GLAUCOMA

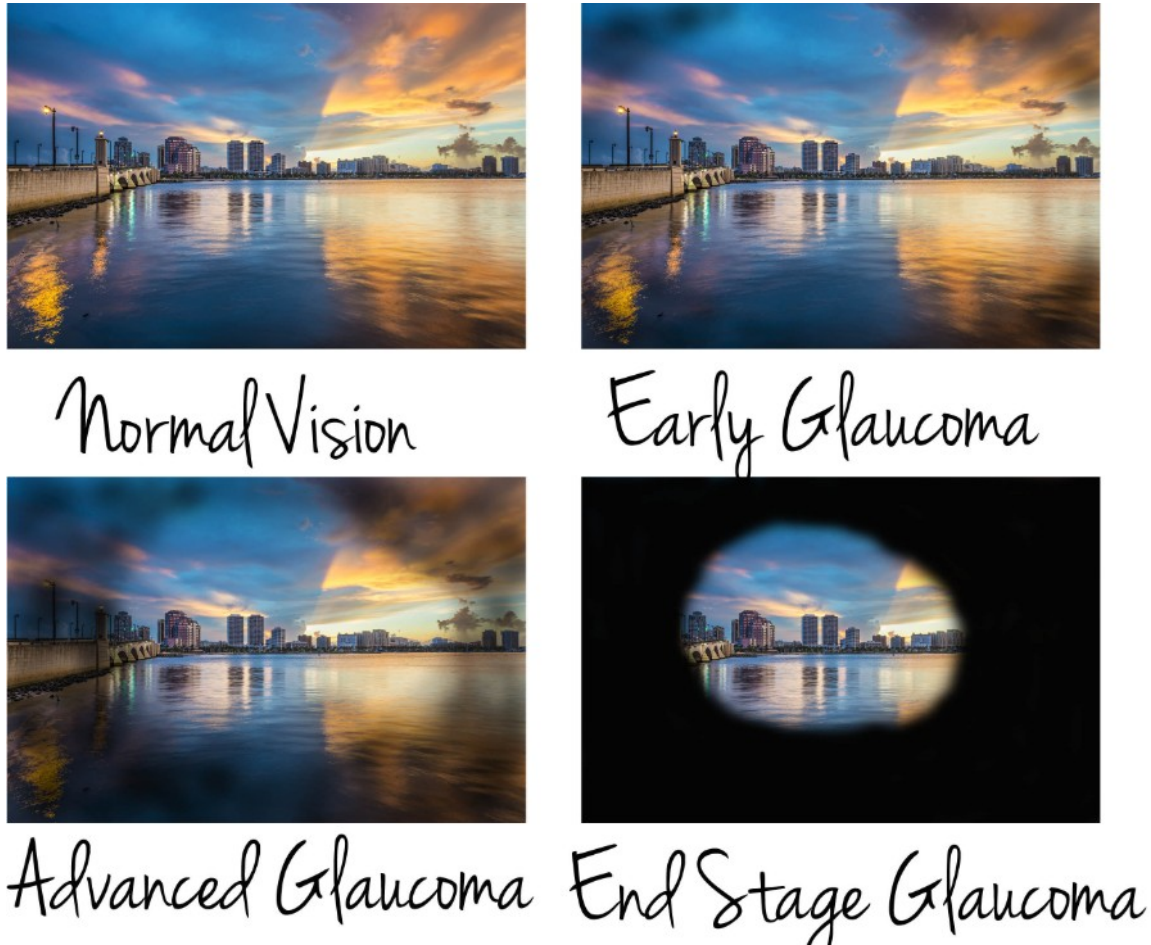
Part 1: glaucoma essentials

GLAUCOMA ESSENTIALS

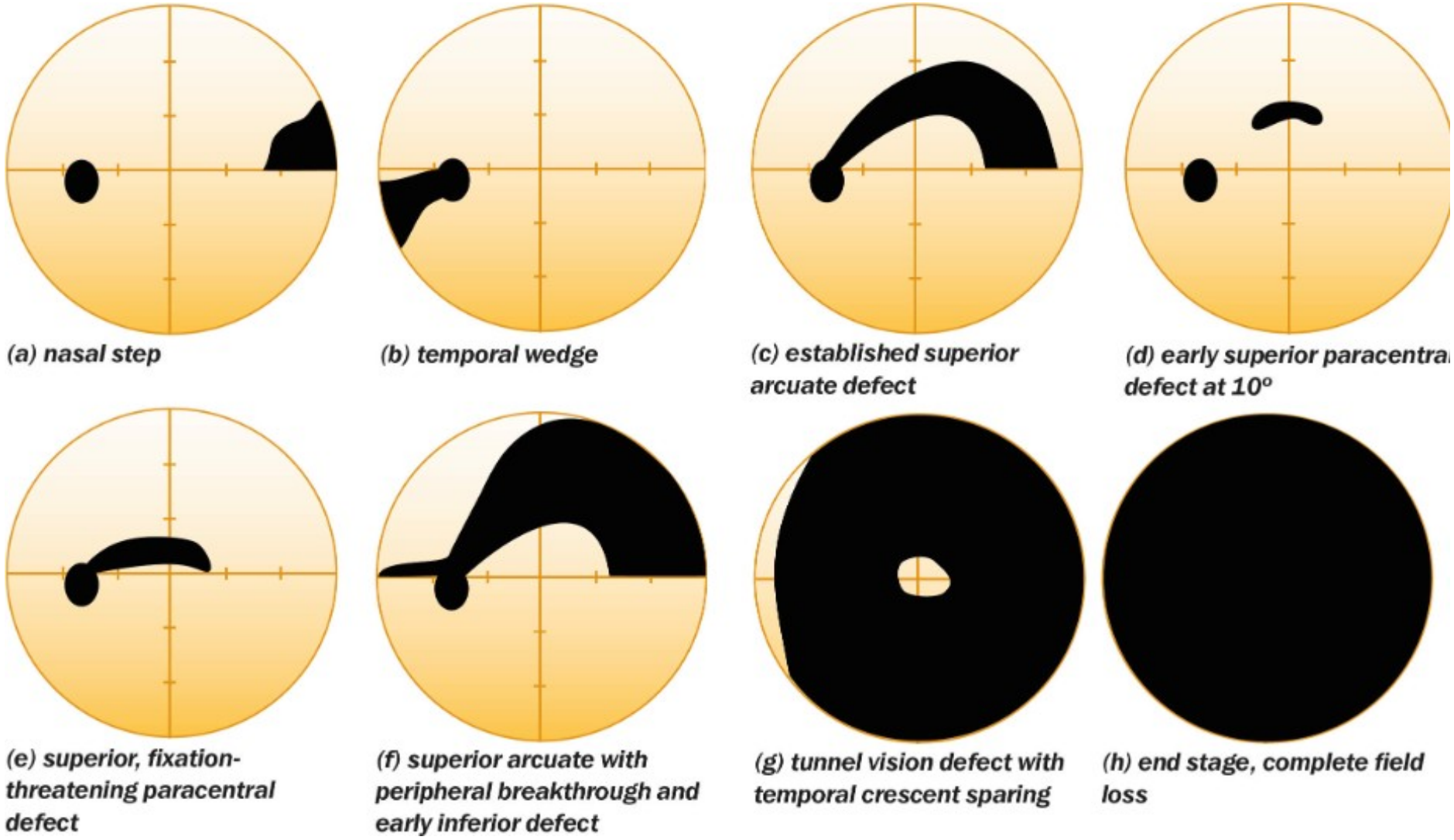
- **Glaucoma ≠ elevated IOP!!**
- **BUT**, glaucoma is usually associated with high IOP (x normal tension glaucoma)
- Late symptoms onset
- Affects 60.5 million people worldwide

GLAUCOMA ESSENTIALS

- accounts for 8% of all cases of blindness and is **the leading cause of irreversible blindness worldwide**
- Early detection is essential



