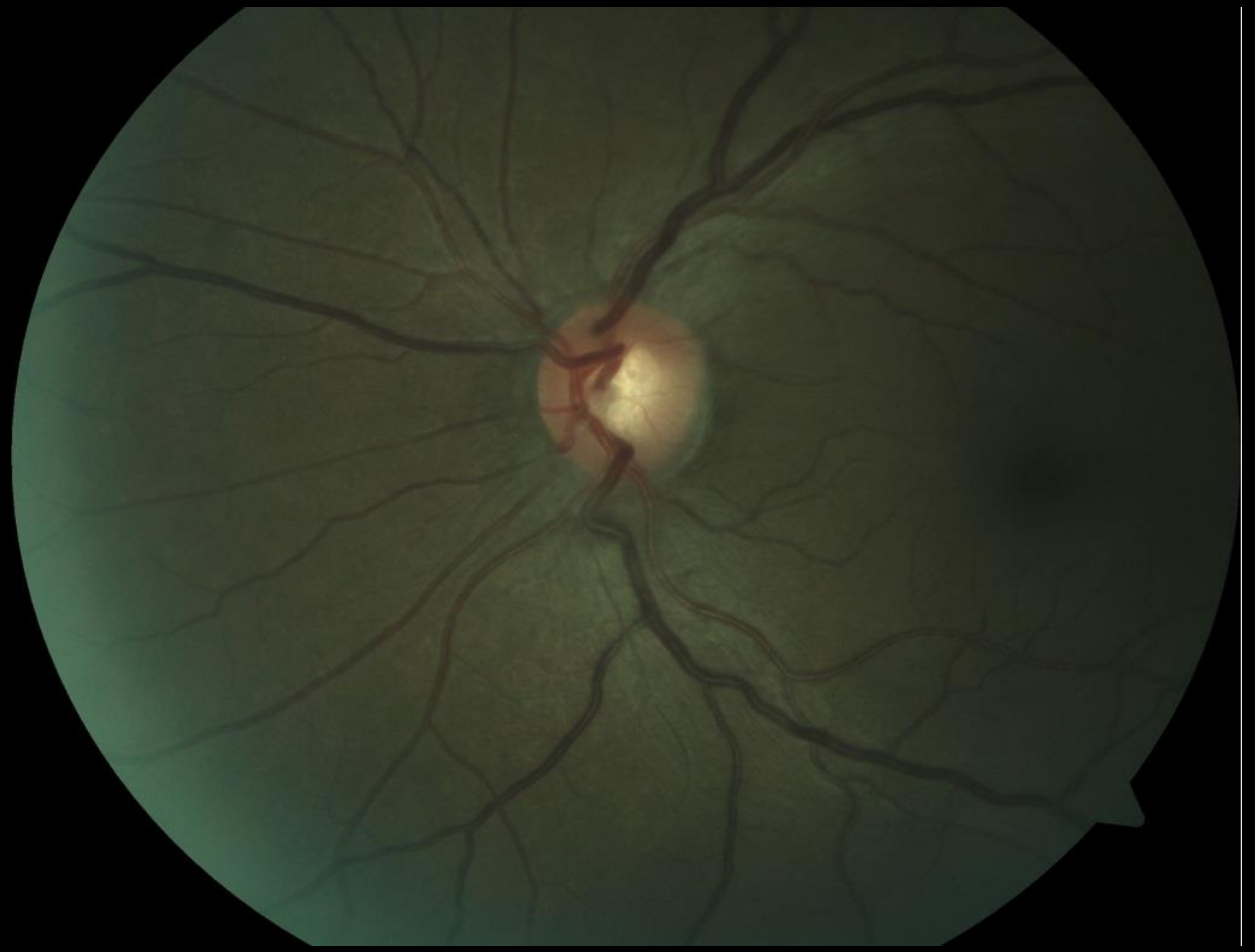
SAME PT C/D ASYMMETRY DUE TO ONH SIZE BUT…NOT GLAUCOMA





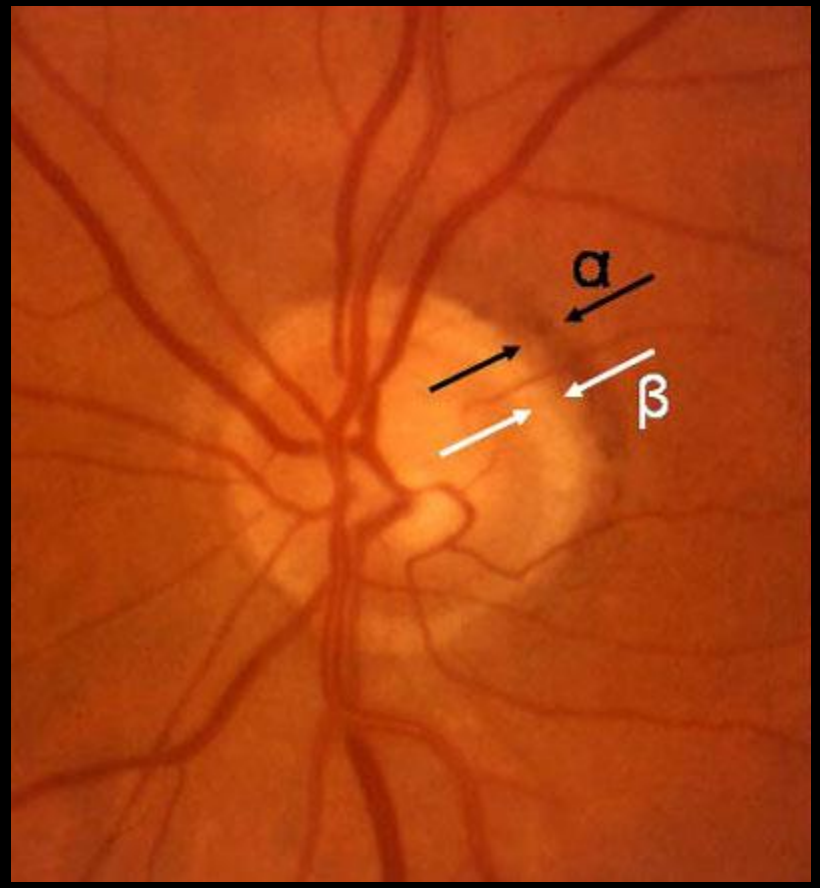
ASYMMETRIC C/D AND DISC SIZES BUT… THIS IS GLAUCOMA OD





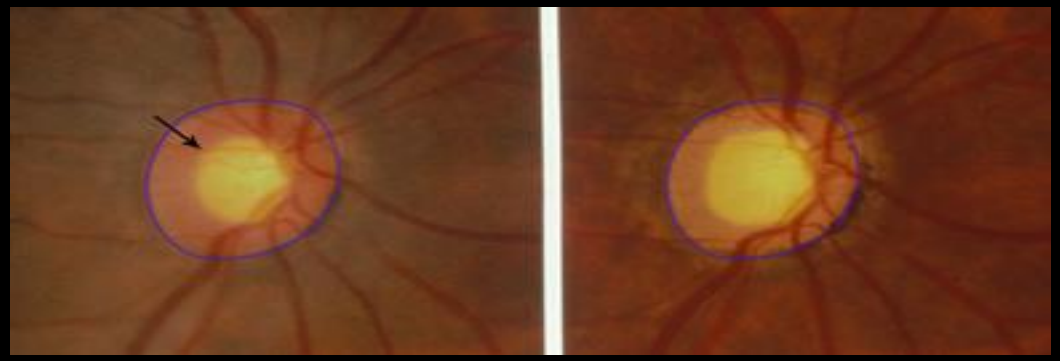
PARAPAPILLARY ATROPHY

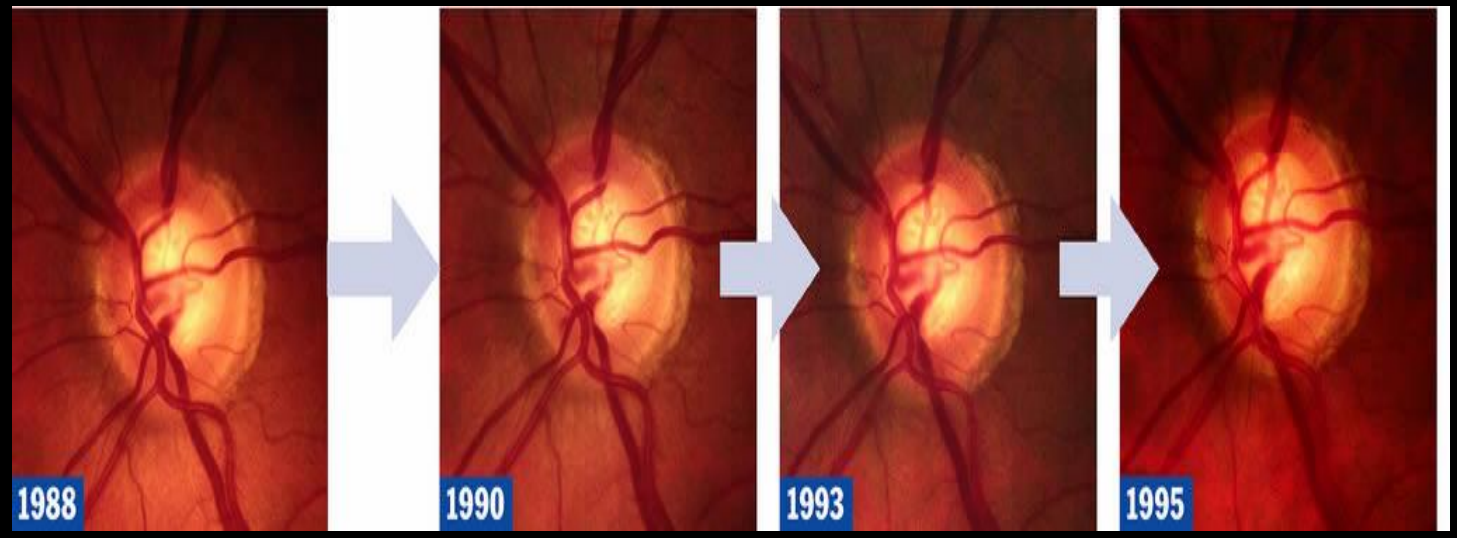
- ZONE BETA
  - CLOSER TO ONH
  - COMPLETE LOSS OF RETINAL PIGMENT EPITHELIUM AND CHORIOCAPILLARIS
  - VISIBILITY OF LARGER CHOROIDAL BLOOD VESSELS AND WHITE SCLERA MORE SPECIFIC TO GLAUCOMA DAMAGE
  - INCREASE IN ZONE BETA
    - ASSOCIATION OF ADJACENT THINNING OF NEURO RETINAL RIM
    - ASSOCIATION OF DECREASED RNFL
  - ABSOLUTE SCOTOMA (ENLARGED BLIND SPOT) ON VISUAL FIELD
- LESS SPECIFIC SIGN OF DAMAGE



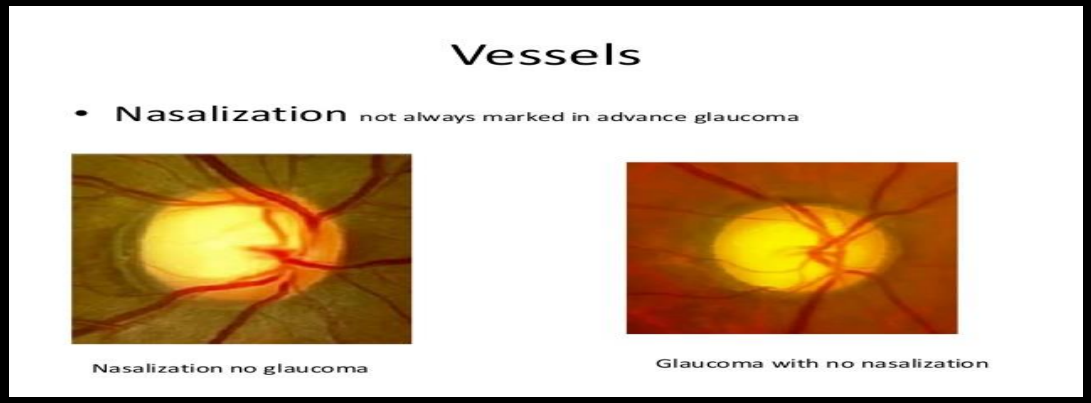
PARAPAPILLARY ATROPHY

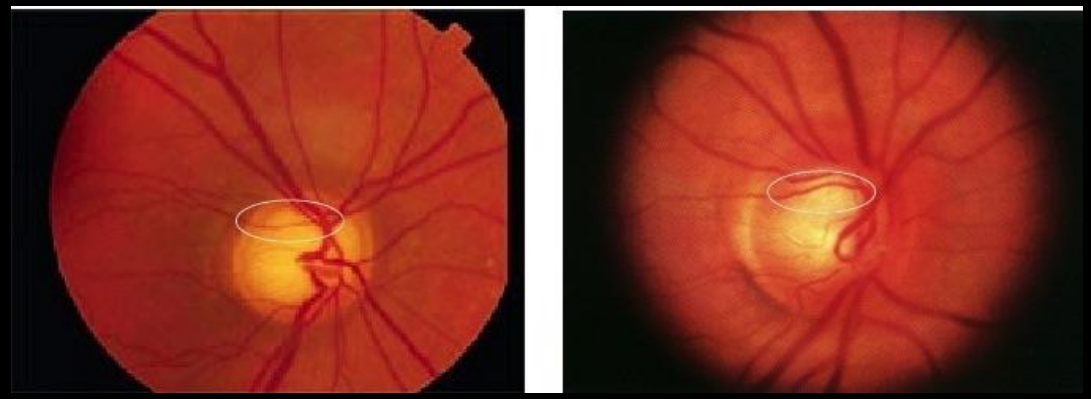
- ETIOLOGY IS NOT CLEAR
  - ? VASCULAR
- BETTER SENSITIVITY IN SMALL DISCS VS C/D
- ASSOCIATED WITH
  - RIM THINNING
  - CONVERSION TO GLAUCOMA IN PATIENTS WITH OC HTN
- PRECURSOR TO
  - VF LOSS (50-54%)
  - DISC DAMAGE (75%)
  - DISC HEMORRHAGE
- CHANGES IN 21% WITH PROGRESSIVE CUPPING VS 4% NORMALS
- LOOK AT PHOTOS FOR CHANGE





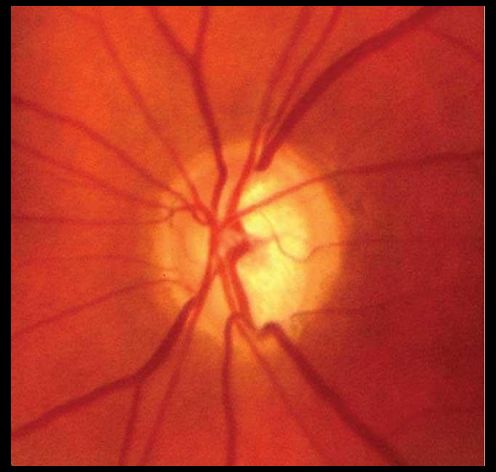
OTHER FEATURES THAT MAY INDICATE GLAUCOMATOUS OPTIC NEUROPATHY

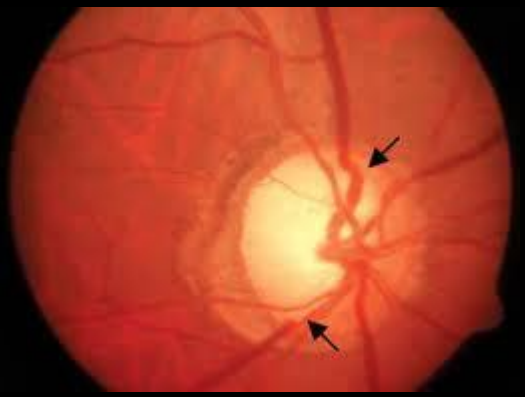




BARING OF CIRCUMLINEAR VESSEL

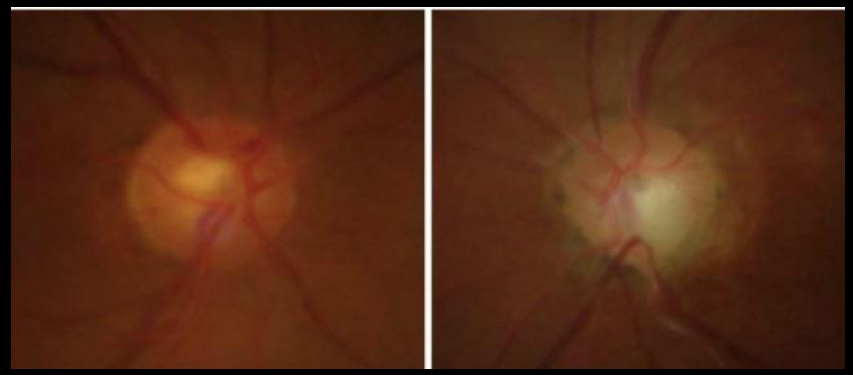
NASALIZATION OF CENTRAL ONH VESSELS

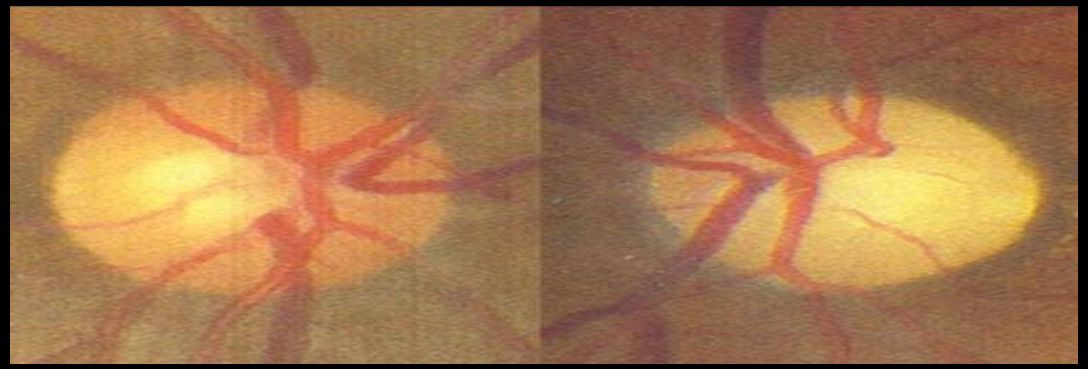




BAYONETING OF ONH VESSELS AT RIM

REMEMBER





THERE SHOULD NOT BE ANY NEURORETINAL RIM PALLOR

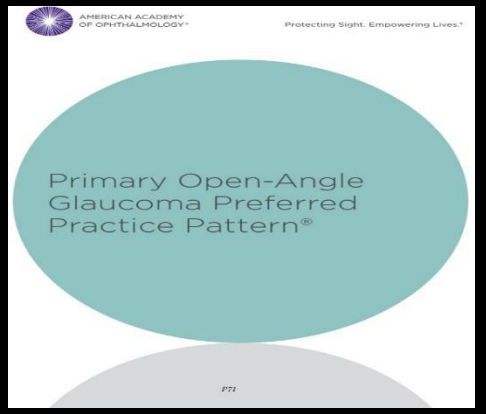
IN OTHER WORDS…IF PALE, IT IS NOT GLAUCOMA.

(UNLESS TRAUMATIC OR OTHER OPTIC NEUROPATHY + GLAUCOMA)

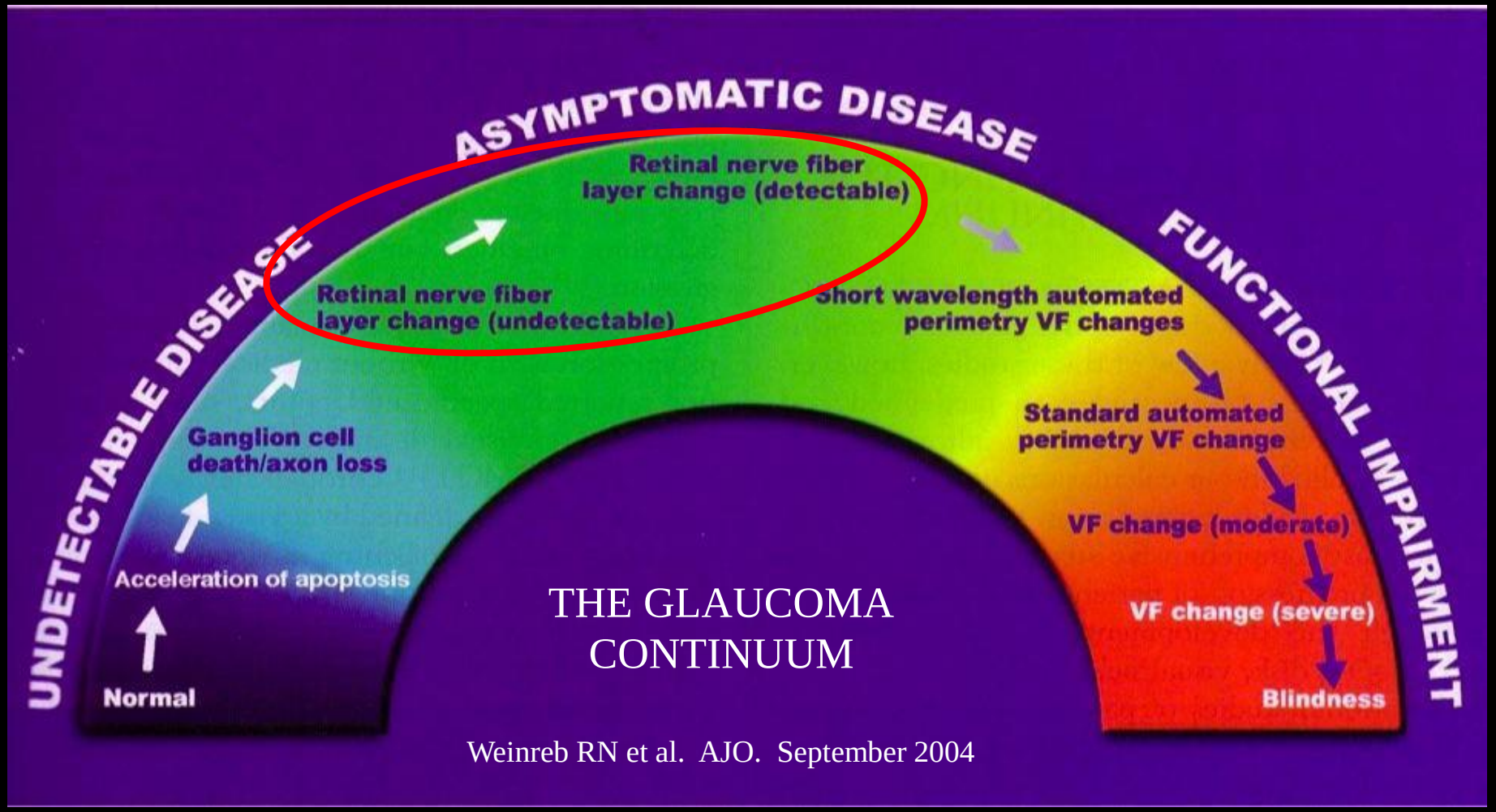
RETINAL NERVE FIBER LAYER STRUCTURAL ABNORMALITIES

- ABNORMALITIES OF PARAPAPILLARY RNFL
  - DIFFUSE OR LOCALIZED
  - ESPECIALLY AT SUPERIOR / INFERIOR POLES

- REMEMBER THE DEFINITION OF POAG…

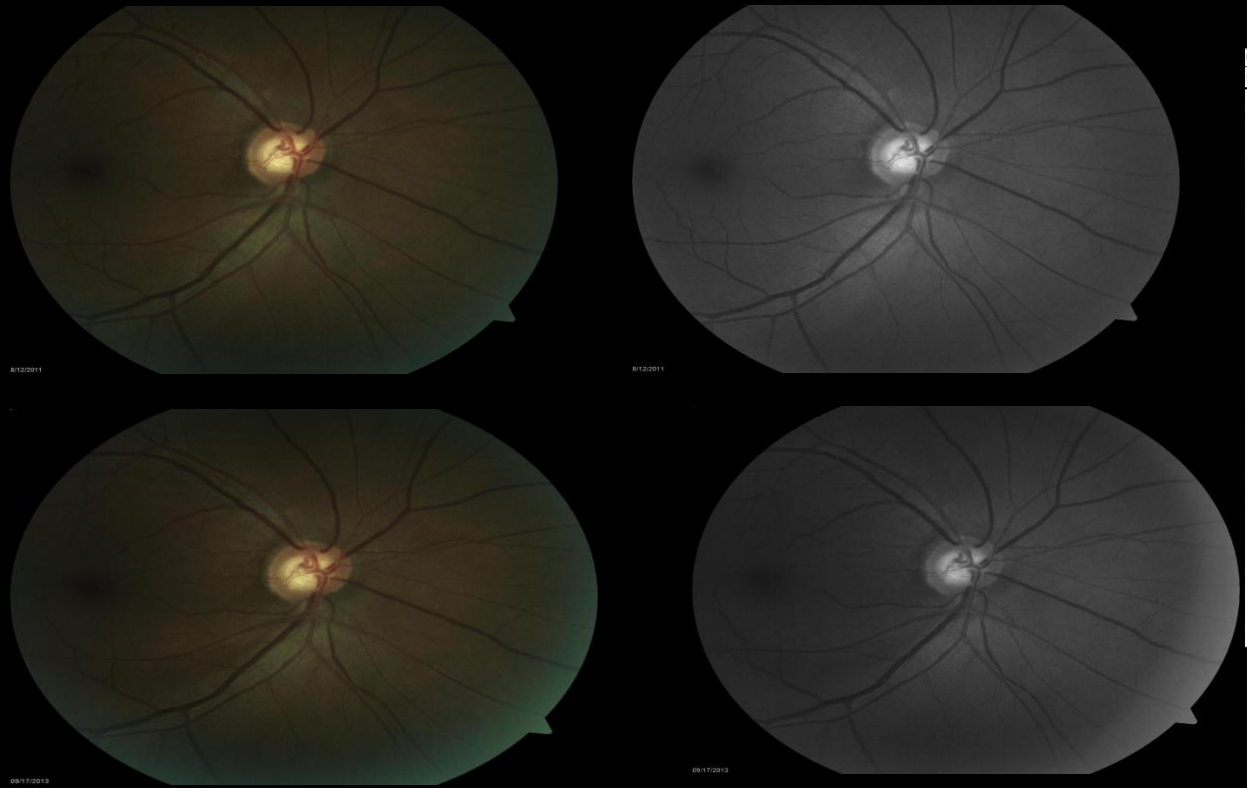


"A CHRONIC, PROGRESSIVE OPTIC NEUROPATHY IN ADULTS IN WHICH THERE IS A CHARACTERISTIC ACQUIRED ATROPHY OF THE OPTIC NERVE AND LOSS OF RETINAL GANGLION CELLS AND THEIR AXONS."

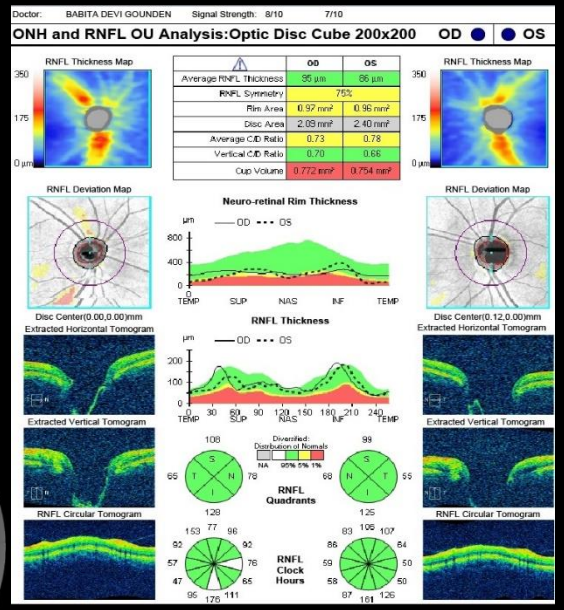


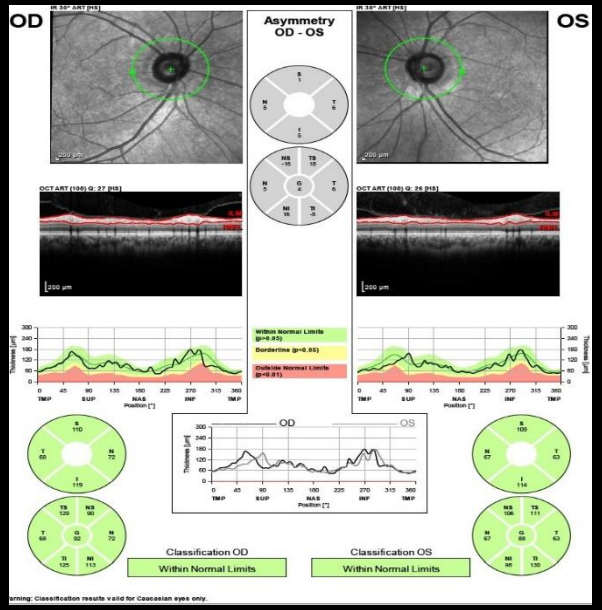
HOW DO WE EVALUATE THE RNFL?

- CLINICALLY



- WITH A MACHINE

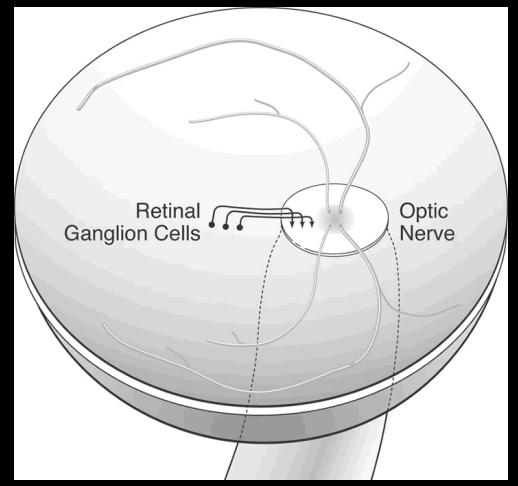


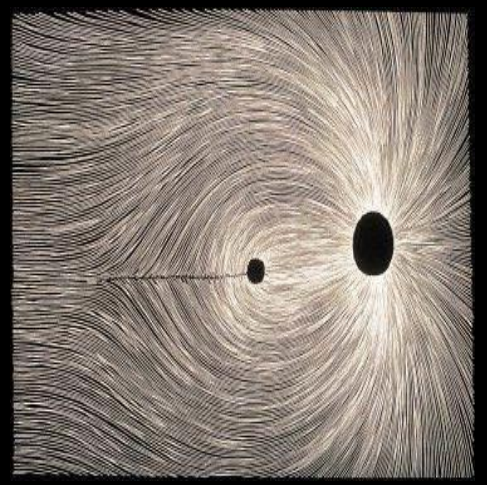


MOST WILL SAY THEY PREFER THE MACHINE. EVEN EXPERTS AGREE. HOWEVER, YOU SHOULD HAVE A FUNDAMENTAL KNOWLEDGE OF WHAT IS BEING EVALUATED.

RNFL BACKGROUND

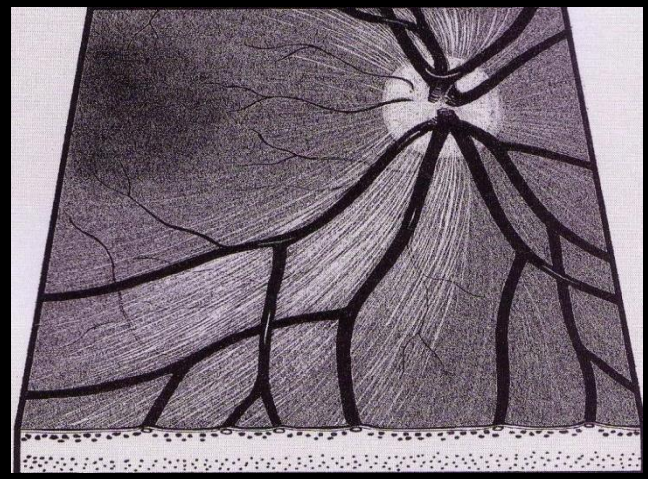
- OPTIC NERVE IS MADE OF
  - 700K-1.5 MILLION GANGLION CELLS
  - THE GANGLION CELL AXONS ARE THE RNFL
  - THEY CROSS RETINA AND CONVERGE TO MAKE THE ONH
  - THEY EXIT THE EYE AT LAMINA ON WAY TO LGN
- CLINICAL APPEARANCE
  - SUPERFICIAL BENEATH ILM
  - ARE IN AN ORGANIZED PATTERN
  - REFLECT LIGHT BACK
  - THE THICKER THE RNFL THE BRIGHTER THE STRIATIONS
    - SUPERIOR / INFERIOR POLES
  - BEST SEEN AGAINST A DARK BACKGROUND
    - DIFFICULT IN A BLONDE FUNDUS
  - NEED CLEAR MEDIA



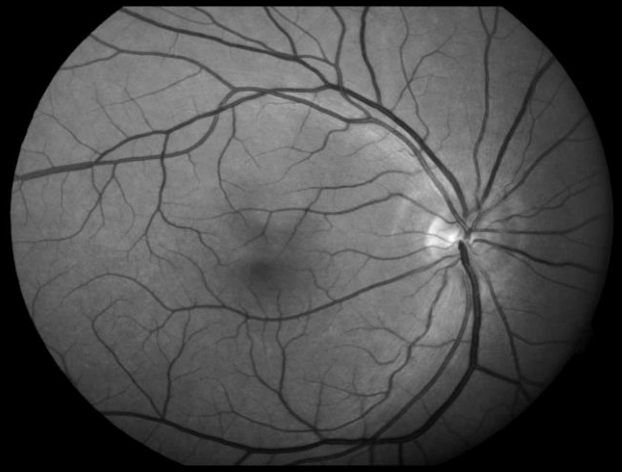


NORMAL RNFL FEATURES

- FINE WHITE LINEAR STRIATIONS IN ANTERIOR RETINAL LAYER
- BRIGHT STRIATIONS WITH A FULMINANT, COARSE TEXTURE
- CAST A WHITE HAZE OVER THE UNDERLYING RETINAL LAYERS
- TERTIARY BLOOD VESSELS ARE HIDDEN BENEATH THE RNFL
- BECOMES BRIGHTER AS YOU GET CLOSER TO THE ONH
- MOST PROMINENT IN THE SUPERIOR AND INFERIOR ARCADES
- BRIGHT-DIM-BRIGHT PATTERN

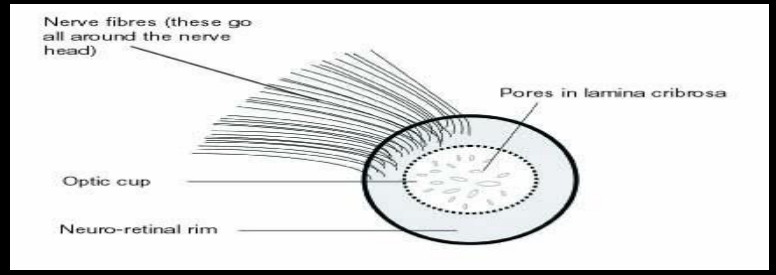


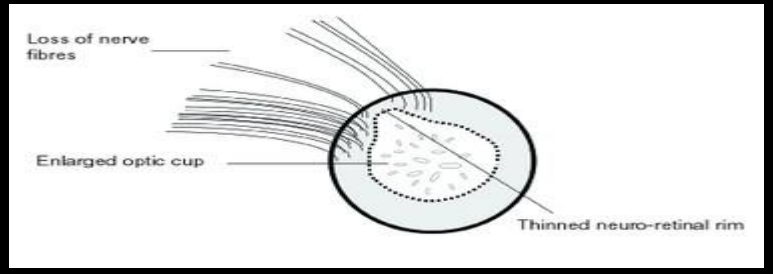
The Glaucoma Handbook. AB Litwak. Butterworth-Heinemann. 2000.



RETINAL NERVE FIBER LAYER DEFECTS

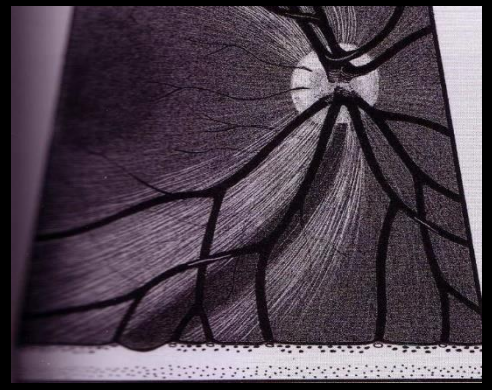
- FIRST DESCRIBED
  - 1973 HOYT ET. AL
    - LOCALIZED RNFL DEFECTS IN GLAUCOMATOUS EYES
- 1991 SOMMER, KATZ, QUIGLEY, MILLER ET AL
  - CLINICAL RNFL DEFECTS MAY PRECEDE VF LOSS BY 6 YEARS
- NORMAL EYES DO NOT HAVE RNFL DEFECTS
- WHEN PRESENT, ALMOST ALWAYS SIGNIFY PATHOLOGY
  - NOT ALWAYS GLAUCOMA
  - OTHER POTENTIAL CAUSES OF RNFL DEFECTS
    - ANY OPTIC NEUROPATHY
    - ANY RETINOPATHY
    - OTHER RETINAL PATHOLOGY
    - SYSTEMIC DISEASES
      - MS, OTHERS

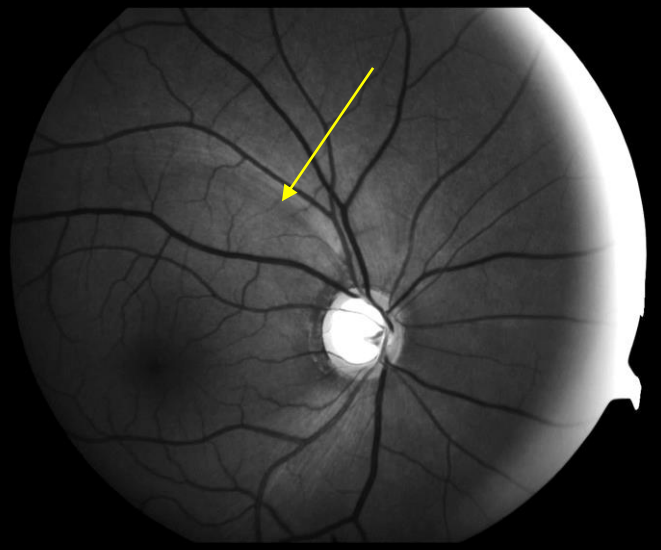




FOCAL, CLINICAL RNFL DEFECTS

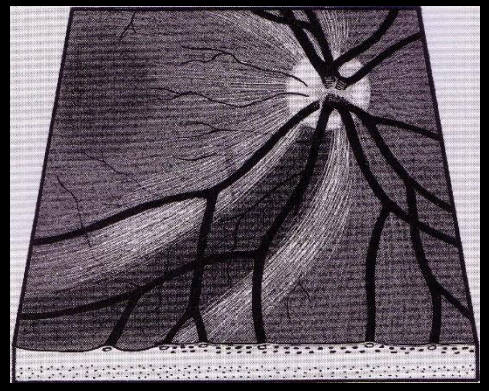
- SLIT DEFECT
  - EVIDENCE OF FOCAL DAMAGE
  - LARGER THAN ARTERIOLE WIDTH
  - TRAVELS ALL THE WAY TO ONH
  - ¼ mm WIDE = 50 um LOSS
  - 50 um LOSS = 15,000 FIBERS
  - 15,000 FIBERS = 1% OF TOTAL

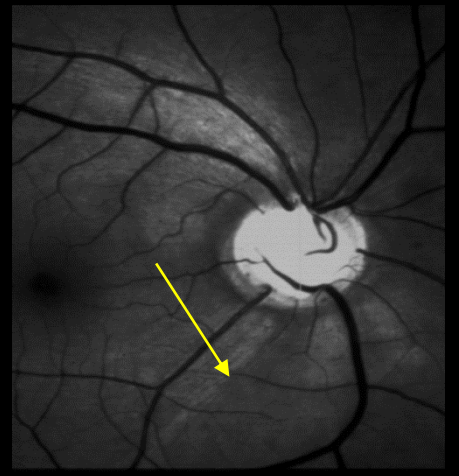




The Glaucoma Handbook. AB Litwak. Butterworth-Heinemann. 2000.

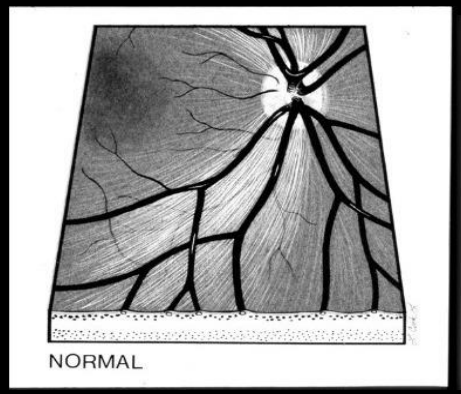
- WEDGE DEFECT
  - EASIEST TO IDENTIFY, LEAST COMMON
  - AN EXPANDING LOSS OF GANGLION CELLS
  - ASSOCIATED ONH NOTCHING
  - ASSOCIATED WITH A VF DEFECT
  - MAY OCCUR AFTER DISC HEME

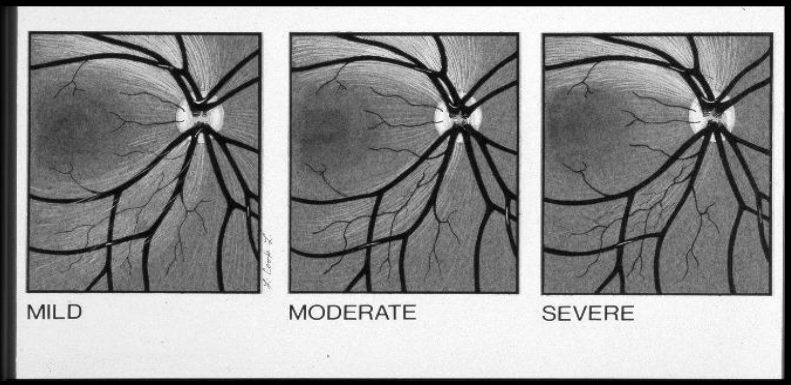




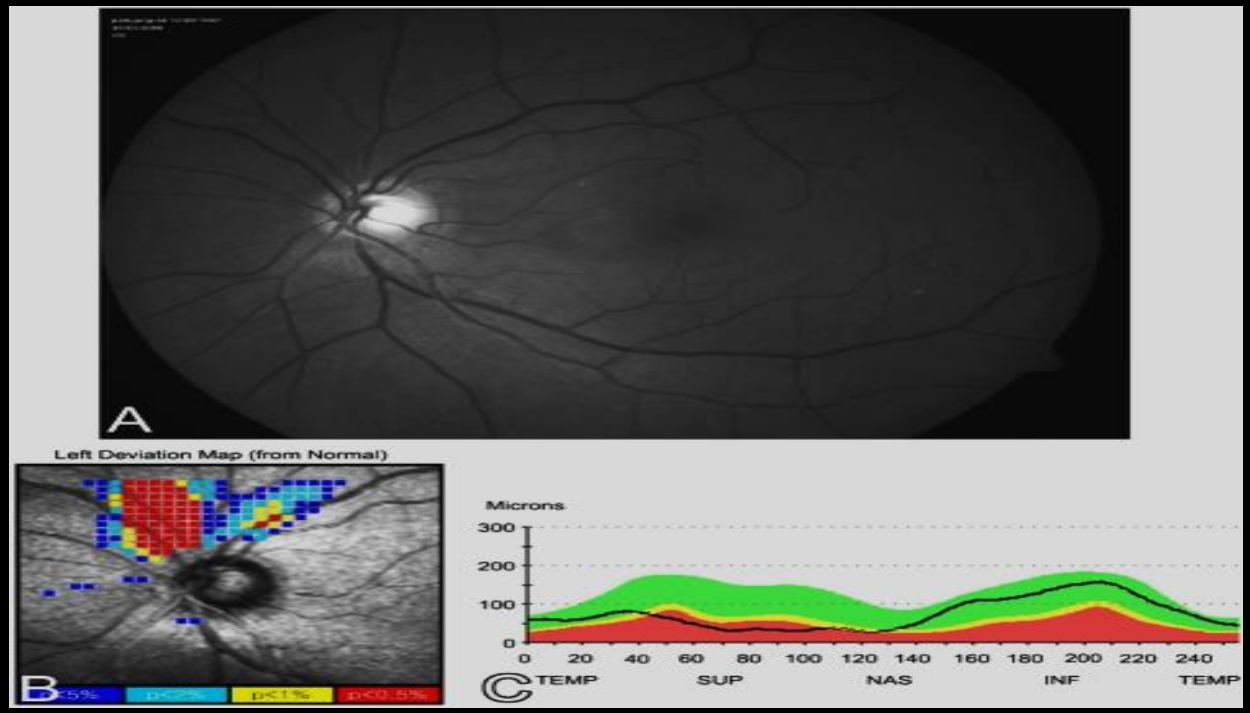
DIFFUSE, CLINICAL RNFL LOSS

- MOST COMMON
- HARDEST TO IDENTIFY
- LOSS OF STRIATIONS IN THE SUPERIOR AND INFERIOR ARCUATE BUNDLES
- RAKED OR THINNED APPEARANCE
- STRIATIONS ARE LESS BRIGHT
- TEXTURE IS FINER
- TERTIARY VESSELS ARE VISIBLE
- COMPARE SUPERIOR TO INFERIOR
- LOOK FOR RIM THINNING OR NOTCH
- COMPARE RIGHT TO LEFT EYE
- REVERSAL MAY OCCUR LATE IN DISEASE
  - DIM / BRIGHT / DIM





The Glaucoma Handbook. AB Litwak. Butterworth-Heinemann. 2000.



THAT'S HARD!

- TAKE PICTURES
- GO BACK AND LOOK AT THEM
- COMPARE TO
  - ONH APPEARANCE
  - VISUAL FIELD
  - AND IF AVAILABLE...DO AN OPTIC NERVE RNFL SCAN
    - OCT, GDX, HRT
- LOOK FOR CHANGE OVER TIME

"HIGHLIGHTS" IN THE HISTORY OF RNFL / OCT EVALUATION

1991 Clinical RNFL Loss MAY precede VF loss by 6 years

1991 First OCT Developed

1995 First Glaucoma OCT Developed

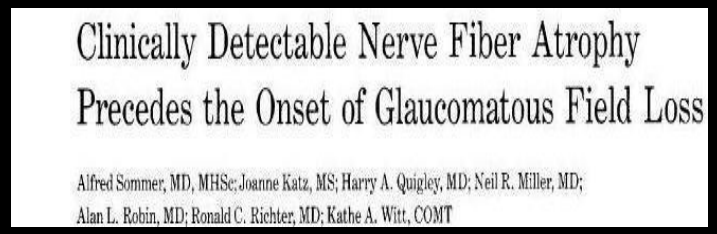
2000 RNFL Photos vs Time Domain OCT are Similar

2006 Time Domain OCT Predicts Early Glaucoma

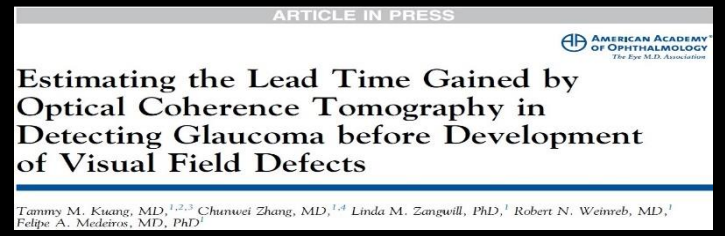
2009 Spectral Domain OCT Similar to Time Domain

2011 Spectral Domain OCTs are all Similar

2015 OCT may detect glaucoma 8 years prior to VF loss


Clinically Detectable Nerve Fiber Atrophy Precedes the Onset of Glaucomatous Field Loss

Alfred Sommer, MD, MHSc; Joanne Katz, MS; Harry A. Quigley, MD; Neil R. Miller, MD; Alan L. Robin, MD; Ronald C. Richter, MD; Kathe A. Witt, COMT


ARTICLE IN PRESS

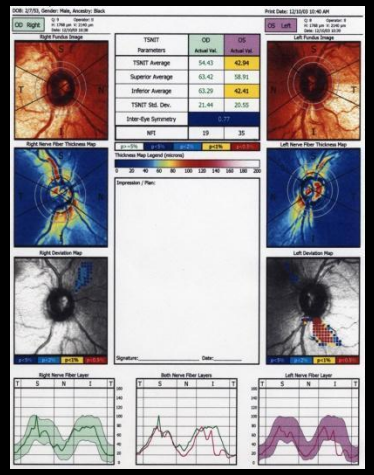
AMERICAN ACADEMY OF OPHTHALMOLOGY The Eye M.D. Association

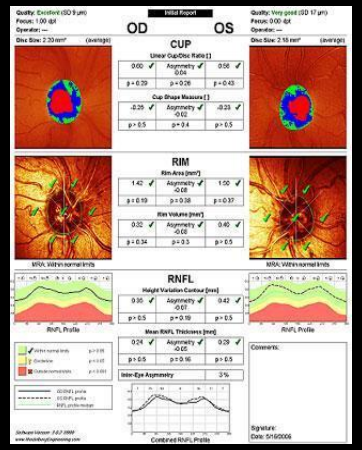
Estimating the Lead Time Gained by Optical Coherence Tomography in Detecting Glaucoma before Development of Visual Field Defects

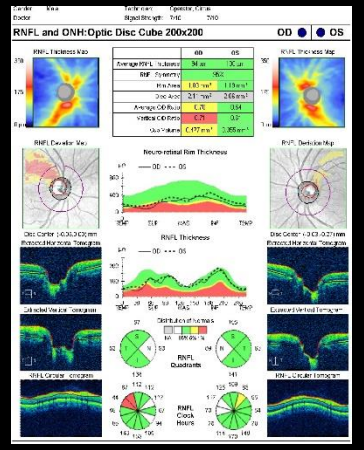
Tammy M. Kuang, MD,[1,2,3] Chunwei Zhang, MD,[1,4] Linda M. Zangwill, PhD,[1] Robert N. Weinreb, MD,[1] Felipe A. Medeiros, MD, PhD[1]

COMPUTER BASED ONH / RNFL ANALYSIS

- OPTIONS
  - GDX (RNFL), HRT (ONH, RNFL, Macula, Cornea), OCT (RNFL, Macula), Etc.
    - ALL REVISED SINCE INCEPTION
    - STUDIES HAVE SHOWN VARIOUS STRENGTHS / WEAKNESSES
    - DIAGNOSTIC CAPABILITIES
      - USED TO HELP DISCRIMINATE NORMALS FROM EARLY GLAUCOMA
      - USED TO MONITOR FOR CHANGE (PROGRESSION)

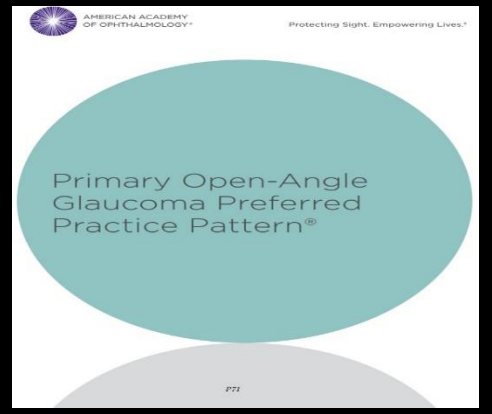






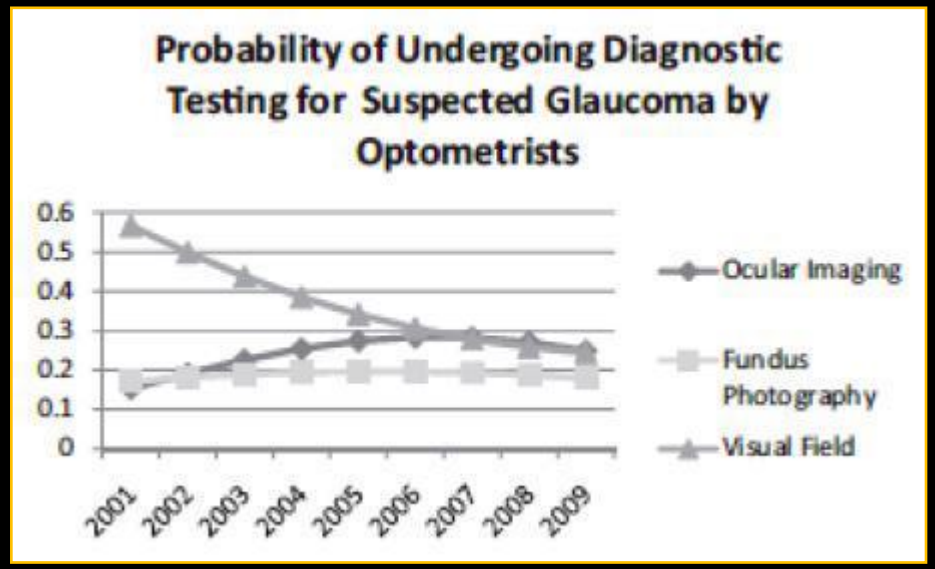
WHAT DOES THE AAO SAY ABOUT ONH DOCUMENTATION / ANALYSIS?

- APPEARANCE OF ONH SHOULD BE DOCUMENTED
  - COLOR STEREOPHOTOGRAPHS ARE ACCEPTABLE
  - COMPUTER ANALYSIS OF ONH AND RNFL IS AN ALTERNATIVE
- 3 TYPES OF COMPUTER BASED IMAGING
  - SIMILAR IN ABILITY TO DISTINGUISH GLAUCOMA FROM CONTROLS
  - USEFUL, WHEN ANALYZED IN CONJUNCTION WITH OTHER RELEVANT CLINICAL PARAMETERS
- EACH METHOD IS COMPLEMENTARY



TRENDS IN DIAGNOSTIC TESTING

- 2001-2009 STUDY
  - MANAGED CARE NETWORK
  - PATIENTS OF OD OR MD
  - > 40 YO, AT LEAST 1 VISIT
- DIAGNOSES
  - –OAG = 169,917
  - –OAG SUSPECTS = 395,721
- RATES OF CHANGE
  - –IMAGING
    - OPHTHALMOLOGISTS INCREASED BUT NOT AS MUCH AS OPTOMETRISTS
  - –VISUAL FIELDS
    - OPHTHALMOLOGISTS DECREASED BUT NOT AS MUCH AS OPTOMETRISTS



Ophthalmology 2012; 119: 748-758

WHICH OCT TO USE?
THAT'S YOUR CALL

REVIEW OF OPTOMETRY

HOME | CE | TOPICS | EVENTS

Published February 15, 2020

How Do OCT Devices for Glaucoma Compare?

An in-person review of four unique instruments helps provide insight on what each can offer glaucoma patients.

By Ryan Schott, OD

Table 1. Comparison of Commonly Used OCT Devices *(includes others not tested)*

	Optovue Avanti	Zeiss Cirrus 6000	Topcon Maestro2	Topcon Triton	Heidelberg Spectralis	Nidek RS-3000 Advance	Canon Xephilio OCT-A1
Imaging platform	SD-OCT	SD-OCT	SD-OCT	SS-OCT	SD-OCT	SD-OCT	SD-OCT
Optical source	840nm superluminescent diode (SLD)	840nm SLD	840nm SLD	wavelength-swept laser at 1,050nm	880nm SLD	880nm SLD	855nm SLD
Scan speed (A-scans/sec)	70,000	100,000	50,000	100,000	85,000	53,000	70,000
A-scan depth	3.0mm	2.0 – 2.9mm (in tissue)	2.3mm	2.6mm	1.92mm	2mm	2.0mm
Axial resolution	5µm	5µm (in tissue)	6µm	8µm (optical), 2.6µm (digital)	7µm (3.9µm/pixel)	7µm	3.4µm (optical) 1.6µm (digital)
Transverse resolution	15µm	15µm (in tissue)	20µm	20µm	14µm (5.7µm/pixel)	20µm	20µm
Imaging modes	Widefield *en face* OCT, OCT-A	Posterior segment, anterior segment, OCT-A, fundus imaging	Fundus (color, red-free, infrared), anterior and posterior segment (color, infrared), anterior and posterior OCT	Fundus (color, red-free, infrared), anterior segment (color, infrared), anterior and posterior OCT, OCT-A (only available in Europe)	Anterior segment, widefield, fundus imaging, IR, blue-reflectance (red-free), multicolor, scanning laser angiography, OCT-A, ultra-widefield, high magnification	Fundus surface imaging, anterior segment OCT (optional module), posterior segment OCT, EDI-OCT	Fundus (SLO), anterior segment, posterior segment
Normative database	442 eyes	284 eyes	399 eyes	410 eyes	368 eyes	N/A	520 eyes

DEVICE COMPARISON

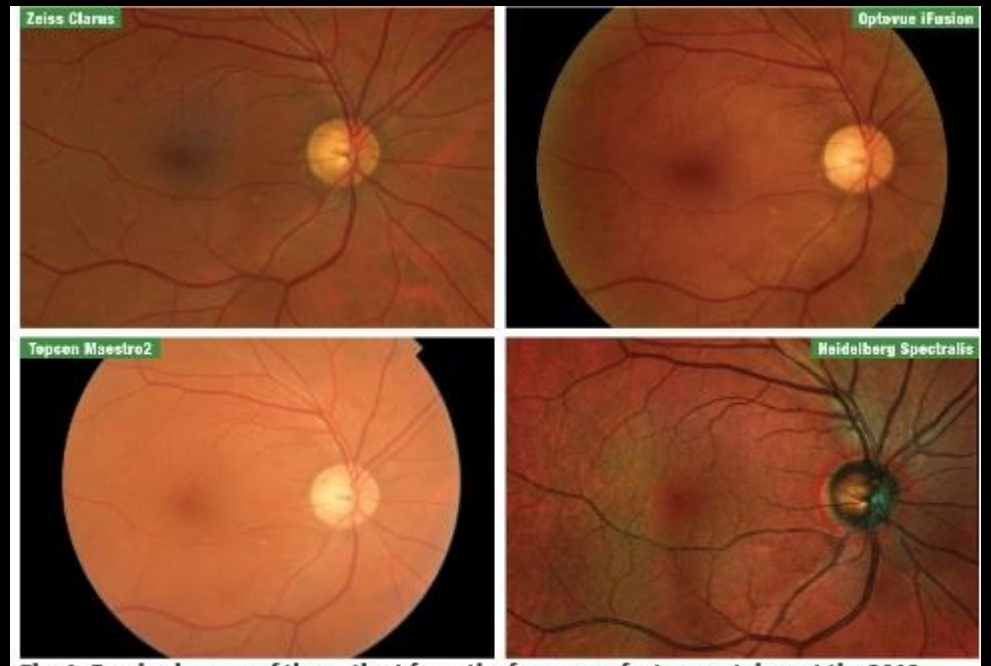


Fig. 1. Fundus images of the patient from the four manufacturers, taken at the 2019 Academy of Optometry meeting in Orlando. From top left clockwise are Zeiss Clarus, Optovue iFusion, Heidelberg Spectralis and Topcon Maestro2. *Click image to enlarge.*

SCHOTT R. Review of Optometry 2/15/20

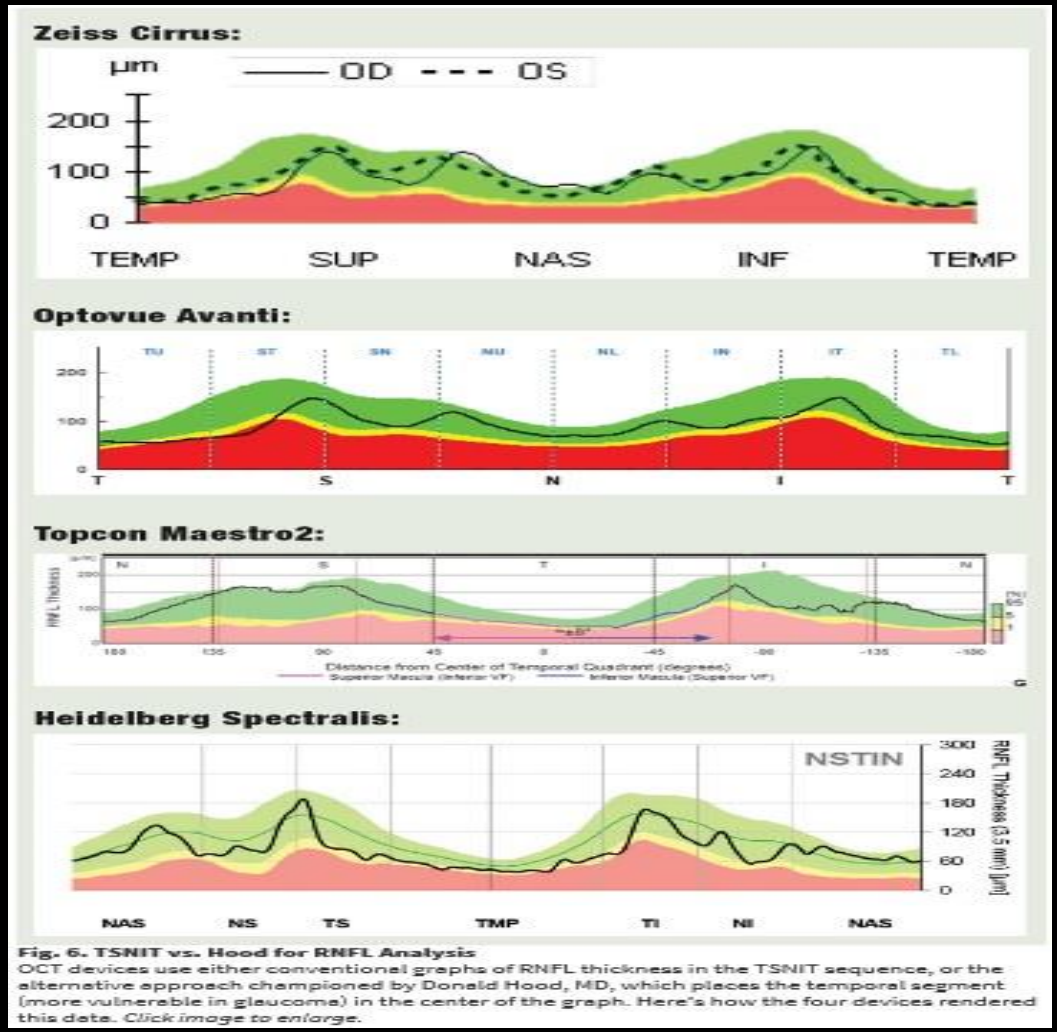
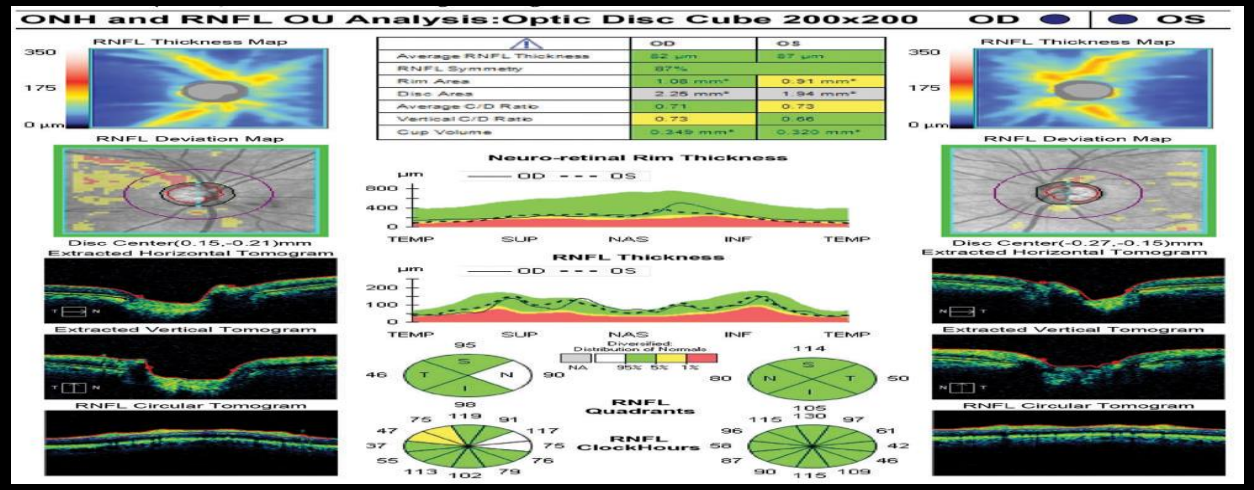
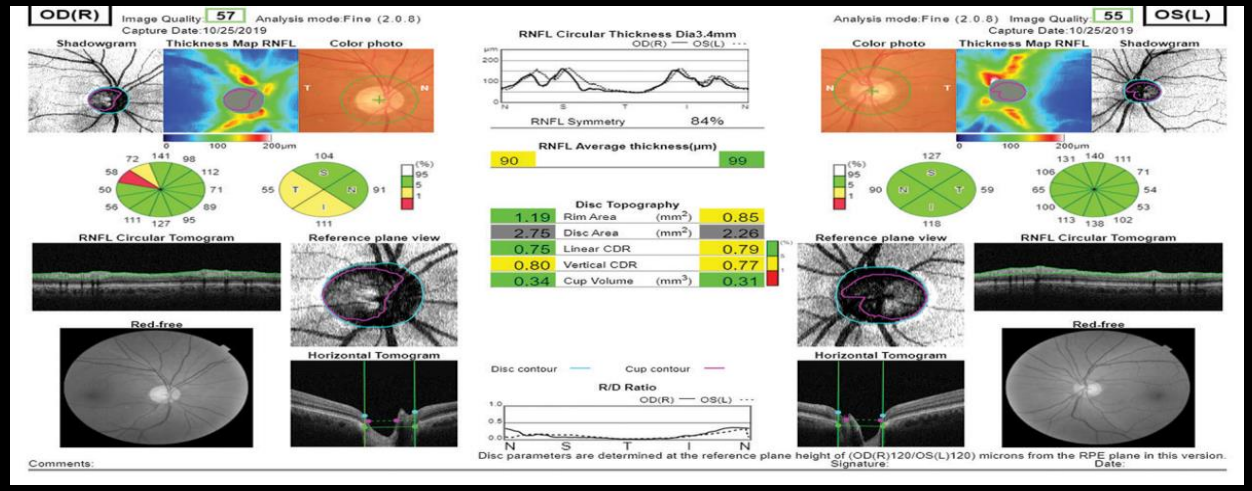


Fig. 6. TSNIT vs. Hood for RNFL Analysis
OCT devices use either conventional graphs of RNFL thickness in the TSNIT sequence, or the alternative approach championed by Donald Hood, MD, which places the temporal segment (more vulnerable in glaucoma) in the center of the graph. Here's how the four devices rendered this data. *Click image to enlarge.*

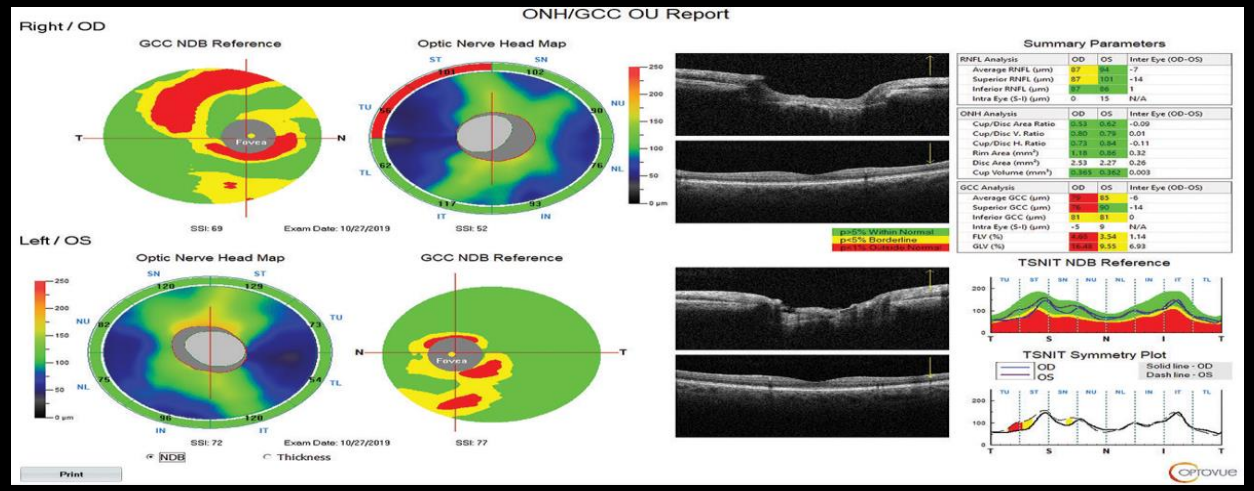
DEVICE DIFFERENCES IN RNFL REPORT



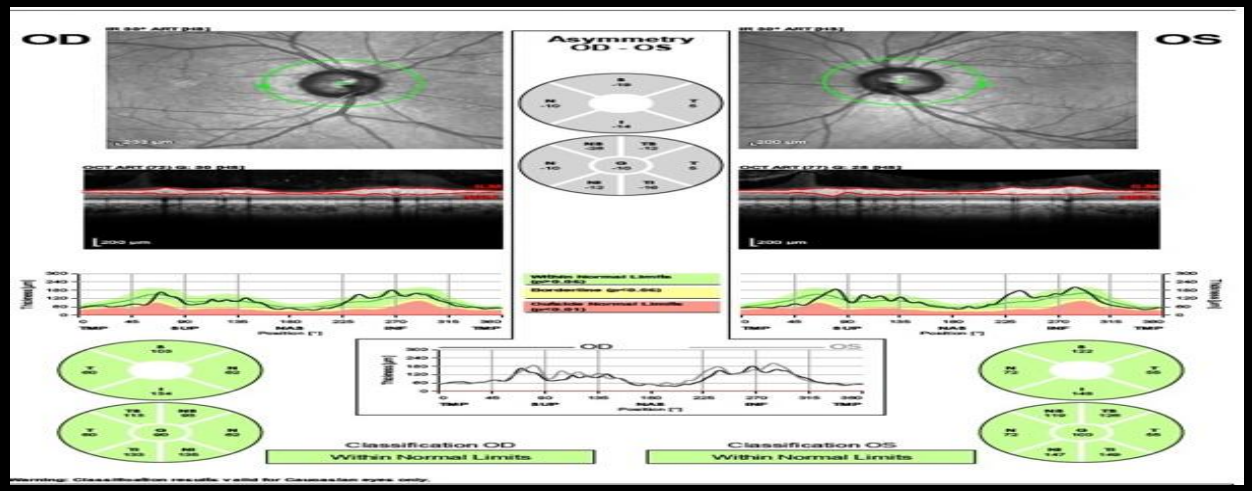
Cirrus 6000 (Dr. Schott)



Topcon Maestro2 (Dr. Schott)



Optovue Avanti (Dr. Schott)



Heidelberg Spectralis (VA example)

THE CIRRUS NORMATIVE DATABASE

- 284 “NORMAL” PATIENTS
- QUALITY SCORE > 6
- AGE 19-84 (MEAN 46.5)
- REFRACTIVE ERROR -12 TO +8
- ETHNIC “DIVERSITY”
  - 43% CAUCASIAN (122)
  - 24% ASIAN
  - 18% AFRICAN AMERICAN (51)
  - 12% HISPANIC (34)
  - 1% INDIAN
  - 6% MIXED ETHNICITY

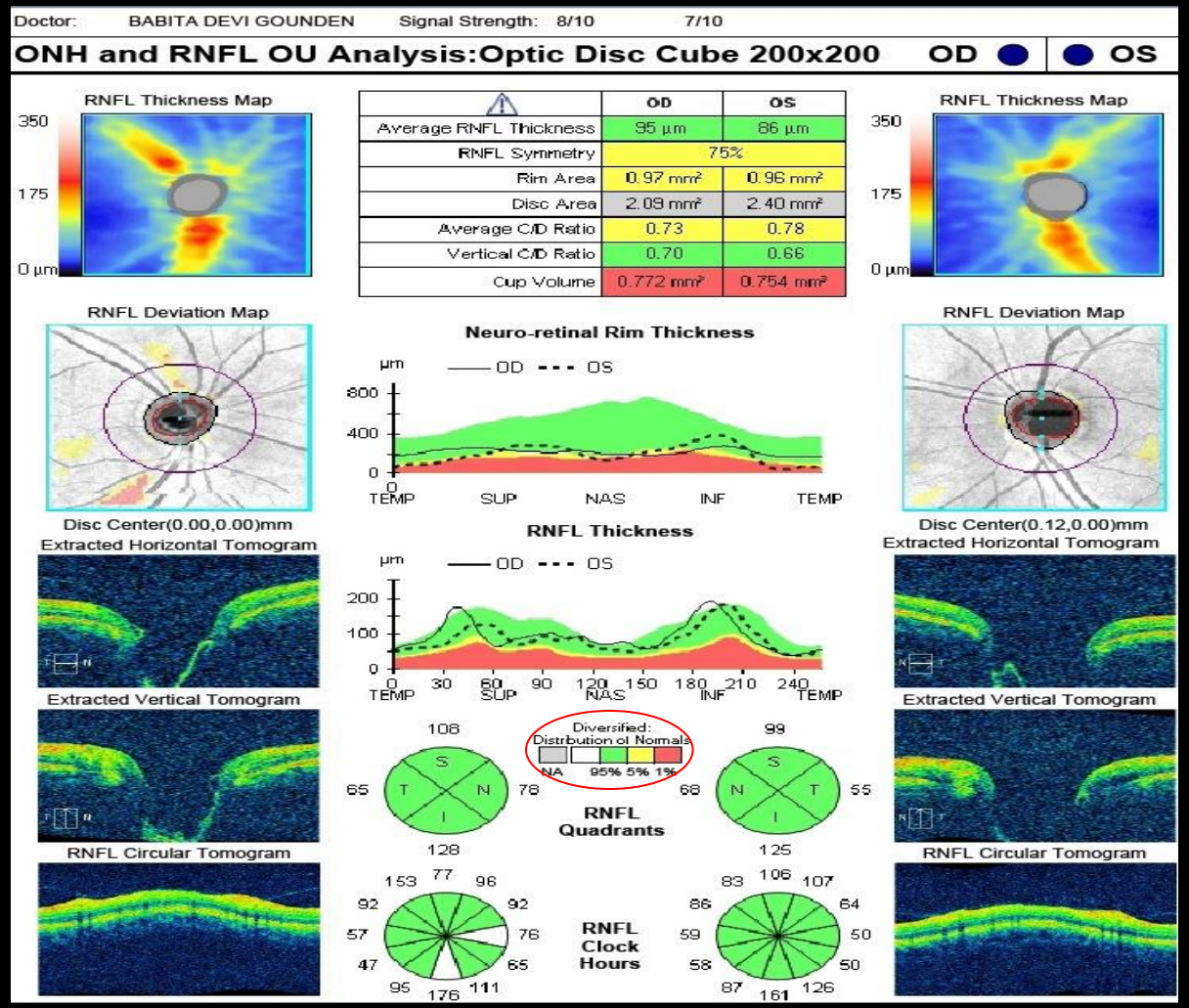
KEEP YOUR OWN BRAND OF OCT’S DIFFERENCES IN MIND

FACTORS THAT IMPACT THE CIRRUS NORMATIVE DATABASE

- RNFL
  - SOFTWARE DOES COMPARE AGE TO AGE FOR RNFL EVALUATION
  - SOFTWARE DOES NOT COMPARE BASED ON ETHNIC GROUP
    - FYI: SPECTRALIS IS ONLY CAUCASIANS (A BIG DEAL OR NOT?)

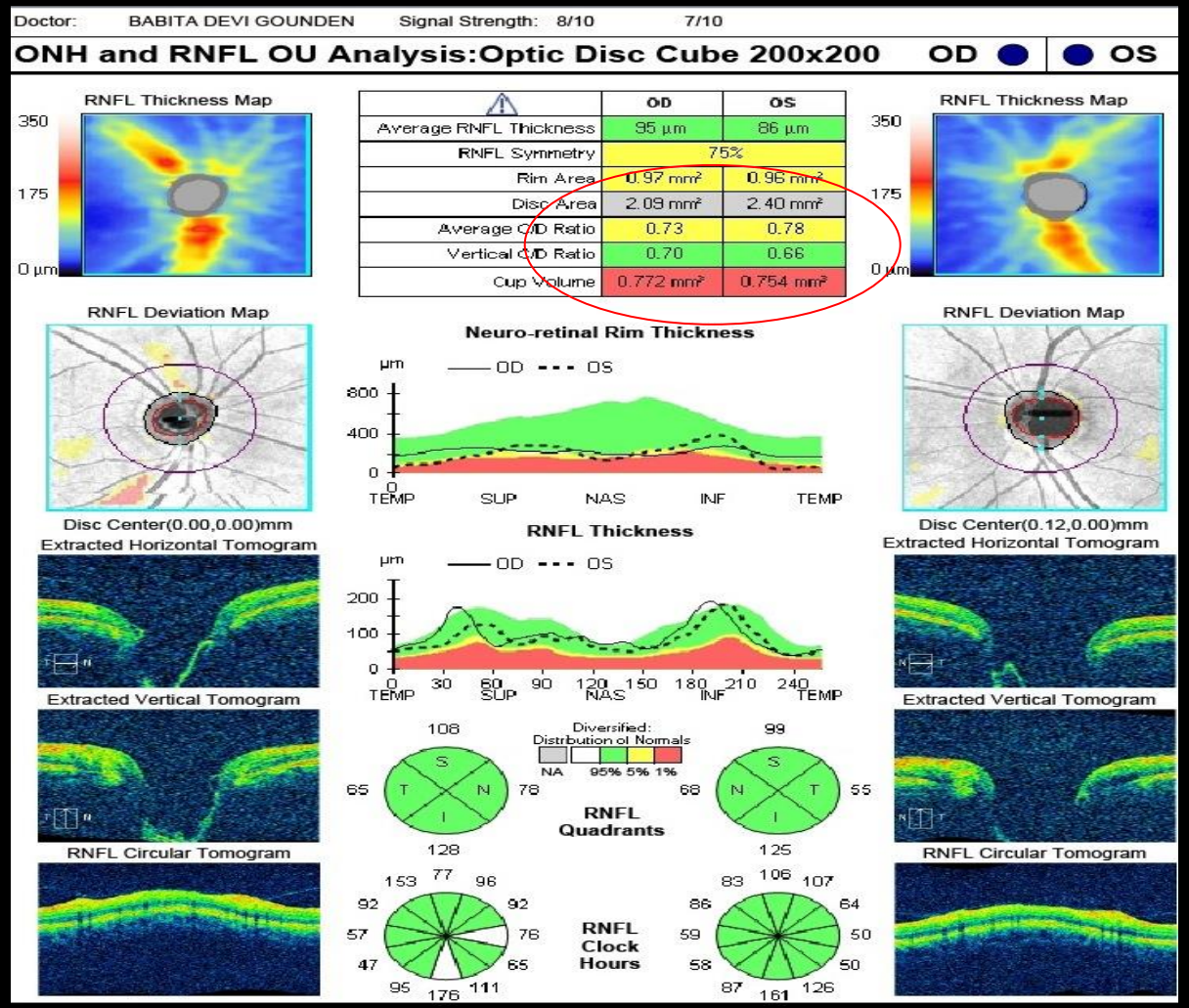
- DISC SIZE
  - DISC AREA 1.06 -3.38 mm^2 (avg 1.83)
    - SMALL < 1.63
    - MEDIUM 1.63-1.97
    - LARGE > 1.97
  - SOFTWARE DOES COMPARE DISC SIZE FOR ONH EVALUATION
    - SMALL OR LARGE DISC AREA NOT COMPARED DUE TO TOO FEW IN DATABASE
  - SOFTWARE DOES NOT COMPARE DISC SIZE FOR RNFL EVALUATION

CIRRUS ONH / RNFL ANALYSIS



- COLORS ARE **NOT**
  - NORMAL
  - THIN
  - LOSS
- COLORS ARE PATIENT COMPARED TO NORMALS
  - WHITE - UPPER 5% OF NORMALS
  - GREEN – MIDDLE 90% OF NORMALS
  - YELLOW – LOWER 5% OF NORMALS
  - RED – LOWEST 1% OF NORMALS
  - GRAY – NOT COMPARED

CIRRUS FOR ONH ANALYSIS



- RIM AREA (RELEVANT? MAYBE)
  - RANGE 0.75-2.38 mm^2 (AVG 1.31)
  - COMPARED TO NORMALS?
    - PEOPLE HAVE A NUMBER GANGLION CELLS (700K-1.5 MILLION)
    - CANNOT ACCOUNT FOR THIS OTHER THAN TO AVG VALUES
- DISC AREA (RELEVANT)
  - ALWAYS GRAY
  - LARGER DA HAVE LARGER C/D, MORE NEURO RIM TISSUE
    - 1.06-3.38 mm^2 (AVG 1.83)
    - SMALL < 1.63 / MEDIUM 1.63-1.9 / LARGE > 1.97
- C/D RATIO (RELEVANT)
  - DEPENDENT ON DISC AREA
  - NUMBER OF GANGLION CELL AXONS IN RETINA
  - INCREASES AS GANGLION CELL AXONS ARE LOST
  - VERTICAL C/D MORE IMPORTANT
- CUP VOLUME (NOT RELEVANT)
  - INCREASES AS EXCAVATION INCREASES
  - POORER REPRODUCIBILITY

GUIDE FOR SUSPECTING GLAUCOMA USING THE CIRRUS FOR ONH ANALYSIS

Ability of Cirrus HD-OCT Optic Nerve Head Parameters to Discriminate Normal from Glaucomatous Eyes

*Jean-Claude Mwanza, MD, PhD,[1] Jonathan D. Oakley, PhD,[2] Donald L. Budenz, MD, MPH,[1] Douglas R. Anderson, MD,[1] for the Cirrus Optical Coherence Tomography Normative Database Study Group**

Purpose: To determine the ability of optic nerve head (ONH) parameters measured with spectral domain Cirrus HD-OCT (Carl Zeiss Meditec, Inc., Dublin, CA) to discriminate between normal and glaucomatous eyes and to compare them with the discriminating ability of peripapillary retinal nerve fiber layer (RNFL) thickness measurements performed with Cirrus HD-OCT.

Design: Evaluation of diagnostic test or technology.

Participants: Seventy-three subjects with glaucoma and 146 age-matched normal subjects.

Methods: Peripapillary ONH parameters and RNFL thickness were measured in 1 randomly selected eye of each participant within a 200×200 pixel A-scan acquired with Cirrus HD-OCT centered on the ONH.

Main Outcome Measures: Optic nerve head topographic parameters, peripapillary RNFL thickness, and area under receiver operating characteristic curves (AUCs).

Results: To distinguish normal from glaucomatous eyes, regardless of disease stage, the 6 best parameters (expressed as AUC) were vertical rim thickness (VRT, 0.963), rim area (0.962), RNFL thickness at clock-hour 7 (0.957), RNFL thickness of the inferior quadrant (0.953), vertical cup-to-disc ratio (VCDR, 0.951), and average RNFL thickness (0.950). The AUC for distinguishing between normal eyes and eyes with mild glaucoma was greatest for RNFL thickness of clock-hour 7 (0.918), VRT (0.914), rim area (0.912), RNFL thickness of inferior quadrant (0.895), average RNFL thickness (0.893), and VCDR (0.890). There were no statistically significant differences between AUCs for the best ONH parameters and RNFL thickness measurements ($P>0.05$).

Conclusions: Cirrus HD-OCT ONH parameters are able to discriminate between normal eyes and eyes with glaucoma or even mild glaucoma. There is no difference in the ability of ONH parameters and RNFL thickness measurement, as measured with Cirrus OCT, to distinguish between normal and glaucomatous eyes.

Financial Disclosure(s): Proprietary or commercial disclosure may be found after the references.

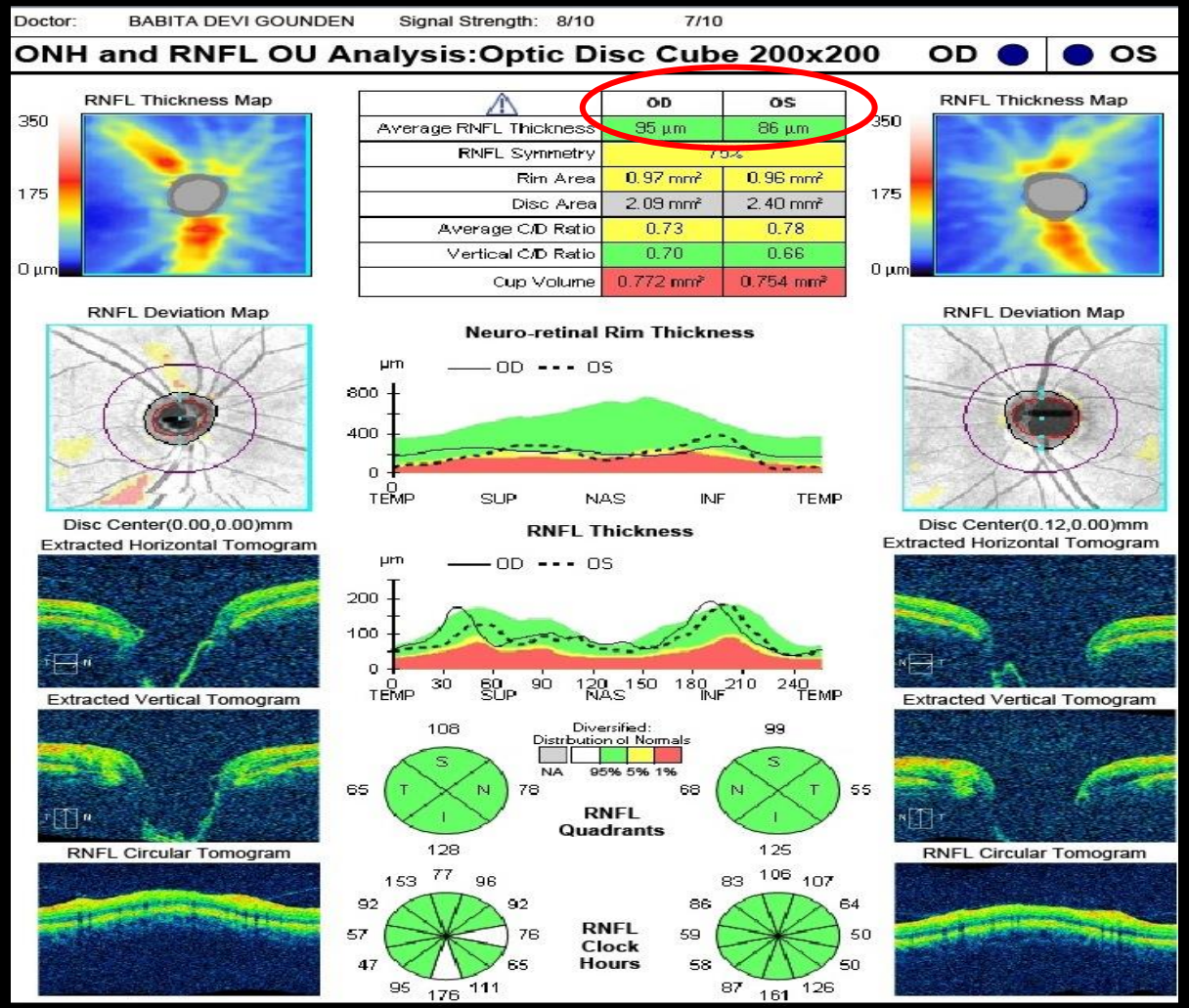
Ophthalmology 2011;118:241–248

- ABNORMAL ONH RIM AREA
  - <5% OR <1%
- ABNORMAL VERTICAL C/D
  - <5% OR <1%
- NO DIFFERENCE IN ABILITY OF ONH PARAMATERS COMPARED TO RNFL PARAMETERS TO DISTINGUISH BETWEEN NORMAL AND GLAUCOMATOUS EYES
  - = JUST AS GOOD AS THE RNFL ANALYSIS
  - THEREFORE...DON'T SKIP IT. LOOK AT IT.

Mwanza JC, Oakley JD, Budenz DJ, et al. Ophthalmology 2011; 118: 241-248.

CIRRUS RNFL ANALYSIS

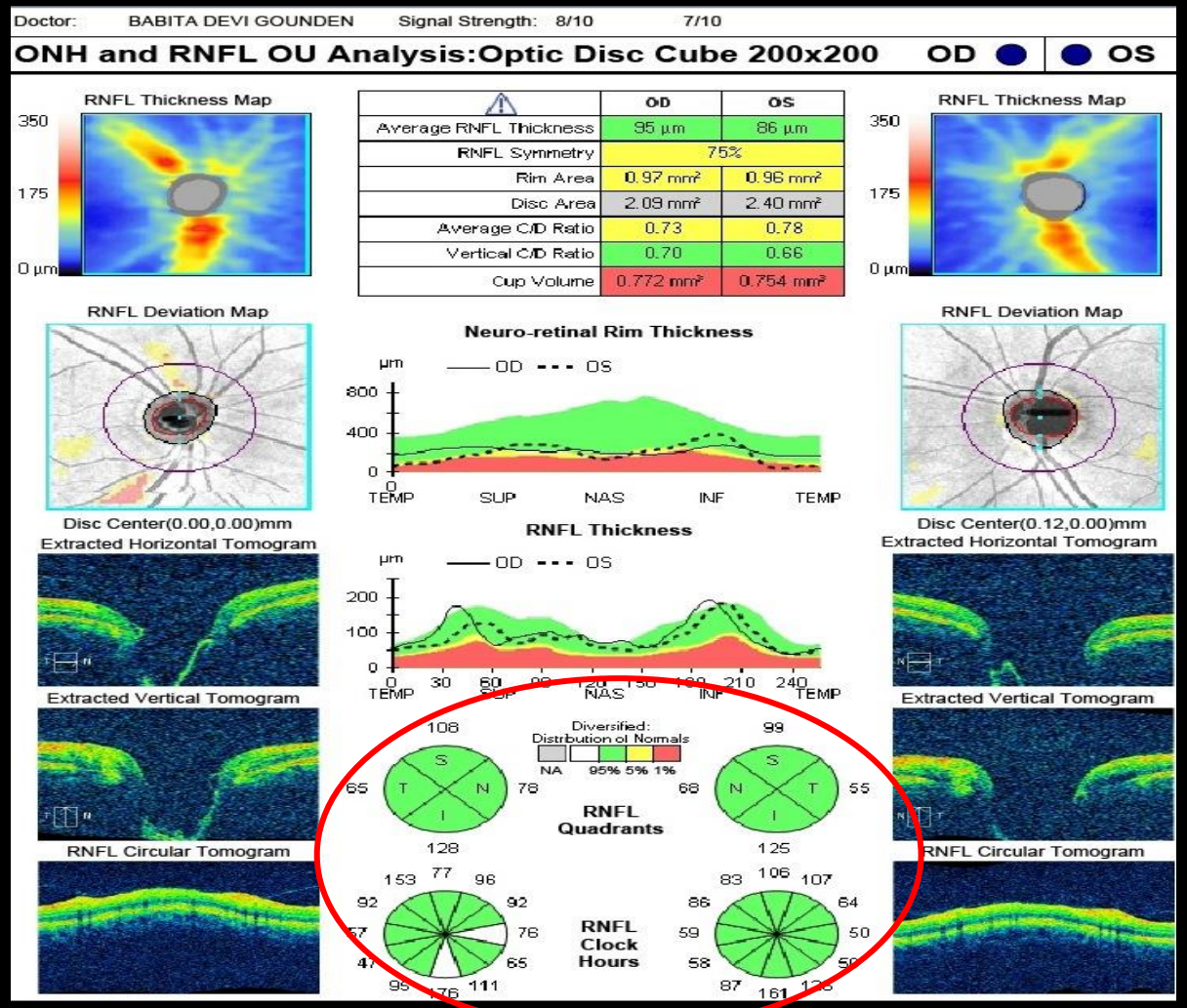
(Information can be loosely applied to Spectralis. I am unsure about other devices)



- AVERAGE (GLOBAL) RNFL THICKNESS
  - COMPARED TO NORMATIVE DATABASE
  - THICKNESS OF GANGLION CELL AXONS 360 DEGREES AROUND ONH
  - IT INCLUDES RNFL, BLOOD VESSELS, ASTROCYTES, GLIAL CELLS
  - IS A GLOBAL INDEX.
    - IT WILL MISS FOCAL DAMAGE!
  - LOOK FOR R / L ASYMMETRY

CIRRUS RNFL ANALYSIS

(Information can be loosely applied to Spectralis. I am unsure about other devices)

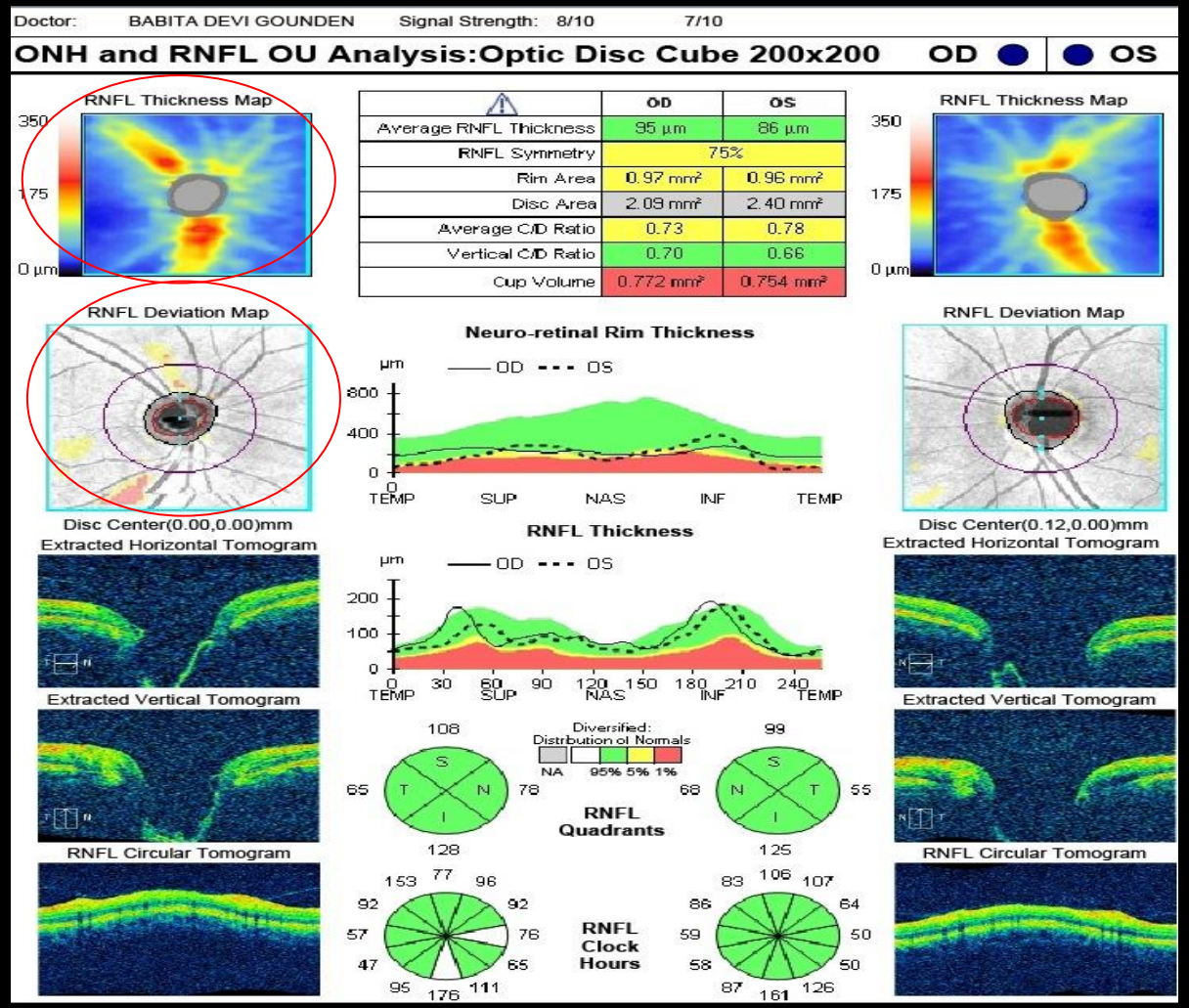


- QUADRANTS
  - COMPARED TO NORMATIVE DATABASE
  - LOOK WHERE MILD GLAUCOMA OCCURS
    - SUPERIOR
    - INFERIOR
  - SIGNS OF FOCAL DAMAGE
    - *LOOK FOR R / L ASYMMETRY

- CLOCK HOURS (SECTORS)
  - COMPARED TO NORMATIVE DATABASE
  - LOOK WHERE MILD GLAUCOMA OCCURS
    - SUPERIOR, SUPERIOR TEMPORAL
    - INFERIOR, INFERIOR TEMPORAL
  - SIGNS OF FOCAL DAMAGE
    - *LOOK FOR R / L ASYMMETRY

CIRRUS RNFL ANALYSIS

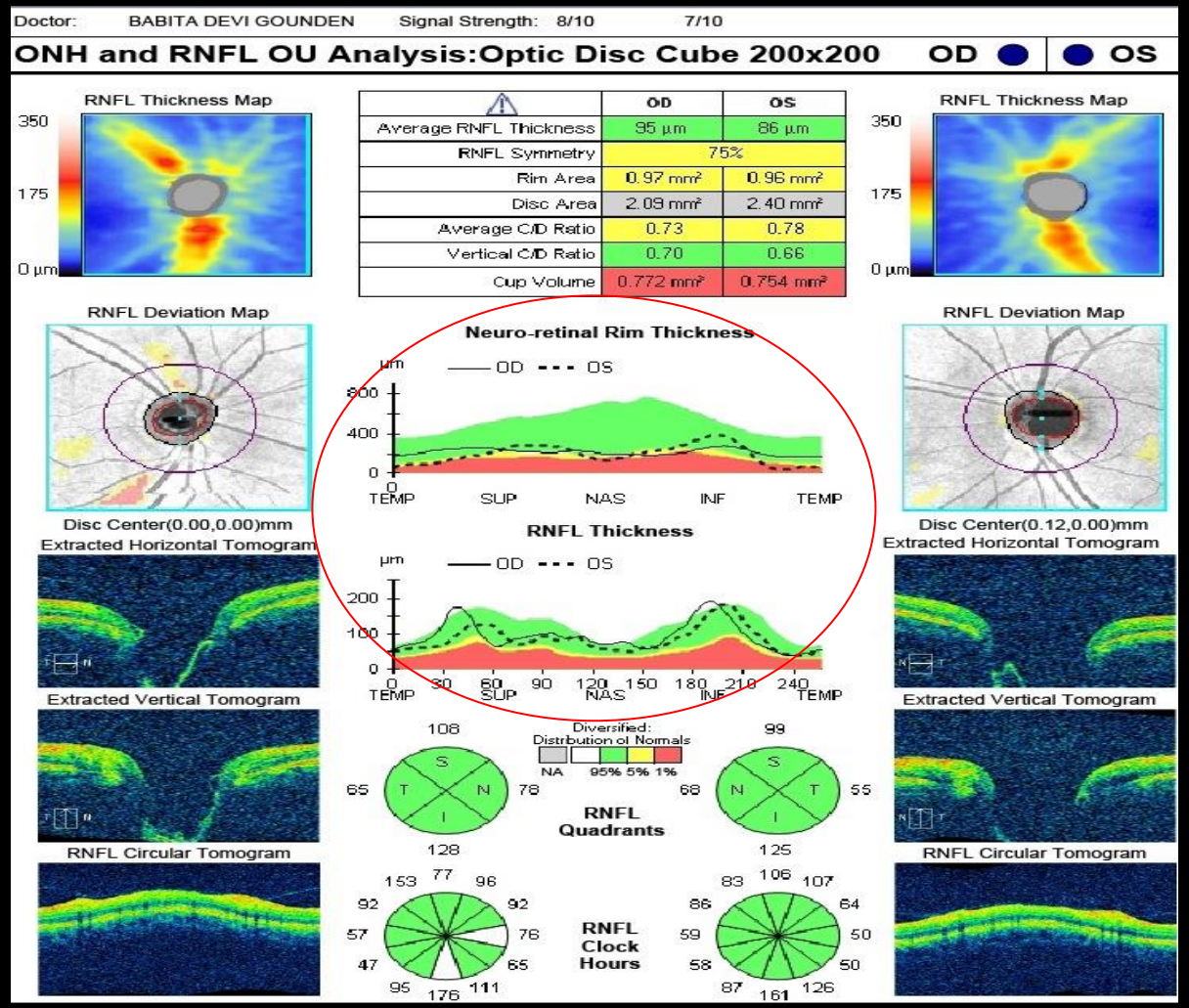
(Information can be loosely applied to Spectralis. I am unsure about other devices)



- RNFL THICKNESS MAP
  - SIMILAR TO APPEARANCE OF THE GDX
    - NOT AS DETAILED
    - "MORE BLURRY"
  - IS A TOPOGRAPHICAL DISPLAY OF THE RNFL
  - AN "HOURGLASS" PATTERN
    - THICKER SUPERIOR AND INFERIOR
    - RED / YELLOW = THICKER
    - BLUE AS RNFL THINS / DECREASES

- RNFL DEVIATION MAP
  - BOUNDARIES OF THE CUP AND DISC ARE PLOTTED
    - TOO SMALL TO BE OF USE?
  - RNFL DEVIATIONS FROM NORMAL ARE PLOTTED
    - YELLOW < 5% OF NORMALS
    - RED < 1% OF NORMALS

CIRRUS ONH / RNFL SYMMETRY ANALYSIS



- NEURO-RETINAL RIM THICKNESS SYMMETRY
  - COMPARED TO NORMATIVE DATABASE
    - LOOK FOR R / L ASYMMETRY
- RNFL THICKNESS / CONTOUR SYMMETRY
  - COMPARED TO NORMATIVE DATABASE
    - LOOK FOR R / L ASYMMETRY
      - DIFFERENCES BETWEEN EYES
      - FOCAL DIPS AT SUP / INF POLES

MY GUIDE FOR SUSPECTING GLAUCOMA

(IF YOU THINK THE CLINICAL ONH / RNFL LOOKS SUSPICIOUS…)

USING THE CIRRUS FOR THE ONH and RNFL

(COMPILED FROM VARIOUS ARTICLES)

Vertical C/D or ONH Rim Area outside 95% CI (yellow <5% or red <1%)

OR

Average thickness outside 95% CI (yellow <5% or red <1%)

OR

1 quadrant (sup / inf) outside 95% CI (yellow <5% or red <1%)

OR

2 clock hours (not directly temporal, nothing nasal) outside 95% CI (yellow <5% or red <1%)

OR

Asymmetry between the R / L eyes' average thickness / quad / clock hr / sector > 9 um

(Information can be loosely applied to Spectralis. I am unsure about other devices)

2 clock hours =1 Spectralis sector

DOES THE ONH / RNFL GUIDE I PROVIDED ALWAYS WORK?

- NOT ALWAYS
  - USE THE INFORMATION COMPILED FROM THE LITERATURE AS A GENERAL GUIDE
  - NO ONE METHOD WILL DIAGNOSE EVERY PATIENT
  - YOUR DEVICE MAY BE SLIGHTLY DIFFERENT
  - DO NOT COMPARE DATA ACROSS DEVICES
- RESULTS SHOULD CORRELATE WITH YOUR CLINICAL EXAM
  - ONH
  - RNFL
  - VISUAL FIELD
- REGARDLESS OF YOUR OPINION OF THE DATABASE…
  - YOU CAN NOW MONITOR YOUR PATIENT FOR CHANGE

KEEP IN MIND

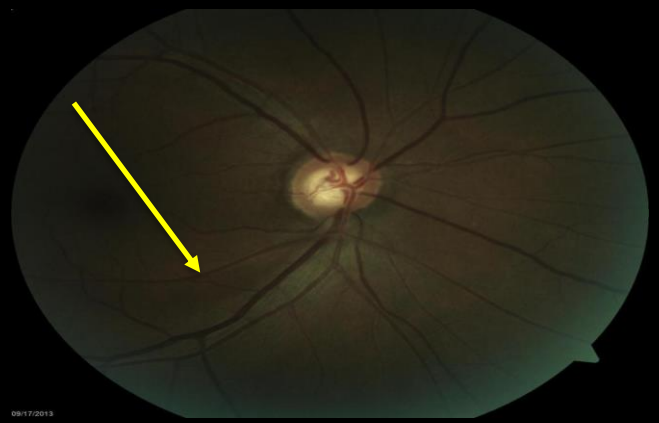
- RED DISEASE (FALSE POSITIVE)
  - A RED (OR YELLOW) OCT THAT IS BELIEVED TO BE GLAUCOMA BUT MAY BE INDICATIVE OF ANOTHER DISEASE OR JUST RED (OR YELLOW) AS A RESULT OF POOR IMAGING QUALITY
    - EX: DECENTRATION, PVD, OTHER MEDIA OPACITY, SEGMENTATION ERROR, POOR SIGNAL QUALITY, ETC.

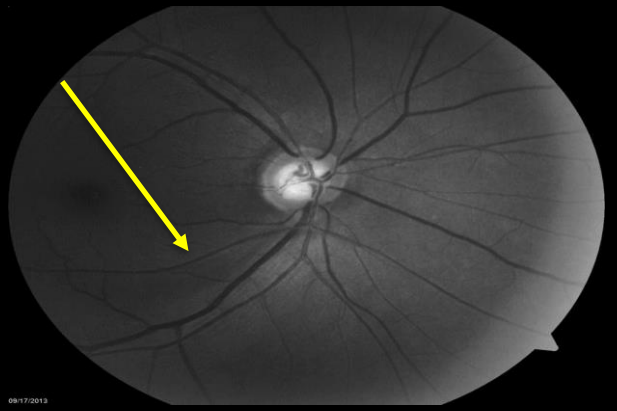
- GREEN DISEASE (FALSE NEGATIVE)
  - A GREEN OCT THAT IS BELIEVED TO BE NORMAL BUT ACTUALLY HAS CLINICALLY DETECTABLE EVIDENCE OF GLAUCOMA FOUND BY METHODS OF TESTING OTHER THAN JUST LOOKING AT THE COLORS ON THE OCT
    - EX: VISIBLE NOTCH / DISC HEMORRHAGE / CLINICAL FOCAL RNFL DEFECT BUT OCT IS GREEN

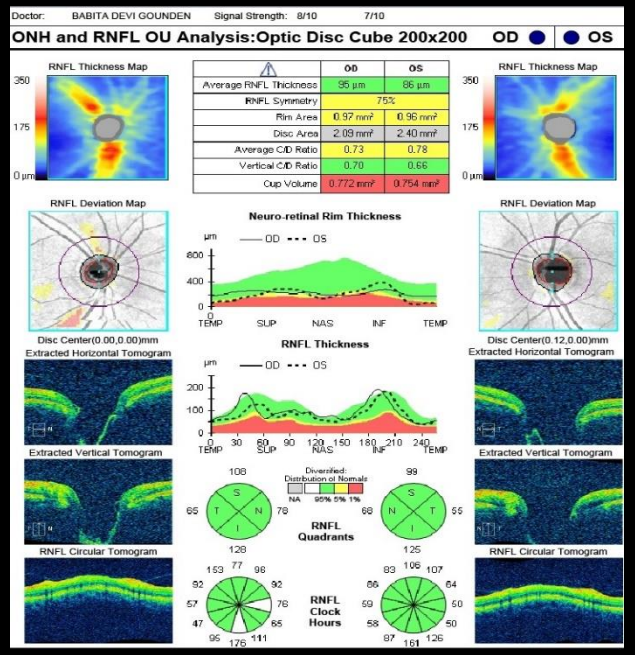
- OPTIC NERVE AND RETINAL NERVE FIBER LAYER IMAGING
  - NEED TO BE INTERPRETED IN THE CONTEXT OF THE CLINICAL EXAM AND OTHER SUPPLEMENTAL TESTS

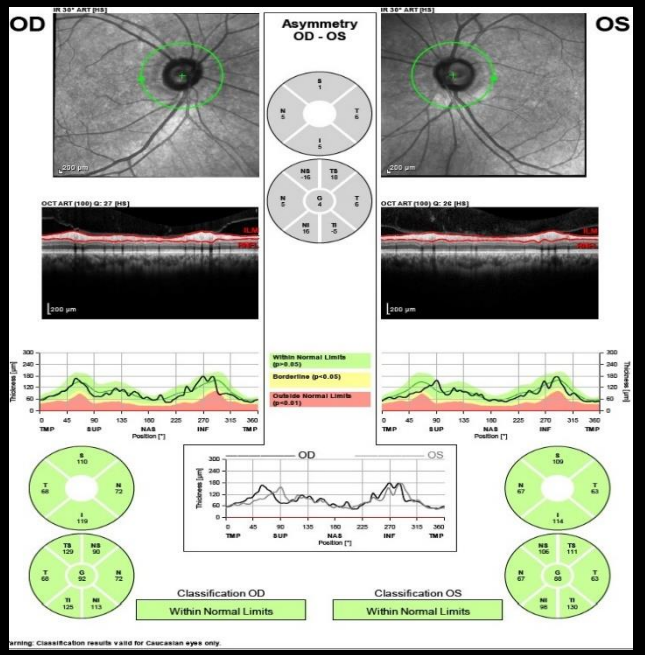
SHOULD YOU STILL BOTHER TO LOOK AT THE ONH OR RNFL?

- YES
  - DO NOT RELY ON A MACHINE
  - YOU ARE THE DOCTOR
    - LOOKING ALLOWS YOU TO DETERMINE IF
      - NORMAL
      - SUSPICIOUS
      - SIGNS OF DAMAGE
    - CORRELATE WHAT SEEN CLINICALLY WITH WHAT SHOWN ON THE OCT
    - THINGS YOU MAY SEE DON'T ALWAYS SHOW UP ON OCT
      - NOTCH, DISC HEME, CHANGE



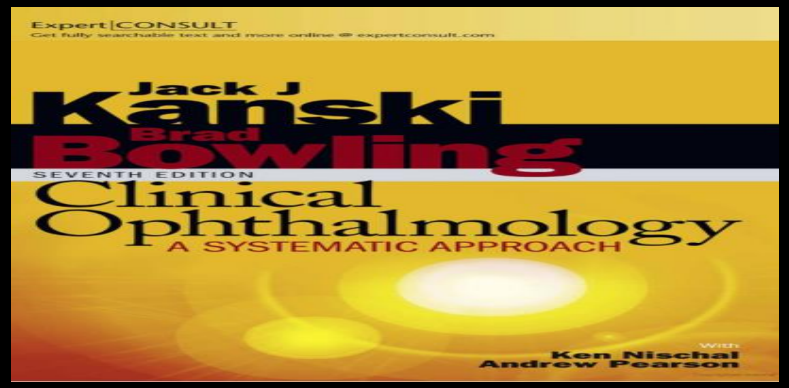






BE AWARE, IF THERE IS ONH DAMAGE OR RNFL LOSS BEFORE VISUAL FIELD LOSS…

- PREVIOUSLY KNOWN AS PREPERIMETRIC GLAUCOMA
  - THE CONCEPT REFERS TO GLAUCOMATOUS DAMAGE, USUALLY MANIFESTED BY A SUSPICIOUS OPTIC DISC AND / OR THE PRESENCE OF RETINAL NERVE FIBER LAYER DEFECTS, IN WHICH NO VISUAL FIELD ABNORMALITY HAS DEVELOPED.

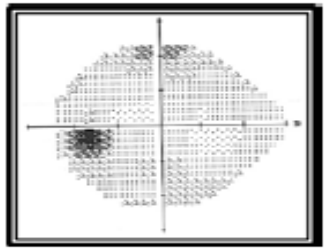


- NOW = MILD / EARLY GLAUCOMA
  - CONSIDER TREATMENT

Mild or Early Stage Glaucoma

ICD-9 365.71; ICD-10 7th digit "1"

- Optic Nerve abnormalities consistent with glaucoma
- but NO visual field abnormalities on any visual field test
- OR abnormalities present only on short-wave-length automated perimetry or frequency doubling perimetry

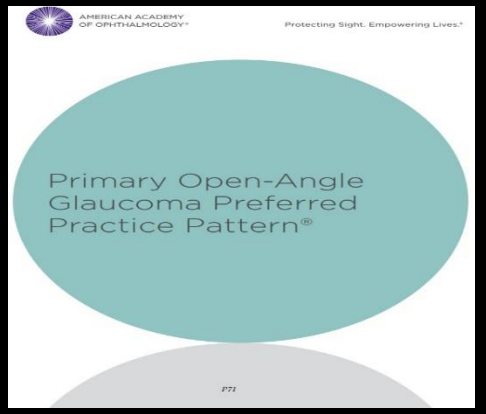


QUESTION

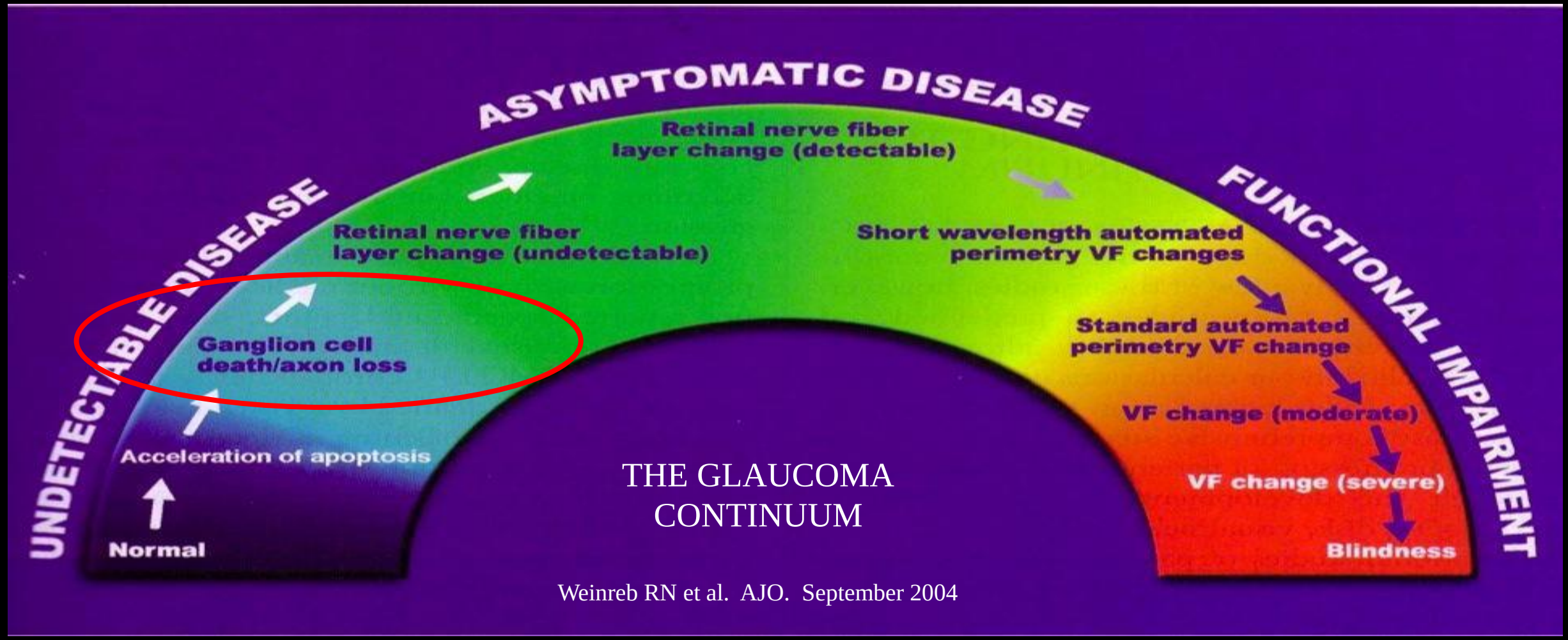
GLAUCOMA IS A DISEASE OF…?

1. THE INTRAOCULAR PRESSURE
2. THE VISUAL FIELD
3. THE OPTIC NERVE
4. THE RETINAL NERVE FIBER LAYER
5. THE RETINAL GANGLION CELLS

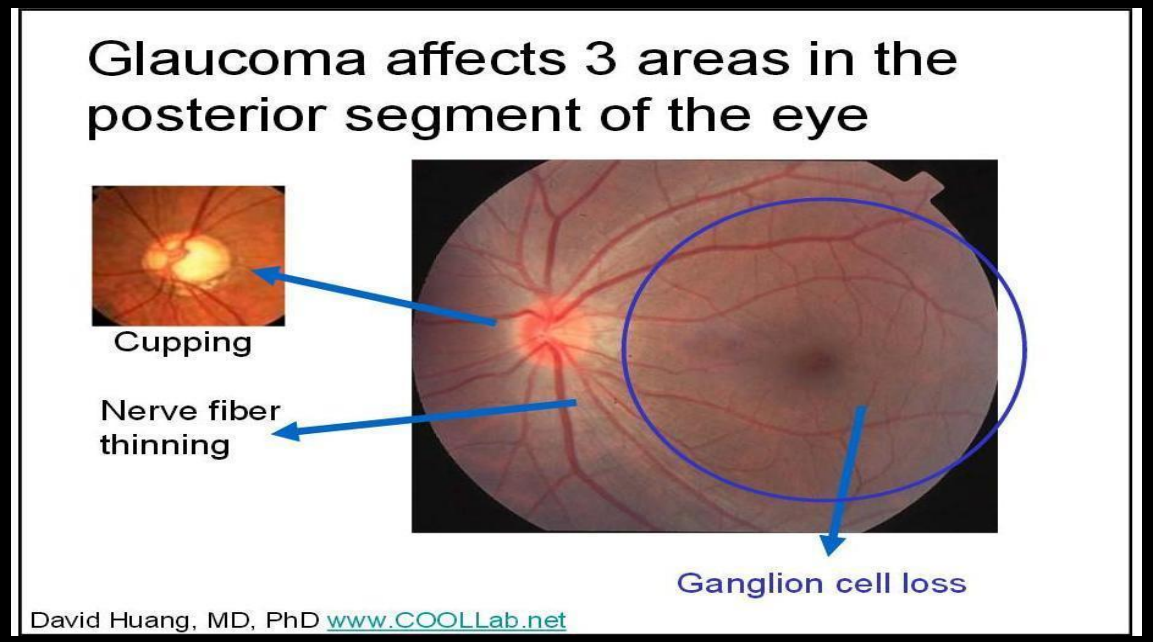
•REMEMBER THE DEFINITION OF POAG…



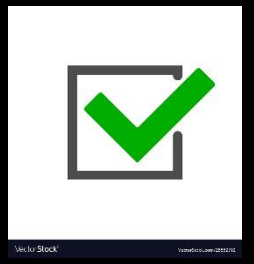
"A CHRONIC, PROGRESSIVE OPTIC NEUROPATHY IN ADULTS IN WHICH THERE IS A CHARACTERISTIC ACQUIRED ATROPHY OF THE OPTIC NERVE AND LOSS OF RETINAL GANGLION CELLS AND THEIR AXONS."

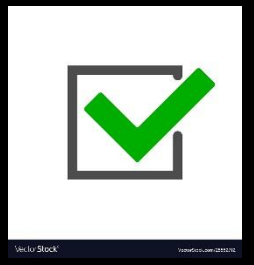


STRUCTURAL LOSS



- 3 AREAS IMPACTED
  - OPTIC NERVE
    - VISUALIZED
    - MEASURABLE
  - NERVE FIBER LAYER
    - VISUALIZED
    - MEASURABLE
  - GANGLION CELLS
    - NOT VISUALIZED
    - MEASURABLE





RETINAL GANGLION CELLS

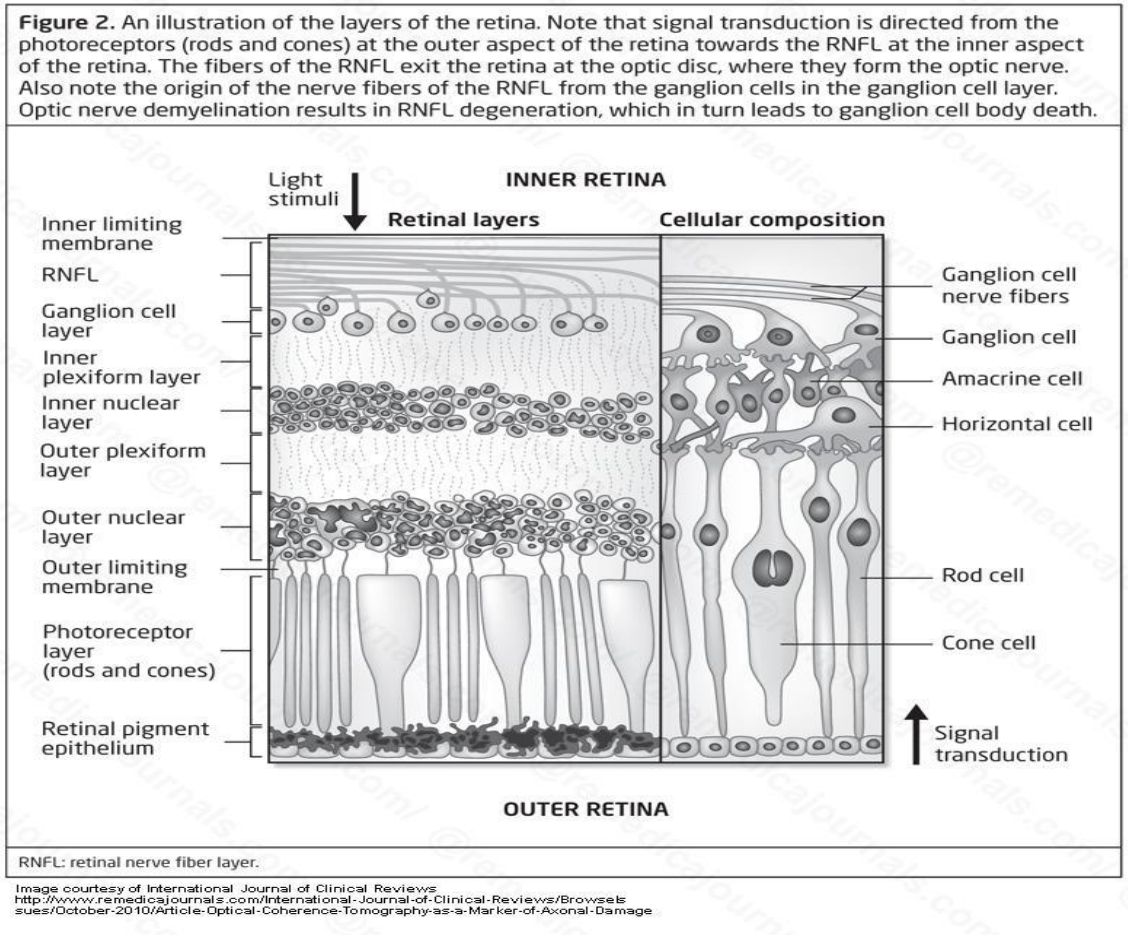


Figure 2. An illustration of the layers of the retina. Note that signal transduction is directed from the photoreceptors (rods and cones) at the outer aspect of the retina towards the RNFL at the inner aspect of the retina. The fibers of the RNFL exit the retina at the optic disc, where they form the optic nerve. Also note the origin of the nerve fibers of the RNFL from the ganglion cells in the ganglion cell layer. Optic nerve demyelination results in RNFL degeneration, which in turn leads to ganglion cell body death.

RNFL: retinal nerve fiber layer.

Image courtesy of International Journal of Clinical Reviews
http://www.remedicajournals.com/International-Journal-of-Clinical-Reviews/Browsels sues/October-2010/Article-Optical-Coherence-Tomography-as-a-Marker-of-Axonal-Damage

- 700K-1.5 MILLION RETINAL GANGLION CELLS
- 50% LOCATED WITHIN 4.5 mm OF THE FOVEA
- LESS VARIABILITY AMONG NORMAL INDIVIDUALS THAN ONH AND RNFL

Optical Coherence Tomography as a Marker of Axonal Damage in Multiple Sclerosis
Shiv Saidha, MRCPI, Christopher Eckstein, MD, and John N Ratchford, MD
Int J Clin Rev 2010;10:01

WHY IMAGE THE GANGLION CELLS

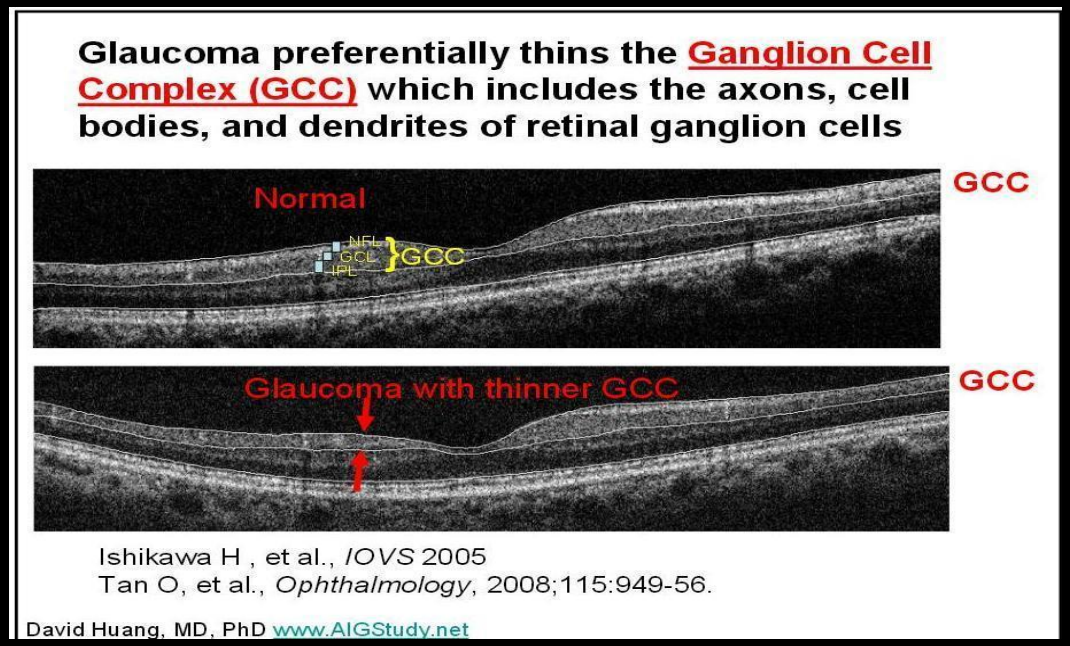
- SINCE A LARGE PROPORTION OF RGCS RESIDE IN THE MACULA, LOSS MIGHT BE A SIGN OF GLAUCOMATOUS DAMAGE
  - ZEIMER R, ASRANI S, ZOU S, ET AL, Ophthal. 1998;105(2):224-231

- MACULAR VOLUME
  - NORMALS > SUSPECTS > EARLY GLAUCOMA > ADVANCED
    - LEDERER DE, SCHUMAN JS, HERTZMARK E, ET. AL. Am J Ophthal. 2003;135(6):838-843

- CORRELATION BETWEEN MACULAR THICKNESS AND VF MD
  - GREENFIELD DS ET AL. Arch Ophthal. 2003;121(1):41-46

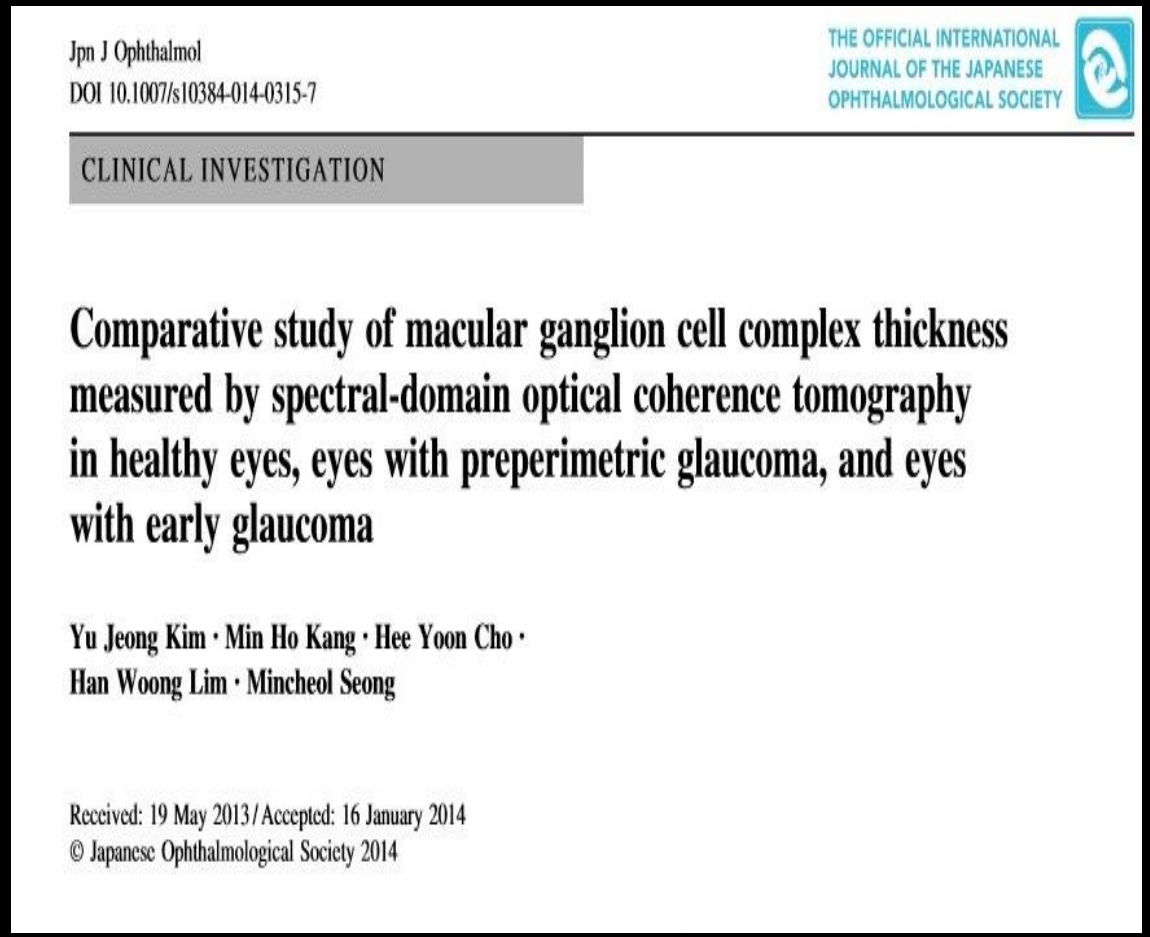
- MACULAR THICKNESS CORRELATES WITH PERIPAPILLARY RNFL
  - WOLLSTEIN G, SCHUMAN JS, PRICE L, ET AL. Am J Ophthal. 2004;138(2):218-225.

RETINAL GANGLION CELLS



- GLAUCOMA AFFECTS
  - THE GANGLION CELL COMPLEX (GCC)
    - RNFL
      - AXONS OF GANGLION CELLS
    - GANGLION CELL LAYER
      - CELL BODIES
    - INNER PLEXIFORM LAYER
      - DENDRITES

GCC vs THE RNFL



Jpn J Ophthalmol
DOI 10.1007/s10384-014-0315-7
THE OFFICIAL INTERNATIONAL JOURNAL OF THE JAPANESE OPHTHALMOLOGICAL SOCIETY

CLINICAL INVESTIGATION

Comparative study of macular ganglion cell complex thickness measured by spectral-domain optical coherence tomography in healthy eyes, eyes with preperimetric glaucoma, and eyes with early glaucoma

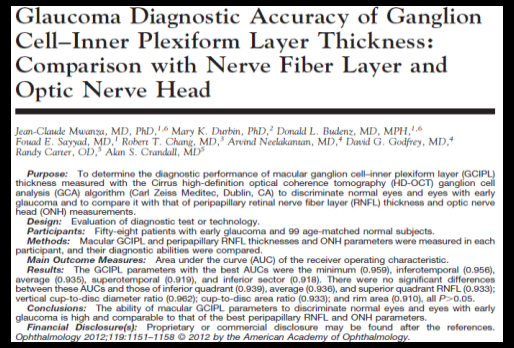
Yu Jeong Kim · Min Ho Kang · Hee Yoon Cho · Han Woong Lim · Mincheol Seong

Received: 19 May 2013 / Accepted: 16 January 2014

- 2014 JAPANESE STUDY
  - TOPCON 3D OCT 2000
  - 264 EYES
    - 64 HEALTHY EYES, 68 PREPERIMETRIC, 72 EARLY GLAUCOMA
  - RETINAL GANGLION CELL COMPLEX MEASUREMENT IS AS ACCURATE AS CIRCUMPAPILLARY RNFL MEASUREMENT
  - GCC EVAL MAY BE USEFUL IN
    - LARGE OR SMALL DISC
    - PERIPAPILLARY ATROPHY
    - TILTED DISC

KIM YJ, KONG MH, LIM HW, ET AL. Japan J Ophthalmol. 2014. Published online 11 March 2014

GUIDE FOR SUSPECTING GLAUCOMA USING THE CIRRUS FOR GCC



Glaucoma Diagnostic Accuracy of Ganglion Cell–Inner Plexiform Layer Thickness: Comparison with Nerve Fiber Layer and Optic Nerve Head

Jean-Claude Mwanza, MD, PhD,[1,6] Mary K. Durbin, PhD,[2] Donald L. Budenz, MD, MPH,[1,6] Fouad E. Sayyad, MD,[1] Robert T. Chang, MD,[3] Arvind Neelakantan, MD,[4] David G. Godfrey, MD,[4] Randy Carter, OD,[5] Alan S. Crandall, MD[5]

Purpose: To determine the diagnostic performance of macular ganglion cell–inner plexiform layer (GCIPL) thickness measured with the Cirrus high-definition optical coherence tomography (HD-OCT) ganglion cell analysis (GCA) algorithm (Carl Zeiss Meditec, Dublin, CA) to discriminate normal eyes and eyes with early glaucoma and to compare it with that of peripapillary retinal nerve fiber layer (RNFL) thickness and optic nerve head (ONH) measurements.

Design: Evaluation of diagnostic test or technology.

Participants: Fifty-eight patients with early glaucoma and 99 age-matched normal subjects.

Methods: Macular GCIPL and peripapillary RNFL thicknesses and ONH parameters were measured in each participant, and their diagnostic abilities were compared.

Main Outcome Measures: Area under the curve (AUC) of the receiver operating characteristic.

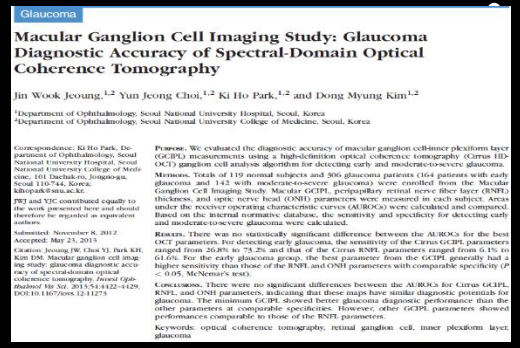
Results: The GCIPL parameters with the best AUCs were the minimum (0.959), inferotemporal (0.956), average (0.935), superotemporal (0.919), and inferior sector (0.918). There were no significant differences between these AUCs and those of inferior quadrant (0.939), average (0.936), and superior quadrant RNFL (0.933); vertical cup-to-disc diameter ratio (0.962); cup-to-disc area ratio (0.933); and rim area (0.910), all $P>0.05$.

Conclusions: The ability of macular GCIPL parameters to discriminate normal eyes and eyes with early glaucoma is high and comparable to that of the best peripapillary RNFL and ONH parameters.

Financial Disclosure(s): Proprietary or commercial disclosure may be found after the references.

Ophthalmology 2012;119:1151–1158 © 2012 by the American Academy of Ophthalmology.

Mwanza JC, Durbin MK, Budenz DJ, et al.
Ophthalmology 2012; 119: 1151-1158



Glaucoma

Macular Ganglion Cell Imaging Study: Glaucoma Diagnostic Accuracy of Spectral-Domain Optical Coherence Tomography

Jin Wook Jeoung,[1,2] Yun Jeong Choi,[1,2] Ki Ho Park,[1,2] and Dong Myung Kim[1,2]

[1]Department of Ophthalmology, Seoul National University Hospital, Seoul, Korea
[2]Department of Ophthalmology, Seoul National University College of Medicine, Seoul, Korea

Purpose. We evaluated the diagnostic accuracy of macular ganglion cell-inner plexiform layer (GCIPL) measurements using a high-definition optical coherence tomography (Cirrus HD-OCT) ganglion cell analysis algorithm for detecting early and moderate-to-severe glaucoma.

Methods. Totals of 119 normal subjects and 306 glaucoma patients (164 patients with early glaucoma and 142 with moderate-to-severe glaucoma) were enrolled from the Macular Ganglion Cell Imaging Study. Macular GCIPL, peripapillary retinal nerve fiber layer (RNFL) thickness, and optic nerve head (ONH) parameters were measured in each subject. Areas under the receiver operating characteristic curves (AUROCs) were calculated and compared. Based on the internal normative database, the sensitivity and specificity for detecting early and moderate-to-severe glaucoma were calculated.

Results. There was no statistically significant difference between the AUROCs for the best OCT parameters. For detecting early glaucoma, the sensitivity of the Cirrus GCIPL parameters ranged from 26.8% to 73.2% and that of the Cirrus RNFL parameters ranged from 6.1% to 61.6%. For the early glaucoma group, the best parameter from the GCIPL generally had a higher sensitivity than those of the RNFL and ONH parameters with comparable specificity ($P < 0.05$, McNemar's test).

Conclusions. There were no significant differences between the AUROCs for Cirrus GCIPL, RNFL, and ONH parameters, indicating that these maps have similar diagnostic potentials for glaucoma. The minimum GCIPL showed better glaucoma diagnostic performance than the other parameters at comparable specificities. However, other GCIPL parameters showed performances comparable to those of the RNFL parameters.

Keywords: optical coherence tomography, retinal ganglion cell, inner plexiform layer, glaucoma

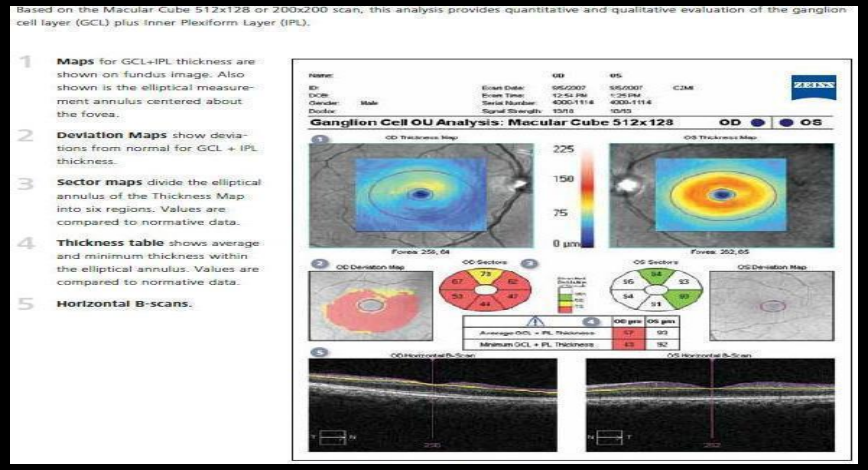
Jeoung JW, Choi YJ, Park KH, et al.
IOVS 2013; 54: 4422-4429

AREAS OF INTEREST

- MINIMUM
  - BEST PERFORMANCE (2013 study)
- INFEROTEMPORAL
  - BEST PERFORMANCE (2012 study)

RESULTS NOT APPLICABLE TO PATIENTS WITH CONCURRENT MACULAR DISEASE

- AMD, CSME, CME, ERM, ETC.

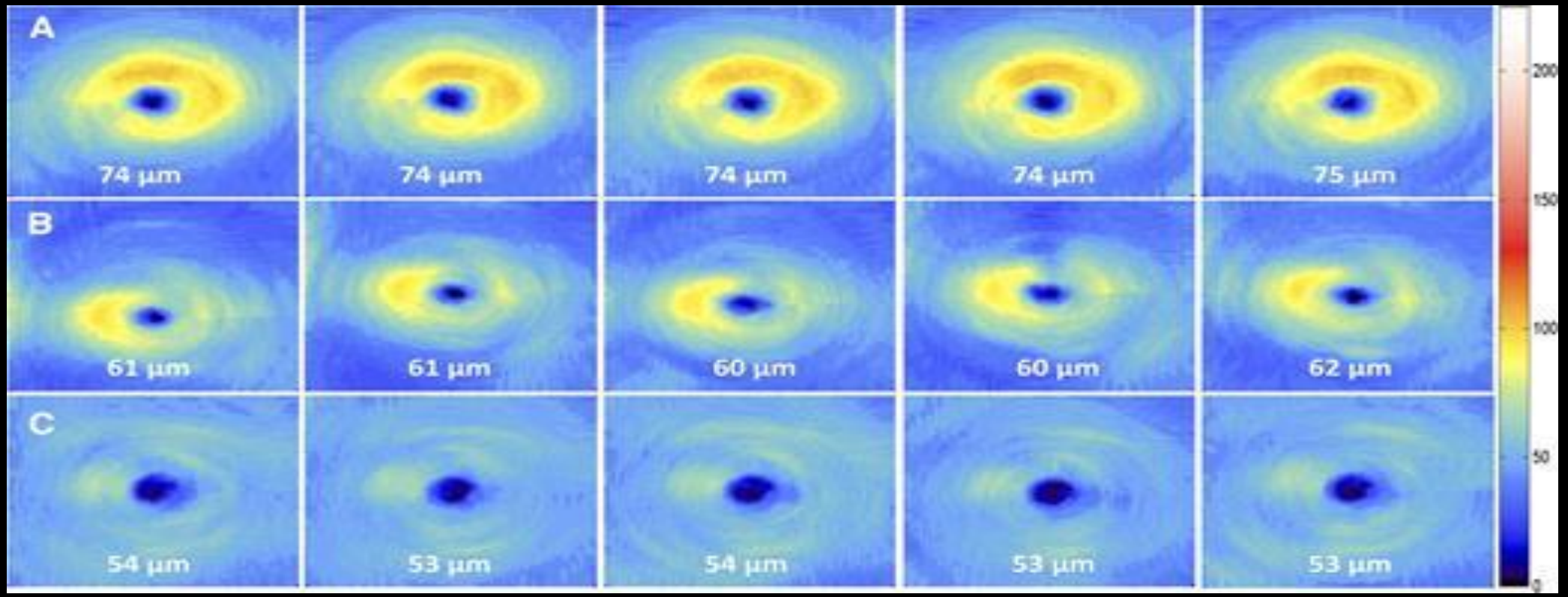


THE GCA IS REPRODUCIBLE

MILD GLAUCOMA

MODERATE GLAUCOMA

SEVERE GLAUCOMA

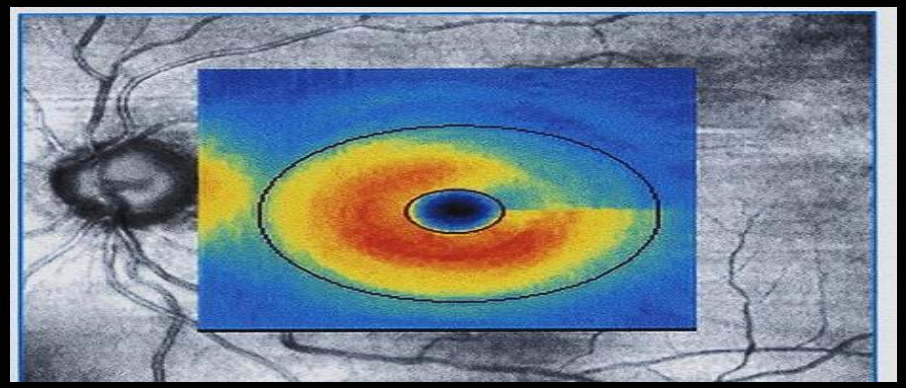


5 VISITS OVER 2 MONTHS

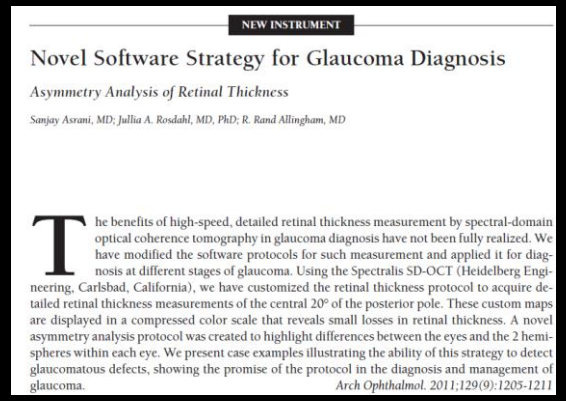
THE GCA
"SQUEEGEE or NAUTILUS"

- GLAUCOMA
  - INITIALLY DAMAGES TEMPORAL SIDE OF GANGLION CELL BODIES IN MACULA
  - ASYMMETRICALLY DAMAGES BETWEEN SUPERIOR / INFERIOR GANGLION CELL BODIES

- "SQUEEGEE SIGN" TO THE SUPERIOR OR INFERIOR TEMPORAL GANGLION CELL BODIES IS THE INITIAL INDICATION OF GLAUCOMA DAMAGE ON THE GCA



SPECTRALIS FOR GCC



NEW INSTRUMENT

Novel Software Strategy for Glaucoma Diagnosis

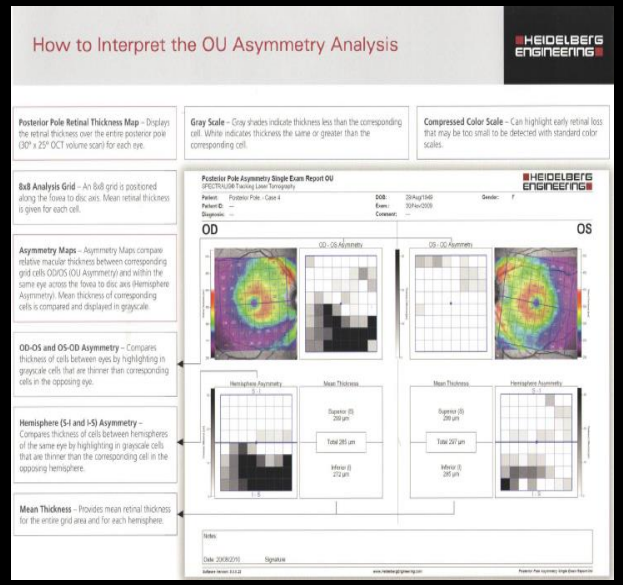
Asymmetry Analysis of Retinal Thickness

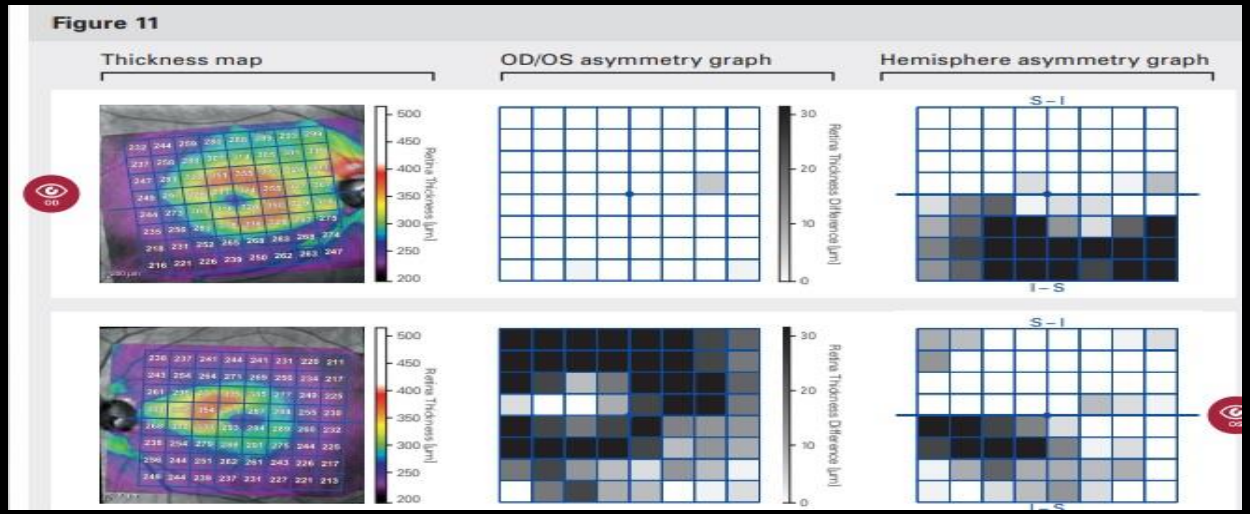
Sanjay Asrani, MD; Jullia A. Rosdahl, MD, PhD; R. Rand Allingham, MD

The benefits of high-speed, detailed retinal thickness measurement by spectral-domain optical coherence tomography in glaucoma diagnosis have not been fully realized. We have modified the software protocols for such measurement and applied it for diagnosis at different stages of glaucoma. Using the Spectralis SD-OCT (Heidelberg Engineering, Carlsbad, California), we have customized the retinal thickness protocol to acquire detailed retinal thickness measurements of the central 20° of the posterior pole. These custom maps are displayed in a compressed color scale that reveals small losses in retinal thickness. A novel asymmetry analysis protocol was created to highlight differences between the eyes and the 2 hemispheres within each eye. We present case examples illustrating the ability of this strategy to detect glaucomatous defects, showing the promise of the protocol in the diagnosis and management of glaucoma.

Arch Ophthalmol. 2011;129(9):1205-1211

Asrani S, Rosdahl, JA, Allingham RR. Arch Ophthal, Vol 129 (9), Sept 2011: 1205-11





- 61 LINES, CENTRAL 20 DEGREES
- 6x6 mm SCAN
  - EQUIVALENT TO 10 DEGREE VF
- 8X8 GRID REPORT
- NO NORMATIVE DATABASE
  - ONE IS COMING
- COMPARISON
  - PATIENT SUPERIOR TO INFERIOR
  - PATIENT RIGHT TO LEFT
- ANOTHER STUDY
  - HIGH DIAGNOSTIC SENSITIVITY (83.3%) AND SPECIFICITY (92.6%) WHEN USING 3 CONSECUTIVE BLACK CELLS TO DETECT GLAUCOMA
- THE DARKER THE SQUARE, THE LARGER THE DIFFERENCE IN THICKNESS BETWEEN OPPPOSITE HEMISPHERES OR OPPOSITE EYES
- BLACK = DIFFERENCE OF 30 um

CAN MY OCT DO THAT?

TABLE. COMPARISON OF COMMERCIALLY AVAILABLE IMAGING DEVICES FOR MACULAR ANALYSIS IN GLAUCOMA

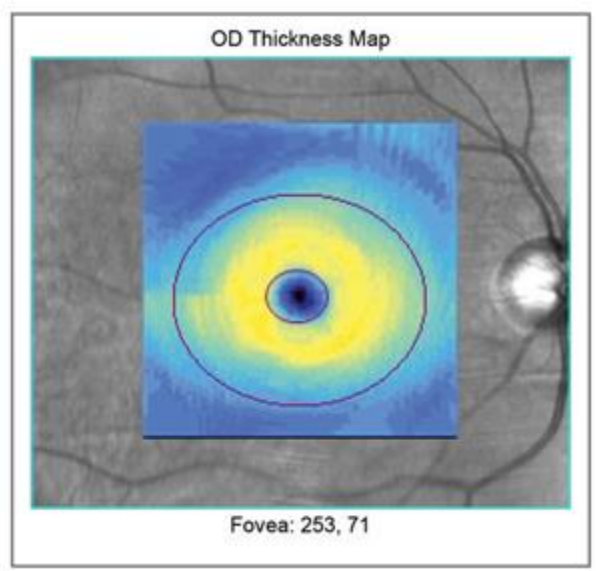
OCT Device	Macular Imaging Protocol	Macular Area of Analysis	Macular Layers Analyzed	Normative Database?
RTVue FD-OCT	Ganglion cell complex analysis	7 mm^2, centered 1 mm temporal to fovea	RNFL, RGC, IPL	Yes
Spectralis SD-OCT	Posterior pole asymmetry analysis	8 mm^2, centered on fovea	All macular layers	No
Cirrus HD-OCT	Ganglion cell analysis	Elliptical annulus (vertical radius of 2 mm, horizontal radius of 2.4 mm), centered on fovea	GC-IPL	Yes

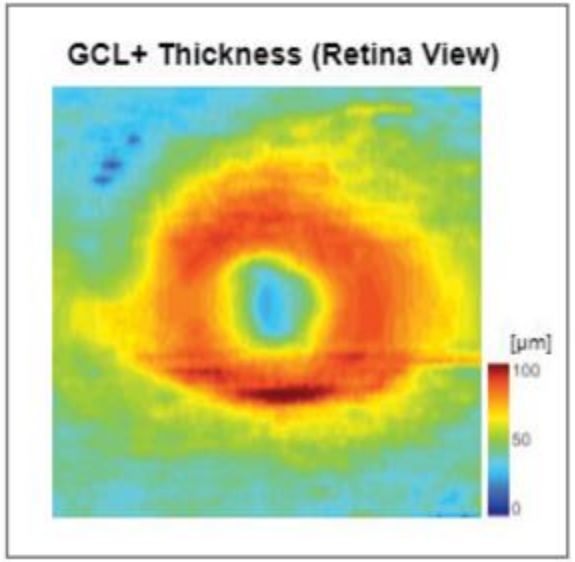
Abbreviations: OCT, optical coherence tomography; RNFL, retinal nerve fiber layer; RGC, retinal ganglion cell; IPL, inner plexiform layer; GC-IPL, ganglion cell and inner plexiform layers.

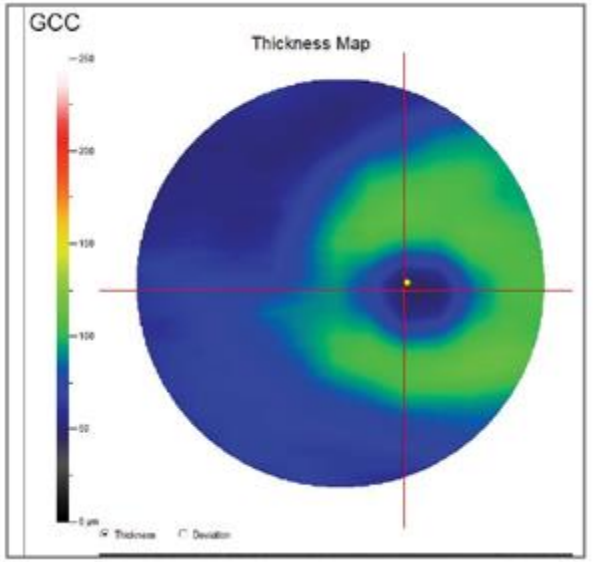
FROM: AREF, AA. GLAUCOMA TODAY, MARCH/APRIL 2013

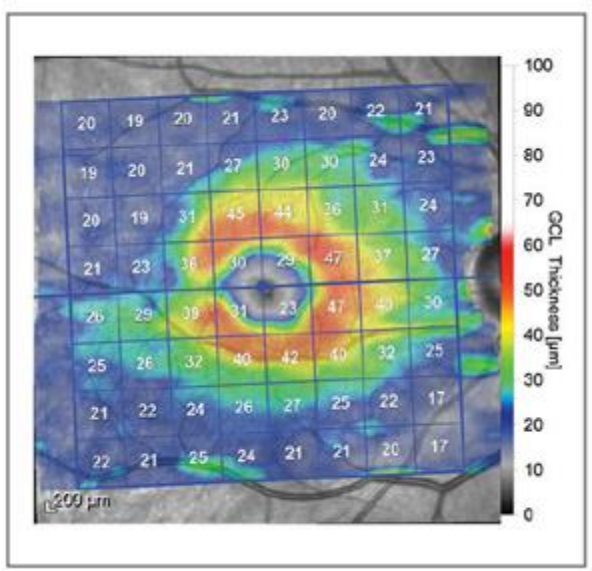
- FROM PREVIOUS ARTICLE
  - ALSO THE TOPCON 3D OCT 2000
- OTHERS?
- DIFFERENCES EXIST BASED ON WHAT IS ACTUALLY BEING SCANNED
  - ENTIRE MACULA THICKNESS
  - GCC
    - RNFL / GC / IPL
  - GC / IPL
- WHICH IS BEST?
  - THAT DEPENDS ON THE STUDY

DEVICE DIFFERENCES IN GCC REPORT









Cirrus 6000 Topcon Maestro2 Optovue Avanti Heidelberg Spectralis

SCHOTT R. Review of Optometry 2/15/20

DISCLAIMER

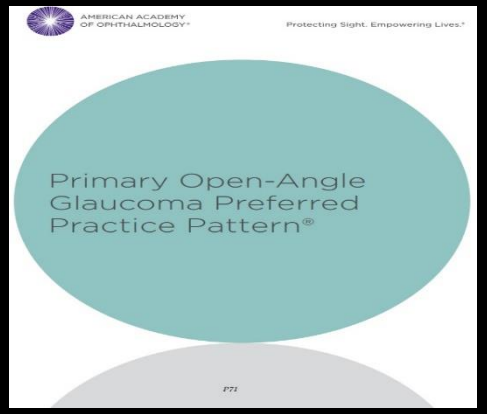
- OTHER THINGS CAN CAUSE GANGLION CELL LOSS
  - ANY OPTIC NEUROPATHY
  - ANY RETINOPATHY
  - OTHER RETINAL PATHOLOGY
  - OTHER NEUROLOGIC DISEASES
    - ALZHEIMERS, PARKINSONS, MS, OTHERS
- NO ONE TEST IS SUFFICIENT FOR ALL PATIENTS
  - NEED ONH, RNFL, GCC, VF
- REGARDLESS OF YOUR OPINION OF THE DATABASE OR LACK THEREOF…
  - YOU CAN NOW MONITOR YOUR PATIENT FOR CHANGE

RELIABLE AND REPRODUCIBLE VISUAL FIELD ABNORMALITY

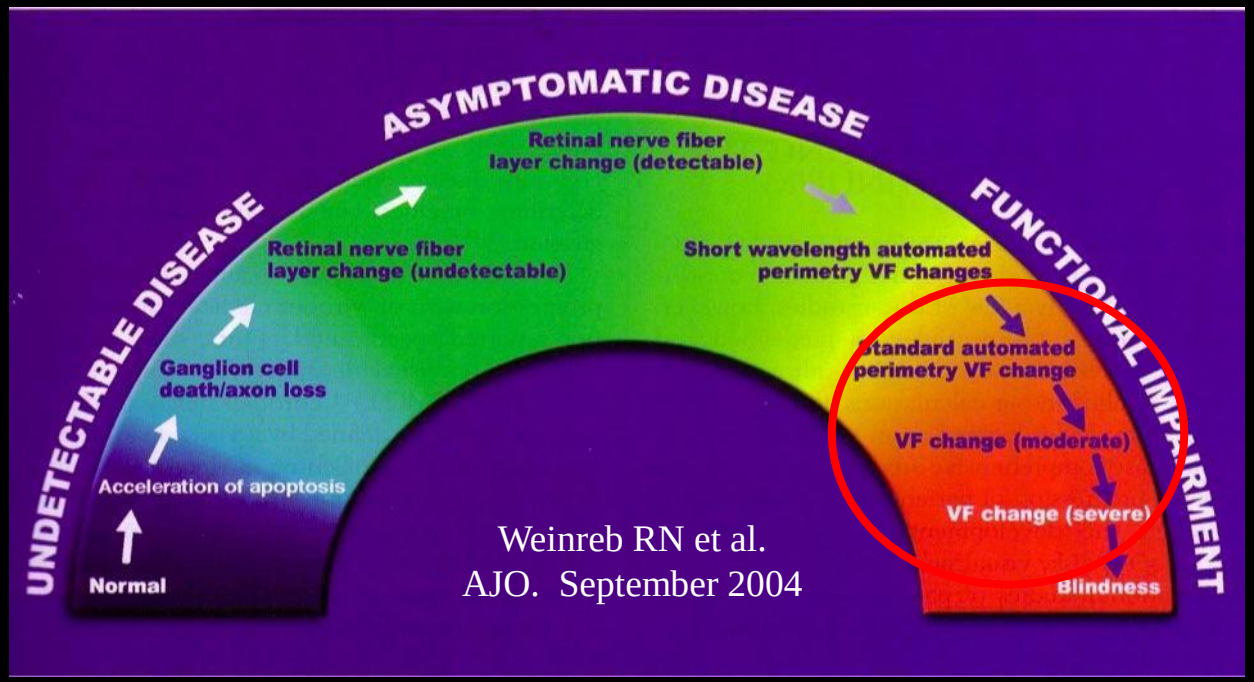
- CONSISTENT WITH RETINAL NERVE FIBER LAYER DAMAGE
  - NASAL STEP
  - ARCUATE DEFECT
  - PARACENTRAL DEPRESSION IN CLUSTERS OF TEST SITES

- VISUAL FIELD LOSS ACROSS HORIZONTAL MIDLINE IN ONE HEMIFIELD EXCEEDS LOSS IN THE OPPOSITE HEMIFELD (IN EARLY / MODERATE CASES)

- ABSENCE OF OTHER EXPLANATIONS

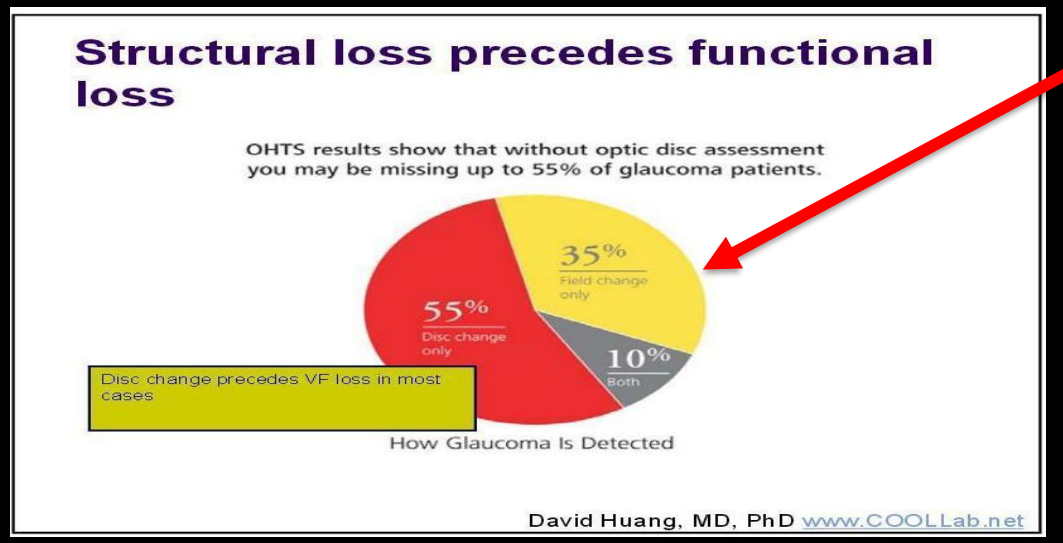


WHY DO WE STILL DO VISUAL FIELDS?



Weinreb RN et al.
AJO. September 2004

- 2002 OHTS
  - –35% PATIENTS HAD VF LOSS WITHOUT SIGNS OF STRUCTURAL PROGRESSION
- 2009 STUDY
  - –34% OF GLAUCOMA SUSPECT CONVERTERS PROGRESSED ON VISUAL FIELD WITHOUT STRUCTURAL CHANGES

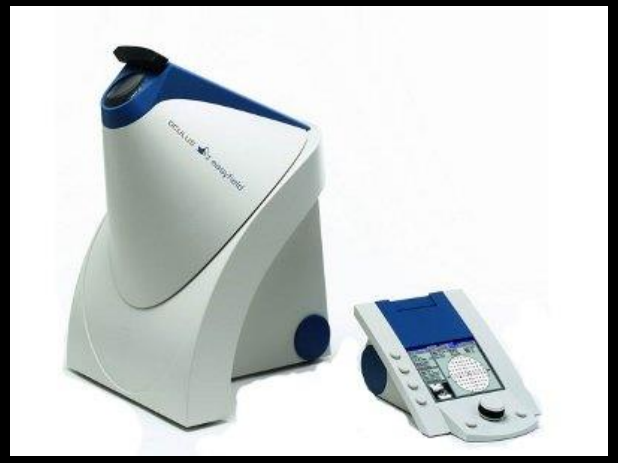


A NORMAL VISUAL FIELD DOES NOT EXCLUDE GLAUCOMA

- NORMAL FIELD EXCLUDES MODERATE / SEVERE DISEASE
  - BUT DOES NOT RULE IT OUT
  - DUE TO OVERLAP OF RECEPTOR SITES IN THE RETINA
- 20-40% OF RGC LOST BEFORE 5-10 DB VF REDUCTION
- SOME SHOW INNOCUOUS VF DESPITE GLAUCOMA
- VF WILL EVENTUALLY CATCH UP TO THE ONH
- IF NORMAL BUT STILL STRONGLY SUSPICIOUS ONH
  - CONSIDER ADDITIONAL ONH / RNFL / GCC / ALTERNATIVE VF TESTING
    - FDT, 10-2, 24-2 C

WHICH VF DEVICE TO USE?

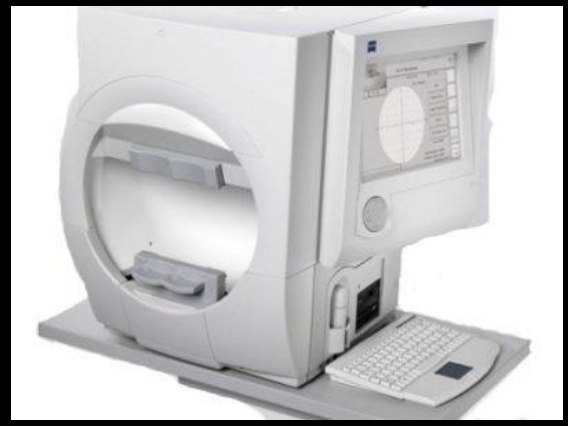
THAT'S YOUR CALL



OCULUS
CENTER FIELD / EASYFIELD

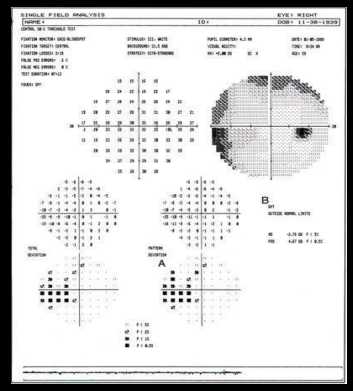
HUMPHREY
FDT / MATRIX / HFA II/III

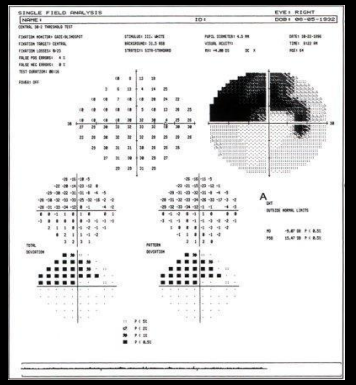
HAAG-STREIT OCTOPUS

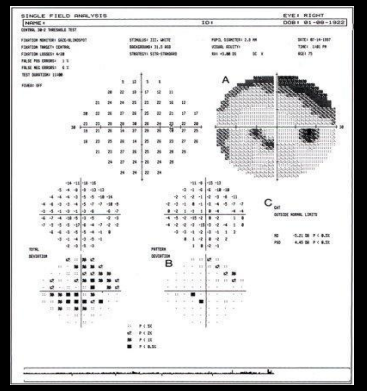


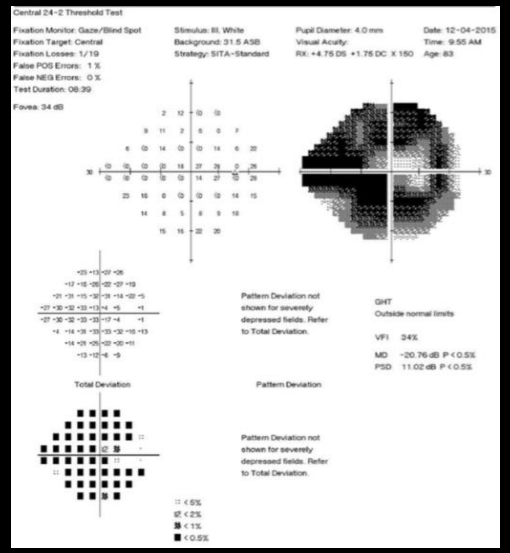
GLAUCOMATOUS VISUAL FIELDS

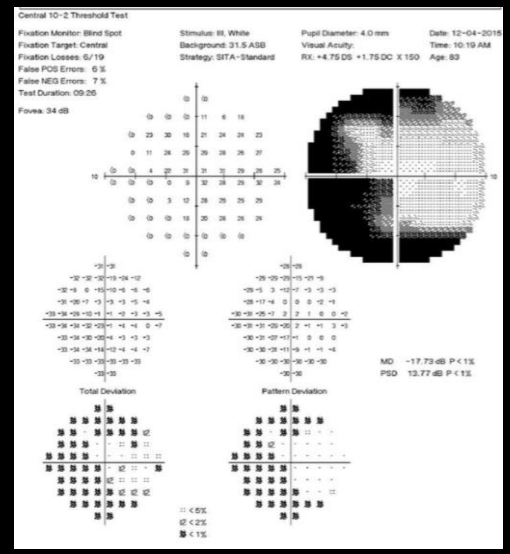
- VF LOSS = MODERATE OR SEVERE DAMAGE
- EARLY IN DISEASE
  - BASELINE VF
  - FOLLOW OPTIC NERVE / RNFL FOR CHANGES
- LATE IN DISEASE
  - FOLLOW VISUAL FIELD FOR CHANGES
    - MAY HAVE TO CONSIDER 10-2 OR MACULA VF
    - SIZE V TARGET 24-2 OR 10-2
    - ESTERMAN FOR DRIVING OR KINETIC III4e FOR LEGAL BLINDNESS
- IS IT GLAUCOMATOUS?
  - OBVIOUS DEFECTS
    - THE NASAL STEP
    - THE ARCUATE DEFECT
    - THE PARACENTRAL DEFECT
  - DIFFUSE VISUAL FIELD LOSS ?
    - TYPICALLY NOT GLAUCOMA
- EARLIEST DEFECTS?
  - COULD BE
    - CENTRAL, MID-PERIPHERAL, PERIPHERAL
  - FIELD MUST MATCH THE OPTIC NERVE / RNFL







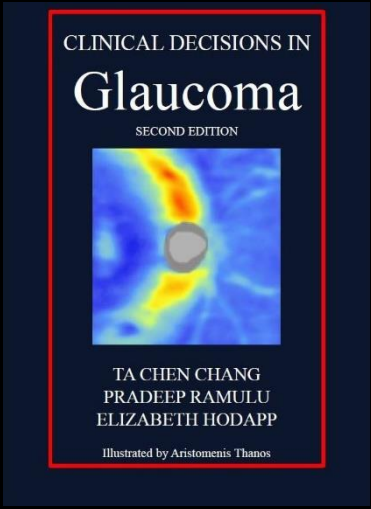




24-2 VS 10-2 OF THE SAME PATIENT

MINIMUM DIAGNOSTIC CRITERIA FOR A GLAUCOMATOUS VISUAL FIELD

- IN THE ABSENCE OF OTHER CAUSES FOR FIELD ABNORMALITY AND IN THE PRESENCE OF SUSPICION FOR GLAUCOMA
  - - CLINICAL DECISION IN GLAUCOMA, 2ND EDITION



- TWO "OUTSIDE NORMAL LIMITS" ON GHT
  - - CLINICAL DECISION IN GLAUCOMA, 2ND EDITION

OR

- CLUSTER OF THREE OR MORE POINTS IN A LOCATION TYPICAL FOR GLAUCOMA, ALL DEPRESSED ON PATTERN DEVIATION PLOT AT A P < 5% AND ONE DEPRESSED AT A P < 1% ON TWO CONSECUTIVE FIELDS (24-2 COUNTS EDGE POINTS, 30-2 ONLY COUNTS 2 NASAL PTS), ALL PTS RESPECT HORIZONTAL MERIDIAN
  - - KATZ, SOMMER, GAASTERLAND, ANDERSON. ARCH OPHTHAL 1991.
  - - CLINICAL DECISION IN GLAUCOMA, 2ND EDITION

OR

- PSD P < 5% (SUMMARIZES EXTENT OF LOCALIZED LOSS, NOT AFFECTED BY GENERALIZED DEPRESSION)
  - - CLINICAL DECISION IN GLAUCOMA, 2ND EDITION

- IF REPEATABLE
  - - Budenz, D. African Glaucoma Summit 8/06/10

WHAT MEETS THE MINIMUM CRITERIA?

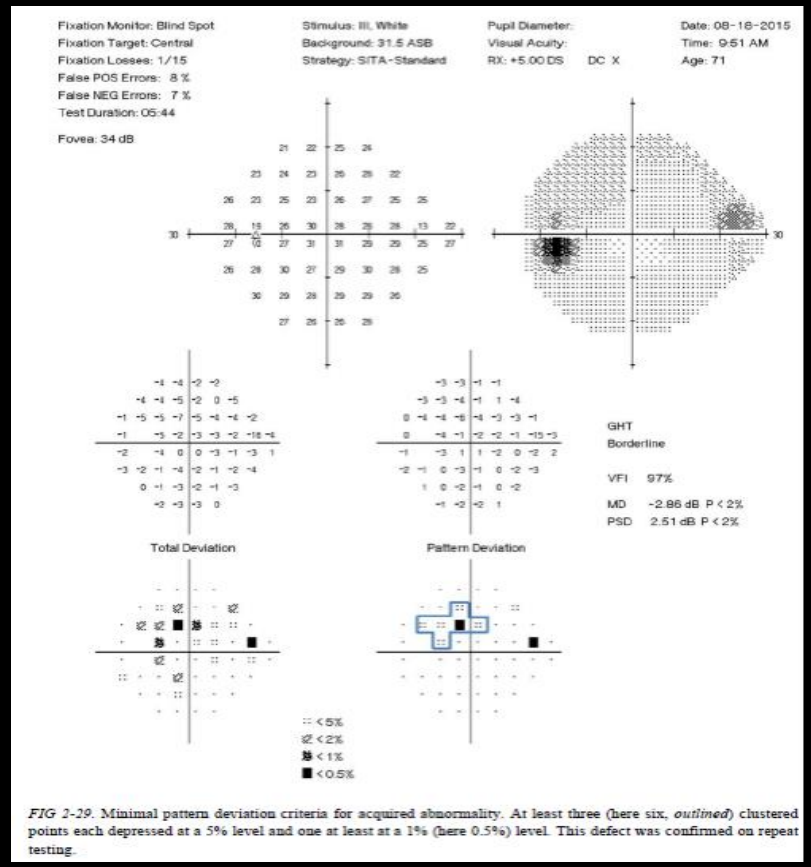


FIG 2-29. Minimal pattern deviation criteria for acquired abnormality. At least three (here six, *outlined*) clustered points each depressed at a 5% level and one at least at a 1% (here 0.5%) level. This defect was confirmed on repeat testing.

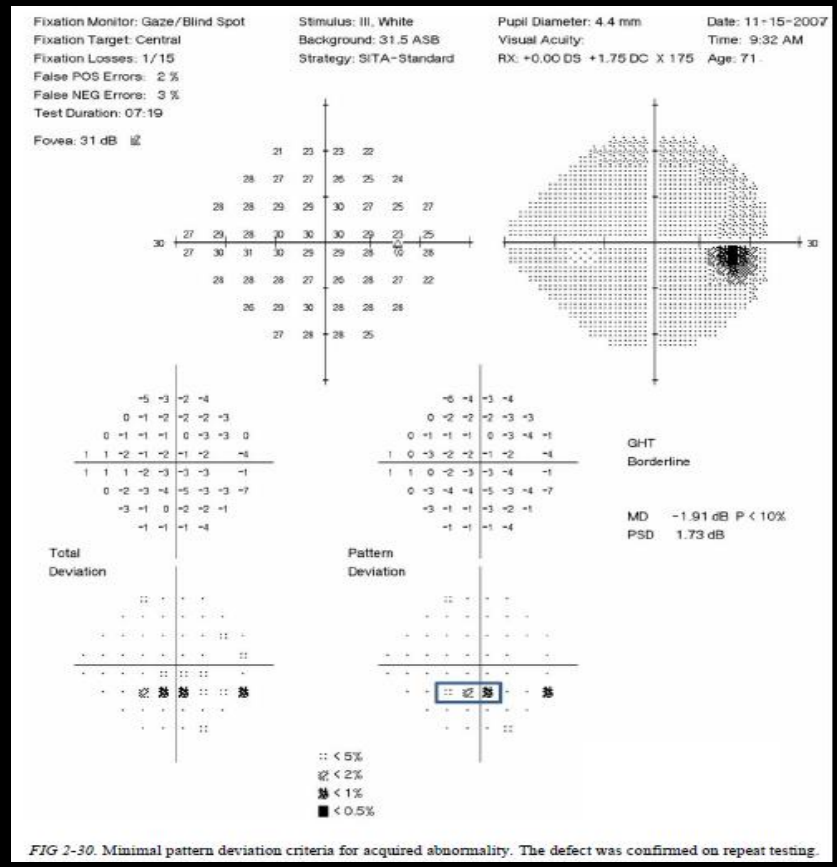


FIG 2-30. Minimal pattern deviation criteria for acquired abnormality. The defect was confirmed on repeat testing.

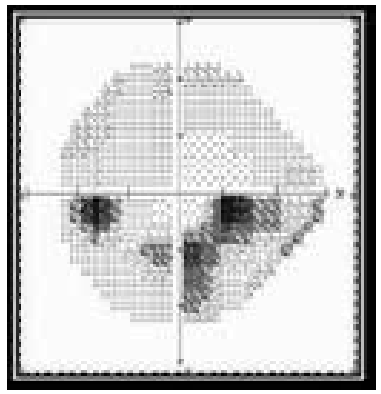
THE VF DEFECT STILL MUST CORRELATE WITH
THE OPTIC NERVE APPEARANCE AND RNFL APPEARANCE / OCT

CLASSIFY THE STAGE OF GLAUCOMA BASED ON VISUAL FIELD LOSS...

Moderate Stage Glaucoma

ICD-9 365.72; ICD-10 7th dIgIt "2"

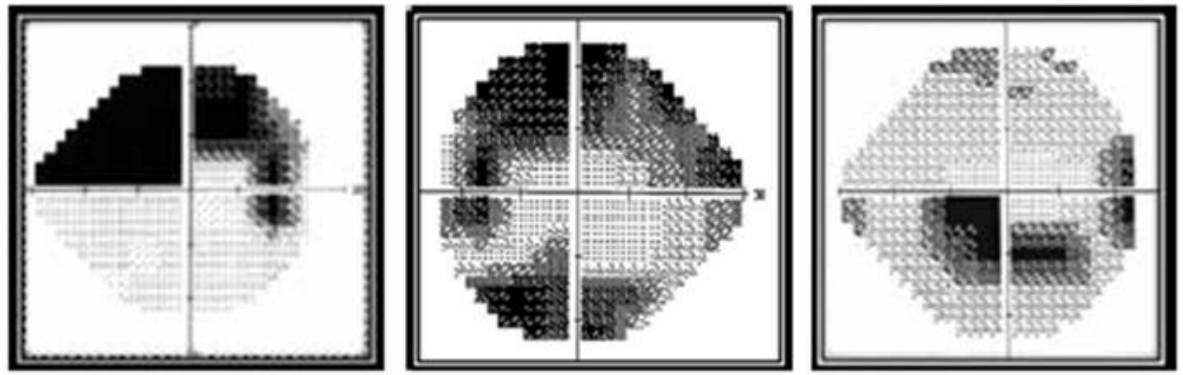
- Optic nerve abnormalities consistent with glaucoma
- AND glaucomatous visual field abnormalities in ONE hemifield and
- NOT within 5 degrees of fixation (note: 5 degrees = involvement of spots nearest fixation)



Advanced, Late, Severe Stage

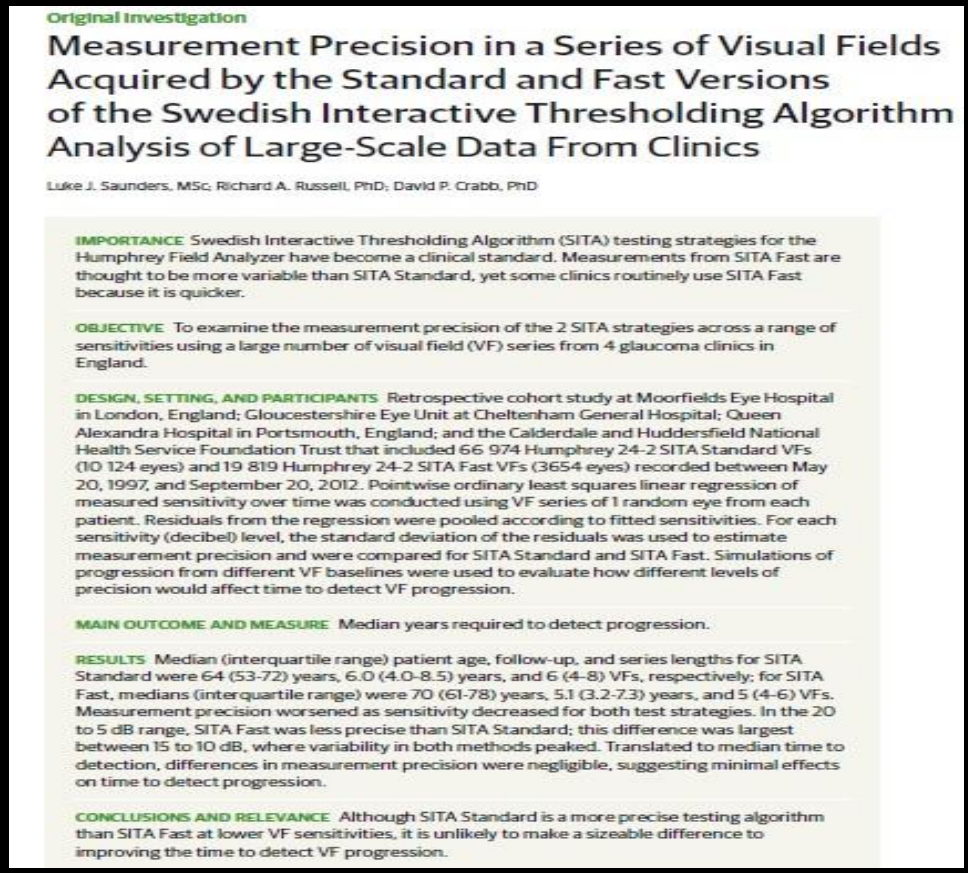
ICD-9 365.73; ICD-10 7th dIgIt "3"

- Optic nerve abnormalities consistent with glaucoma
- AND glaucomatous visual field abnormalities in BOTH hemifields
- AND/OR loss within 5 degrees of fixation in at least one hemifield.



STD / FAST (OR FASTER)?

- MAJORITY OF CLINICAL TRIALS / STUDIES DONE WITH SITA STANDARD
- EXPERTS OPINION
  - STD IS MORE PRECISE
  - BUT…UNLIKELY TO MAKE SIZEABLE DIFFERENCE TO IMPROVE THE TIME TO DETECT VF PROGRESSION
- THOUGHTS
  - PATIENTS PREFER A FASTER PROGRAM
  - MAY HELP RELIABILITY
  - START PATIENTS WITH SITA FAST
  - CONVERT STD TO FAST?
    - IT DEPENDS. IF EARLY IN PROCESS, YES.
      - GPA DATA MAY NOT BE COMPARABLE
- NEWEST PROGRAM
  - SITA FASTER
    - AVAILABLE ON HFA 3



Original Investigation

Measurement Precision in a Series of Visual Fields Acquired by the Standard and Fast Versions of the Swedish Interactive Thresholding Algorithm Analysis of Large-Scale Data From Clinics

Luke J. Saunders, MSc; Richard A. Russell, PhD; David P. Crabb, PhD

IMPORTANCE Swedish Interactive Thresholding Algorithm (SITA) testing strategies for the Humphrey Field Analyzer have become a clinical standard. Measurements from SITA Fast are thought to be more variable than SITA Standard, yet some clinics routinely use SITA Fast because it is quicker.

OBJECTIVE To examine the measurement precision of the 2 SITA strategies across a range of sensitivities using a large number of visual field (VF) series from 4 glaucoma clinics in England.

DESIGN, SETTING, AND PARTICIPANTS Retrospective cohort study at Moorfields Eye Hospital in London, England; Gloucestershire Eye Unit at Cheltenham General Hospital; Queen Alexandra Hospital in Portsmouth, England; and the Calderdale and Huddersfield National Health Service Foundation Trust that included 66 974 Humphrey 24-2 SITA Standard VFs (10 124 eyes) and 19 819 Humphrey 24-2 SITA Fast VFs (3654 eyes) recorded between May 20, 1997, and September 20, 2012. Pointwise ordinary least squares linear regression of measured sensitivity over time was conducted using VF series of 1 random eye from each patient. Residuals from the regression were pooled according to fitted sensitivities. For each sensitivity (decibel) level, the standard deviation of the residuals was used to estimate measurement precision and were compared for SITA Standard and SITA Fast. Simulations of progression from different VF baselines were used to evaluate how different levels of precision would affect time to detect VF progression.

MAIN OUTCOME AND MEASURE Median years required to detect progression.

RESULTS Median (interquartile range) patient age, follow-up, and series lengths for SITA Standard were 64 (53-72) years, 6.0 (4.0-8.5) years, and 6 (4-8) VFs, respectively; for SITA Fast, medians (interquartile range) were 70 (61-78) years, 5.1 (3.2-7.3) years, and 5 (4-6) VFs. Measurement precision worsened as sensitivity decreased for both test strategies. In the 20 to 5 dB range, SITA Fast was less precise than SITA Standard; this difference was largest between 15 to 10 dB, where variability in both methods peaked. Translated to median time to detection, differences in measurement precision were negligible, suggesting minimal effects on time to detect progression.

CONCLUSIONS AND RELEVANCE Although SITA Standard is a more precise testing algorithm than SITA Fast at lower VF sensitivities, it is unlikely to make a sizeable difference to improving the time to detect VF progression.

SAUNDERS LJ, RUSSELL RA, CRABB DP. JAMA OPHTHALMOL 2015; 133(1): 74-80.

SHOULD I DO A 10-2 or 24-2?

Prevalence, Features, and Severity of Glaucomatous Visual Field Loss Measured With the 10-2 Achromatic Threshold Visual Field Test

MICHAEL SULLIVAN-MEE, MY THO KARIN TRAN, DENISE PENSYL, GRACE TSAN, AND SUCHITRA KATIYAR

• PURPOSE: To investigate the clinical characteristics of 10-2 visual field defects in subjects with a diagnosis of glaucoma or glaucoma suspicion.
• DESIGN: Prospective, observational cohort study.
• METHODS: From participants enrolled in an ongoing glaucoma research study at our institution, we identified 354 eyes in 180 subjects (97 with primary open-angle glaucoma, 83 with glaucoma suspicion) who had 2 or more reliable 24-2 and 10-2 visual field tests and good-quality spectral-domain optical coherence tomography (SDOCT) scans. Eyes with macular pathology, significant cataract, or nonglaucomatous vision loss were excluded. We applied previously published cluster criteria to define 10-2 visual field loss, and then calculated prevalence, location, severity, and pattern of 10-2 visual field loss as well as its relationships with various functional and structural parameters.
• RESULTS: Repeatable 10-2 visual field defects were present in 89 of 180 subjects (49%) and usually exhibited an arcuate or nasal pattern. In eyes with no, mild, moderate, and advanced 24-2 visual field loss, 15 of 236 (6%), 49 of 67 (73%), 25 of 26 (96%), and 25 of 25 (100%) had 10-2 visual field defects, respectively. Of the 114 eyes with 10-2 visual field loss, 93 (82%) demonstrated abnormal points within the central 10 degrees of the 24-2 visual field test. Mean defect on the 10-2 and 24-2 tests was highly correlated ($r^2 = 0.72$).
• CONCLUSIONS: Although central VF loss appears to be common in glaucoma and may have an important role in glaucoma management, additional study is warranted to more definitively determine the optimal methods to detect presence, severity, and functional impact of central glaucomatous visual field loss. (Am J Ophthalmol 2016;168:40–51. Published by Elsevier Inc.)

AJO.com Supplemental Material available at AJO.com.
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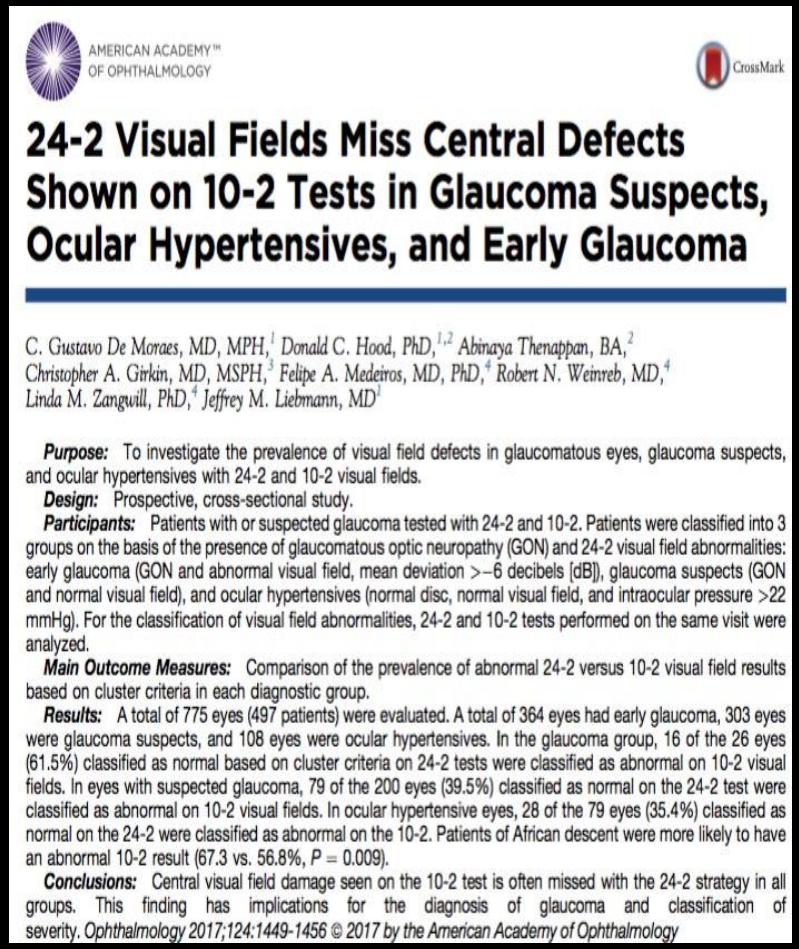
From New Mexico VA HCS, Raymond G. Murphy VA Medical Center (M.S.-M., D.P., G.T., S.K.), and Department of Ophthalmology, University of New Mexico Hospitals (M.T.K.T.), Albuquerque, New Mexico.
Inquiries to Michael Sullivan-Mee, New Mexico VA HCS, Raymond G. Murphy VA Medical Center, 1501 San Pedro SE, Albuquerque, NM

OVER THE PAST 4 DECADES, ACCUMULATING evidence has shown that central visual dysfunction is a characteristic not just of late stages of glaucoma but also of its earliest stages.[1–7] Types of central visual dysfunction that have been identified in early stages of glaucoma include color vision defects,[8] abnormalities of contrast sensitivity,[9] and visual field defects within 10 degrees of fixation.[10–13] Considering that 30% of all retinal ganglion cells serve the central 8 degrees of the macula,[14] and that these cells have been shown to be compromised in early glaucoma,[1–11] the existence of central visual dysfunction in early glaucoma should not be surprising.

At the present time, however, central visual dysfunction in early stages of glaucoma often goes underappreciated because methods for detecting it are not part of the standard clinical assessment. Particularly, while assessment of later stages of glaucoma often includes visual field testing with a high density of test points within the central 10 degrees, typical visual field assessment of early and moderate glaucoma uses a testing grid that has been shown to substantially undersample the central field. Specifically, the 24-2 grid on the Humphrey Field Analyzer II (Carl Zeiss Meditec Inc, Dublin, California, USA) measures visual function within 8 degrees of fixation with only 4 central test points.[15] Conversely, the 10-2 test pattern on the same instrument measures this central 8 degrees with 44 points. Consequently, central visual field loss in glaucoma can be underestimated and even missed altogether when relying solely on the 24-2 pattern.[11,15,16]

Few studies have investigated the prevalence and clinical features of glaucomatous central visual field loss as measured by the 10-2 visual field test. In 1997, Langerhorst and associates[10] prospectively studied 121 subjects diagnosed with glaucoma or glaucoma suspicion and reported that 10-2 field loss was present in 36% of all hemifields, while 12% demonstrated 10-2 field loss without concurrent 30-2 field loss. In 2010, Schiefer and associates[16] identified regions within 30-2 visual field testing that were suspicious for glaucoma, and then further tested those regions with high spatial resolution testing. The high-resolution testing identified central field defects in 50% of eyes with mild to moderate glaucoma. More recently, Traynis and associates[12] prospectively compared the prevalence of 10-2 and 24-2 visual field loss in eyes with early glaucoma and found

2016 MAYBE



AMERICAN ACADEMY OF OPHTHALMOLOGY

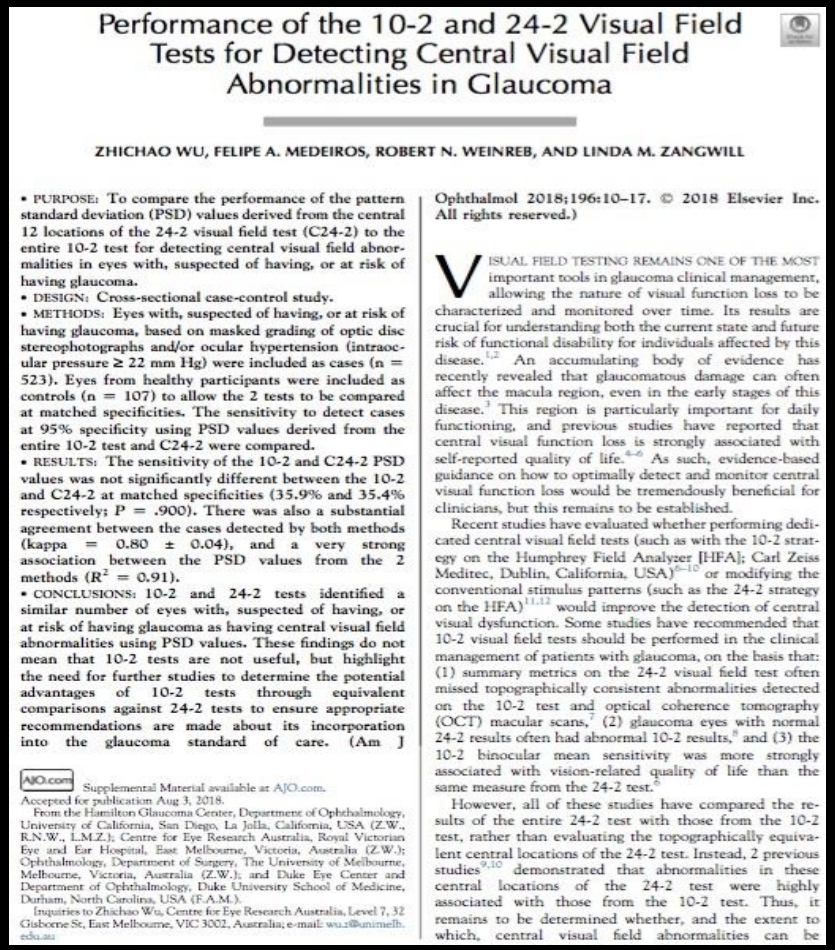
CrossMark

24-2 Visual Fields Miss Central Defects Shown on 10-2 Tests in Glaucoma Suspects, Ocular Hypertensives, and Early Glaucoma

C. Gustavo De Moraes, MD, MPH,[1] Donald C. Hood, PhD,[1,2] Abinaya Thenappan, BA,[2] Christopher A. Girkin, MD, MSPH,[3] Felipe A. Medeiros, MD, PhD,[4] Robert N. Weinreb, MD,[4] Linda M. Zangwill, PhD,[4] Jeffrey M. Liebmann, MD[1]

Purpose: To investigate the prevalence of visual field defects in glaucomatous eyes, glaucoma suspects, and ocular hypertensives with 24-2 and 10-2 visual fields.
Design: Prospective, cross-sectional study.
Participants: Patients with or suspected glaucoma tested with 24-2 and 10-2. Patients were classified into 3 groups on the basis of the presence of glaucomatous optic neuropathy (GON) and 24-2 visual field abnormalities: early glaucoma (GON and abnormal visual field, mean deviation >−6 decibels [dB]), glaucoma suspects (GON and normal visual field), and ocular hypertensives (normal disc, normal visual field, and intraocular pressure >22 mmHg). For the classification of visual field abnormalities, 24-2 and 10-2 tests performed on the same visit were analyzed.
Main Outcome Measures: Comparison of the prevalence of abnormal 24-2 versus 10-2 visual field results based on cluster criteria in each diagnostic group.
Results: A total of 775 eyes (497 patients) were evaluated. A total of 364 eyes had early glaucoma, 303 eyes were glaucoma suspects, and 108 eyes were ocular hypertensives. In the glaucoma group, 16 of the 26 eyes (61.5%) classified as normal based on cluster criteria on 24-2 tests were classified as abnormal on 10-2 visual fields. In eyes with suspected glaucoma, 79 of the 200 eyes (39.5%) classified as normal on the 24-2 test were classified as abnormal on 10-2 visual fields. In ocular hypertensive eyes, 28 of the 79 eyes (35.4%) classified as normal on the 24-2 were classified as abnormal on the 10-2. Patients of African descent were more likely to have an abnormal 10-2 result (67.3 vs. 56.8%, $P = 0.009$).
Conclusions: Central visual field damage seen on the 10-2 test is often missed with the 24-2 strategy in all groups. This finding has implications for the diagnosis of glaucoma and classification of severity. *Ophthalmology 2017;124:1449-1456 © 2017 by the American Academy of Ophthalmology*

2017 YES



Performance of the 10-2 and 24-2 Visual Field Tests for Detecting Central Visual Field Abnormalities in Glaucoma

ZHICHAO WU, FELIPE A. MEDEIROS, ROBERT N. WEINREB, AND LINDA M. ZANGWILL

• PURPOSE: To compare the performance of the pattern standard deviation (PSD) values derived from the central 12 locations of the 24-2 visual field test (C24-2) to the entire 10-2 test for detecting central visual field abnormalities in eyes with, suspected of having, or at risk of having glaucoma.
• DESIGN: Cross-sectional case-control study.
• METHODS: Eyes with, suspected of having, or at risk of having glaucoma, based on masked grading of optic disc stereophotographs and/or ocular hypertension (intraocular pressure ≥ 22 mm Hg) were included as cases (n = 523). Eyes from healthy participants were included as controls (n = 107) to allow the 2 tests to be compared at matched specificities. The sensitivity to detect cases at 95% specificity using PSD values derived from the entire 10-2 test and C24-2 were compared.
• RESULTS: The sensitivity of the 10-2 and C24-2 PSD values was not significantly different between the 10-2 and C24-2 at matched specificities (35.9% and 35.4% respectively; P = .900). There was also a substantial agreement between the cases detected by both methods (kappa = 0.80 ± 0.04), and a very strong association between the PSD values from the 2 methods ($R^2 = 0.91$).
• CONCLUSIONS: 10-2 and 24-2 tests identified a similar number of eyes with, suspected of having, or at risk of having glaucoma as having central visual field abnormalities using PSD values. These findings do not mean that 10-2 tests are not useful, but highlight the need for further studies to determine the potential advantages of 10-2 tests through equivalent comparisons against 24-2 tests to ensure appropriate recommendations are made about its incorporation into the glaucoma standard of care. (Am J Ophthalmol 2018;196:10–17. © 2018 Elsevier Inc. All rights reserved.)

AJO.com Supplemental Material available at AJO.com.
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From the Hamilton Glaucoma Center, Department of Ophthalmology, University of California, San Diego, La Jolla, California, USA (Z.W., R.N.W., L.M.Z.); Centre for Eye Research Australia, Royal Victorian Eye and Ear Hospital, East Melbourne, Victoria, Australia (Z.W.); Ophthalmology, Department of Surgery, The University of Melbourne, Melbourne, Victoria, Australia (Z.W.); and Duke Eye Center and Department of Ophthalmology, Duke University School of Medicine, Durham, North Carolina, USA (F.A.M.).
Inquiries to Zhichao Wu, Centre for Eye Research Australia, Level 7, 32 Gisborne St, East Melbourne, VIC 3002, Australia; e-mail: wu.z@unimelb.edu.au

VISUAL FIELD TESTING REMAINS ONE OF THE MOST important tools in glaucoma clinical management, allowing the nature of visual function loss to be characterized and monitored over time. Its results are crucial for understanding both the current state and future risk of functional disability for individuals affected by this disease.[1,2] An accumulating body of evidence has recently revealed that glaucomatous damage can often affect the macula region, even in the early stages of this disease.[3] This region is particularly important for daily functioning, and previous studies have reported that central visual function loss is strongly associated with self-reported quality of life.[4–6] As such, evidence-based guidance on how to optimally detect and monitor central visual function loss would be tremendously beneficial for clinicians, but this remains to be established.

Recent studies have evaluated whether performing dedicated central visual field tests (such as with the 10-2 strategy on the Humphrey Field Analyzer [HFA]; Carl Zeiss Meditec, Dublin, California, USA)[6–10] or modifying the conventional stimulus patterns (such as the 24-2 strategy on the HFA)[11,12] would improve the detection of central visual dysfunction. Some studies have recommended that 10-2 visual field tests should be performed in the clinical management of patients with glaucoma, on the basis that: (1) summary metrics on the 24-2 visual field test often missed topographically consistent abnormalities detected on the 10-2 test and optical coherence tomography (OCT) macular scans,[7] (2) glaucoma eyes with normal 24-2 results often had abnormal 10-2 results,[8] and (3) the 10-2 binocular mean sensitivity was more strongly associated with vision-related quality of life than the same measure from the 24-2 test.[5]

However, all of these studies have compared the results of the entire 24-2 test with those from the 10-2 test, rather than evaluating the topographically equivalent central locations of the 24-2 test. Instead, 2 previous studies[9,10] demonstrated that abnormalities in these central locations of the 24-2 test were highly associated with those from the 10-2 test. Thus, it remains to be determined whether, and the extent to which, central visual field abnormalities can be

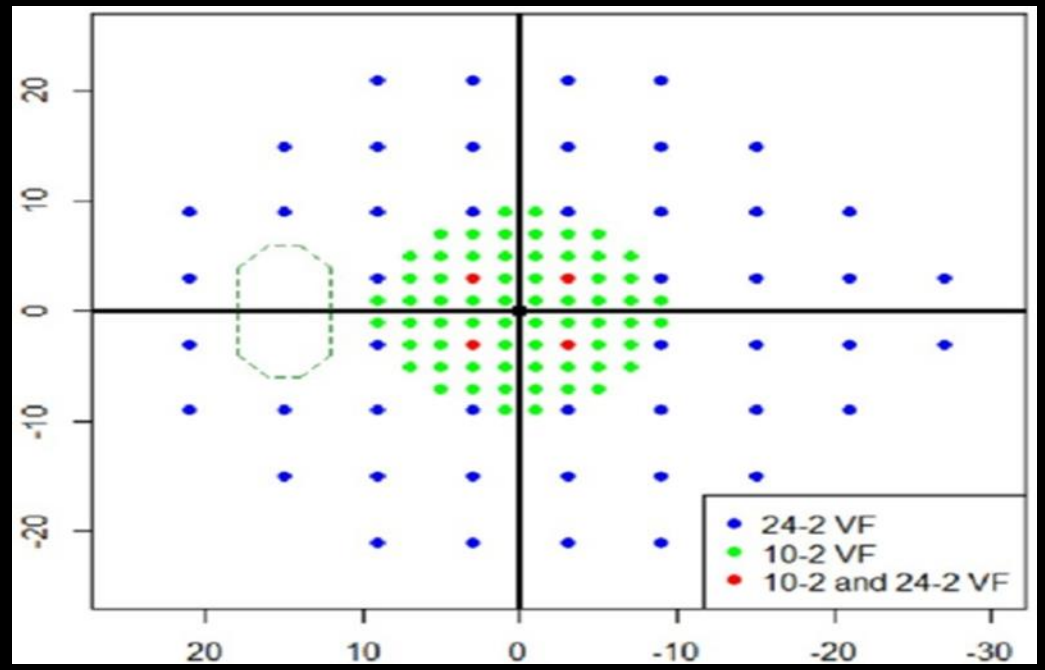
2018 MAYBE

SHOULD I ORDER A 10-2 FOR SUSPECTS?
MY OPINION

- START WITH 24-2
  - STICK WITH WHAT YOU STARTED (STD, FAST OR FASTER)
    - TIME SAVINGS NOT MUCH
    - EXTENT/ DEPTH OF DEFECT MAY BE UNDERESTIMATED ON SITA-FAST / FASTER BUT TIME SAVED HELPS PT
- IF ABNORMAL, STICK WITH IT
  - SHOULD MATCH
    - ONH
    - CLINICAL RNFL
    - OCT
- IF 24-2 HAS CENTRAL INVOLVEMENT
  - DO 10-2
- IF 24-2 NORMAL AND ONH / RNFL / OCT / GCC ARE ABNORMAL OR SUSPICIOUS
  - CONSIDER FDT AND/OR 10-2
- REGARDLESS…MONITOR FOR CHANGE

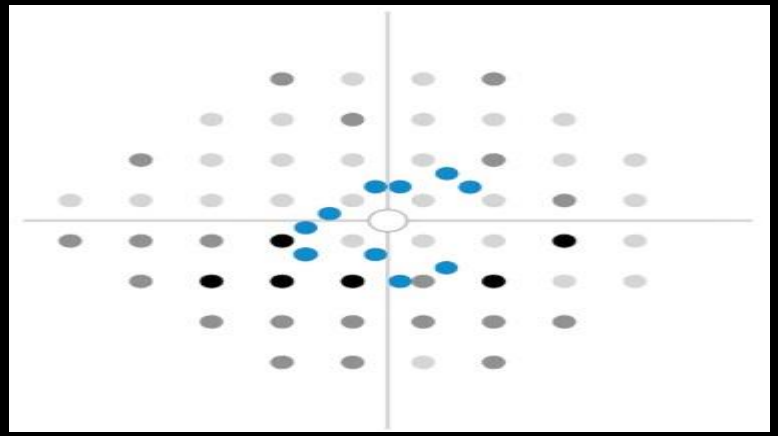
VISUAL FIELDS ARE HERE TO STAY.

IS THERE ANYTHING FASTER OR COMBINING TESTS?



New SITA Faster 24-2C Test

- More information in the central 10 degrees where macular visual field defects reside.
- The 24-2C test pattern combines all 24-2 points plus ten selected points from the 10-2 pattern that cover areas known to be susceptible to glaucomatous defects both from structural and functional studies (1-6)
- SITA™ Faster 24-2C test takes ~20% less time than SITA Fast 24-2 test



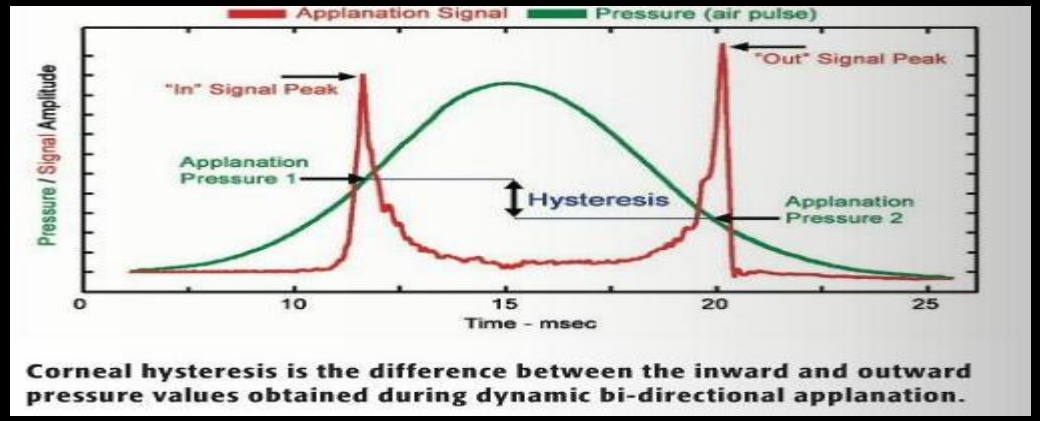
SOME OTHER TESTS

CORNEAL HYSTERESIS

- GLAUCOMA INTERPRETATION
  - HIGHER CORNEAL HYSTERESIS (> 9)
    - MORE LIKELY TO CUSHION SHORT / LONGTERM IOP INCREASES = MORE PROTECTIVE
  - LOWER CORNEAL HYSTERESIS (< 9)
    - LOWER CAPACITY TO DAMPEN IOP SPIKES AND/OR REDUCED ABILITY OF ONH STRUCTURES TO RESPOND TO IOP FLUCTUATIONS
    - INCREASED RISK FOR DEVELOPING GLAUCOMA
    - 2006, 2012 STUDIES
      - ASSOCIATED WITH PROGRESSIVE VF WORSENING
- CAN IT HELP IMPACT TREATMENT DECISIONS?
  - LESS CONCERNED IN A PATIENT WITH HIGH IOP AND HIGH CORNEAL HYSTERESIS
    - LESS LIKELY TO PROGRESS
  - MORE CONCERNED IN A PATIENT WITH LOW CORNEAL HYSTERESIS
    - MORE LIKELY TO HAVE RAPID PROGRESSION
    - BE MORE AGGRESSIVE IN TREATMENT, FOLLOW MORE FREQUENTLY

OCULAR RESPONSE ANALYZER

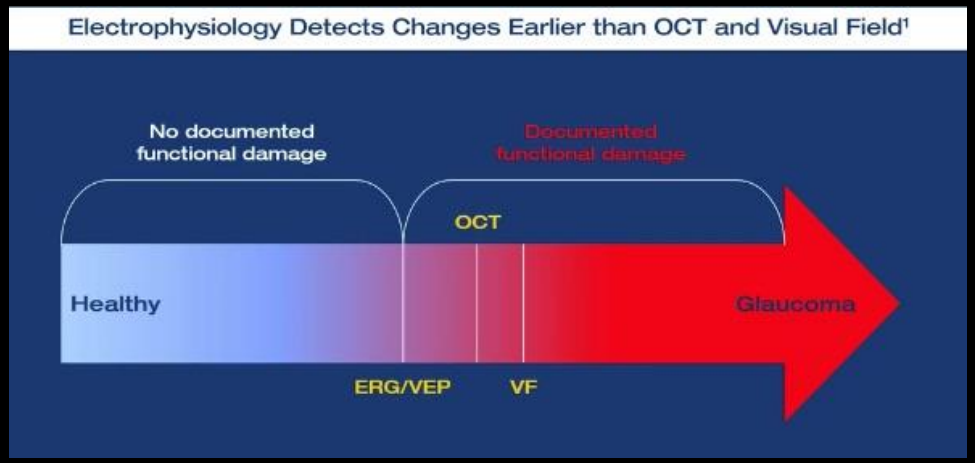
- AROUND SINCE 2008
- MEASURES
  - BIOMECHANICAL PROPERTIES OF CORNEA
  - SPECIFICALLY: CORNEAL HYSTERESIS
    - THEORY
      - THOUGHT TO REPRESENT VISCOELASTICITY
      - CORNEAL DAMPENING CAPACITY
        - RESISTANCE TO DEFORMATION
        - ABILITY TO BUFFER FLUCTUATIONS IN IOP
        - ABILITHY TO ABSORB / DISSIPATE ENERGY
- COMPANIES: REICHERT



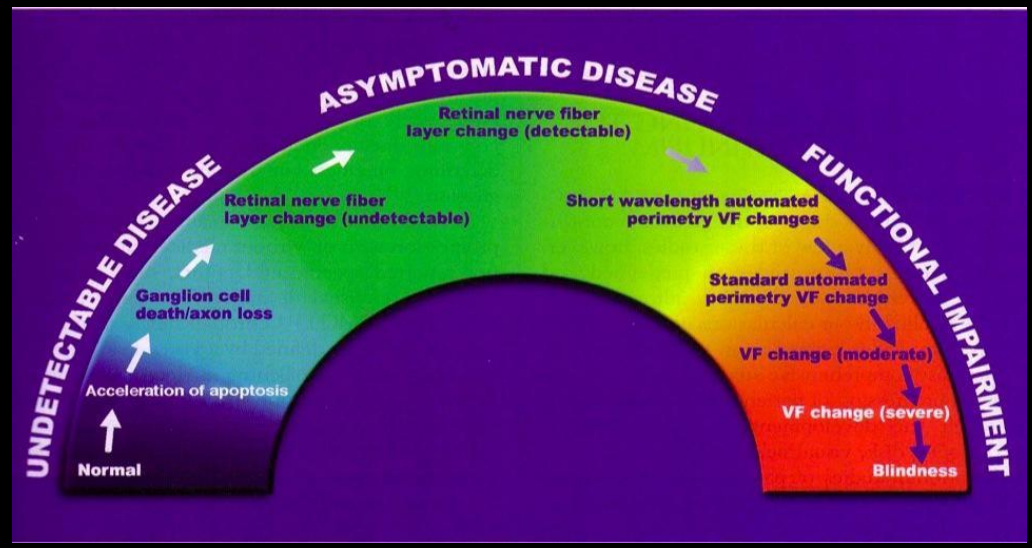
Corneal hysteresis is the difference between the inward and outward pressure values obtained during dynamic bi-directional applanation.

ELECTRORETINOGRAPHY

- PATTERN ERG
  - MEASURES ACTIVITY OF RETINAL GANGLION CELLS
  - THEORY
    - TESTS HEALTHY/UNHEALTHY CELLS
      - NOT DEAD CELLS
        - OCT GANGLION CELL LOSS
        - VISUAL FIELD DEFECT
      - DETECT FUNCTIONAL ABNORMALITY EARLY
        - HOWEVER, TESTS WERE DONE WITH TIME DOMAIN OCT, NOT SPECTRAL
        - WOULD RESULTS HOLD UP?
      - ONCE DAMAGE, USE VEP
- COMPANIES
  - LKC TECHNOLOGIES, KONAN MEDICAL, METROVISION, DIOPSYS



http://info.diopsys.com



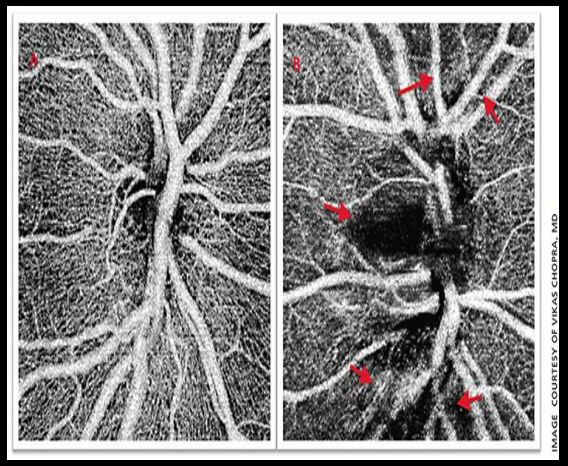
Weinreb RN et al. AJO. September 2004

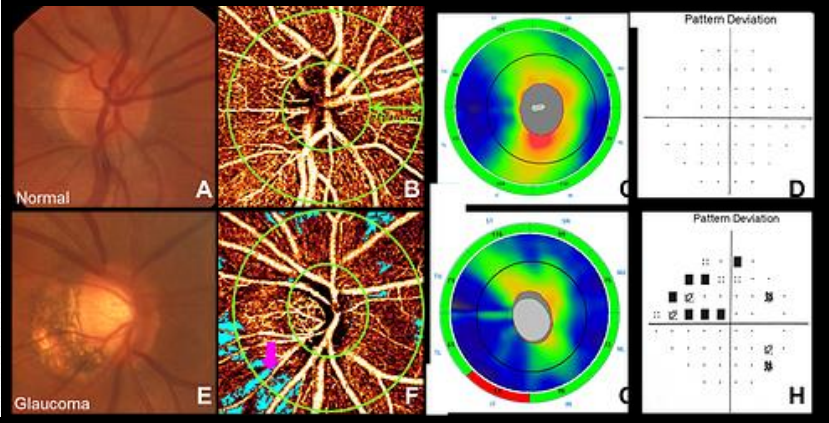
OCT ANGIOGRAPHY and GLAUCOMA

- USES
  - RETINA
    - DM RET, DRY/WET AMD, CSC, VASCULAR OCCLUSION, MAC TELANGIECTASIA, CNVM
  - GLAUCOMA
    - OPTIC DISC PERFUSION
    - MACULAR PERFUSION
  - UVEITIS
    - SUPERFICIAL / DEEP RETINAL CAPILLARY PLEXUS
    - CHORIOCAPILLARIS
- THEORY
  - GLAUCOMA PATIENTS HAVE
    - REDUCED BLOOD SUPPLY IN OPTIC NERVE AND PERIPAPILLARY REGION
- COMPANIES
  - OPTOVUE. ZEISS

ZEISS ANGIOPLEX OCT

ANGIOVUE



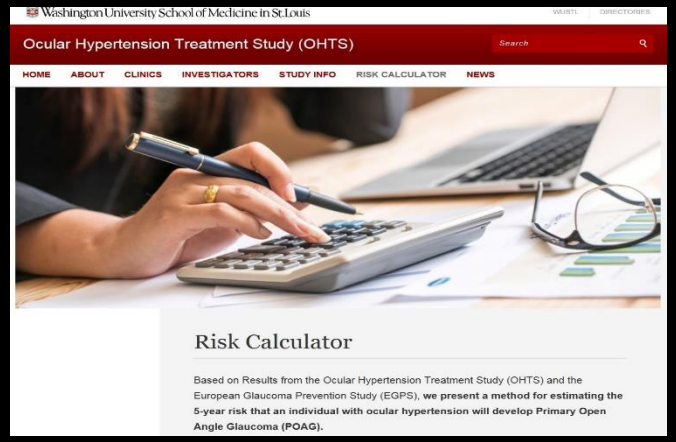


RISK ASSESSMENT

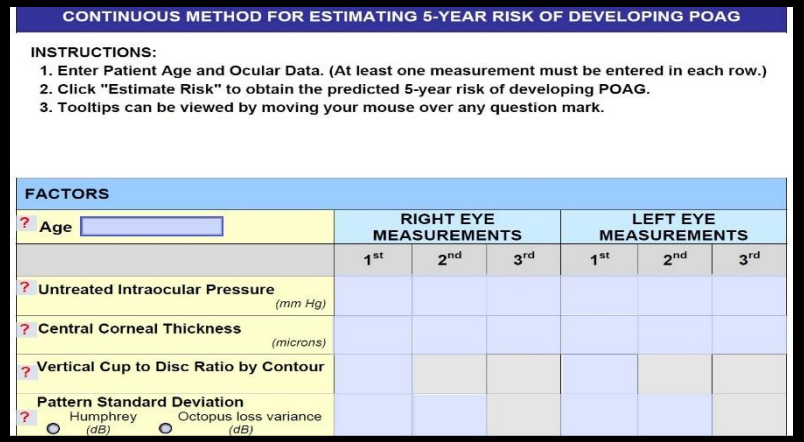
- ALLOWS YOU TO ASSESS RISK
  - RISK OF PROGRESSION
  - RISK OF VISION LOSS
- DETERMINES
  - MONITORING / FOLLOW-UP INTERVAL
  - NEED FOR REFERRAL / TREATMENT
  - PATIENT EDUCATION
- ALLOWS FOR PROPER CODING AND BILLING

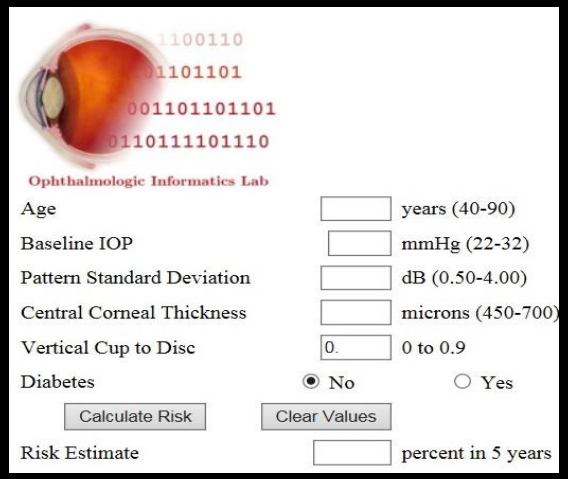
THERE ARE GLAUCOMA RISK CALCULATORS

(BUT ONLY FOR PATIENTS WITH OCULAR HTN)

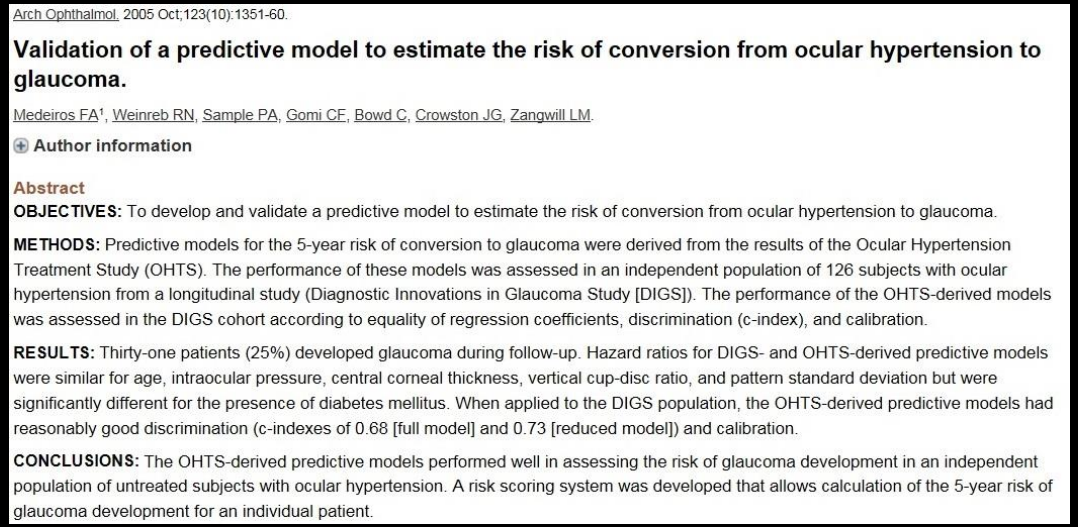


https://ohts.wustl.edu/risk/





https://oil.wilmer.jhu.edu/risk/



RISK ASSESSMENT: SIMPLIFIED

Glaucoma Quick Reference Guide

H40.00 Preglaucoma, unspecified	**H40.001** Right eye **H40.002** Left eye **H40.003** Bilateral	Excludes1 Absolute glaucoma **H44.51-** Congenital glaucoma **Q15.0** Traumatic glaucoma due to birth injury **P15.3**
H40.01 Open angle with borderline findings, low risk (1–2 risk factors) Open angle, low risk	**H40.011** Right eye **H40.012** Left eye **H40.013** Bilateral	Excludes1 Absolute glaucoma **H44.510-** Congenital glaucoma **Q15.0** Traumatic glaucoma due to birth injury **P15.3**
H40.02 Open angle with borderline findings, high risk (3 or more risk factors)	**H40.021** Right eye **H40.022** Left eye **H40.023** Bilateral	Excludes1 Absolute glaucoma **H44.510-** Congenital glaucoma **Q15.0** Traumatic glaucoma due to birth injury **P15.3**

https://www.americanglaucomasociety.net/client_data/files/2015/433_15289.codingcheetsheet.lowres2.pdf

Risk Factors for OAG Suspect Codes

- African American or Hispanic race
- Family history of glaucoma in 1st degree relative
- Thin central corneal thickness
- High IOP
- Pseudoexfoliation or pigment dispersion syndrome

≥ 3 risk factors = high risk
≤ 2 risk factors = low risk

https://www.aao.org/practice-management/news-detail/coding-low-and-high-risk-glaucoma-suspect

LOW OR HIGH RISK...
CAN IT BE THAT SIMPLE?

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