GLAUCOMA ESSENTIALS (OS)



(a) nasal step

(b) temporal wedge

(c) established superior arcuate defect

(d) early superior paracentra defect at 10°

(e) superior, fixation-threatening paracentral defect

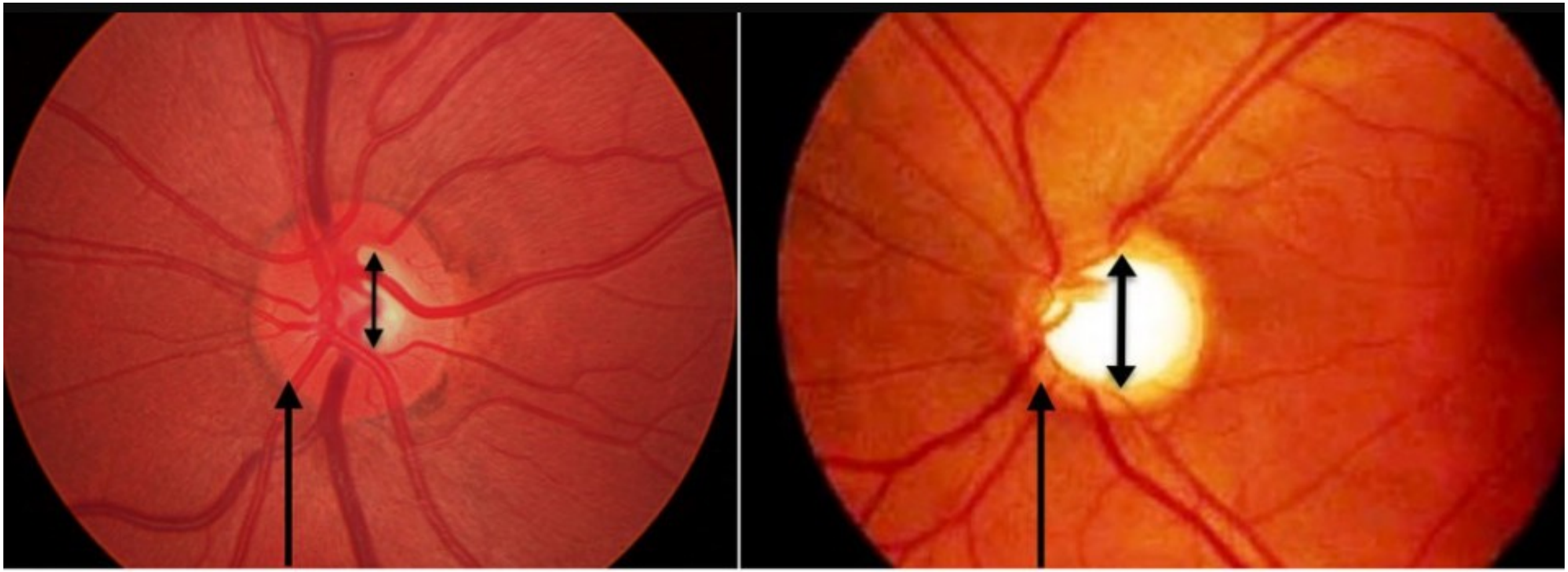
(f) superior arcuate with peripheral breakthrough and early inferior defect

(g) tunnel vision defect with temporal crescent sparing

(h) end stage, complete field loss

GLAUCOMA ESSENTIALS

- Optic nerve damage.



Normal optic nerve head

Glaucomatous cupping

GLAUCOMA ESSENTIALS

Part 2: definition, anatomy, patophysilogy

Definition

- a group of diseases defined by a characteristic **irreversible optic neuropathy**
  - remodeling of the connective tissue elements of the optic nerve head
  - loss of neural tissue (ganglion cells)
    - associated with the eventual development of visual dysfunction.
- intraocular pressure (IOP) level is one of the primary risk factors for development of glaucoma, **BUT does not have a role in the definition of the disease**
- **Glaucoma ≠ elevated IOP!!**

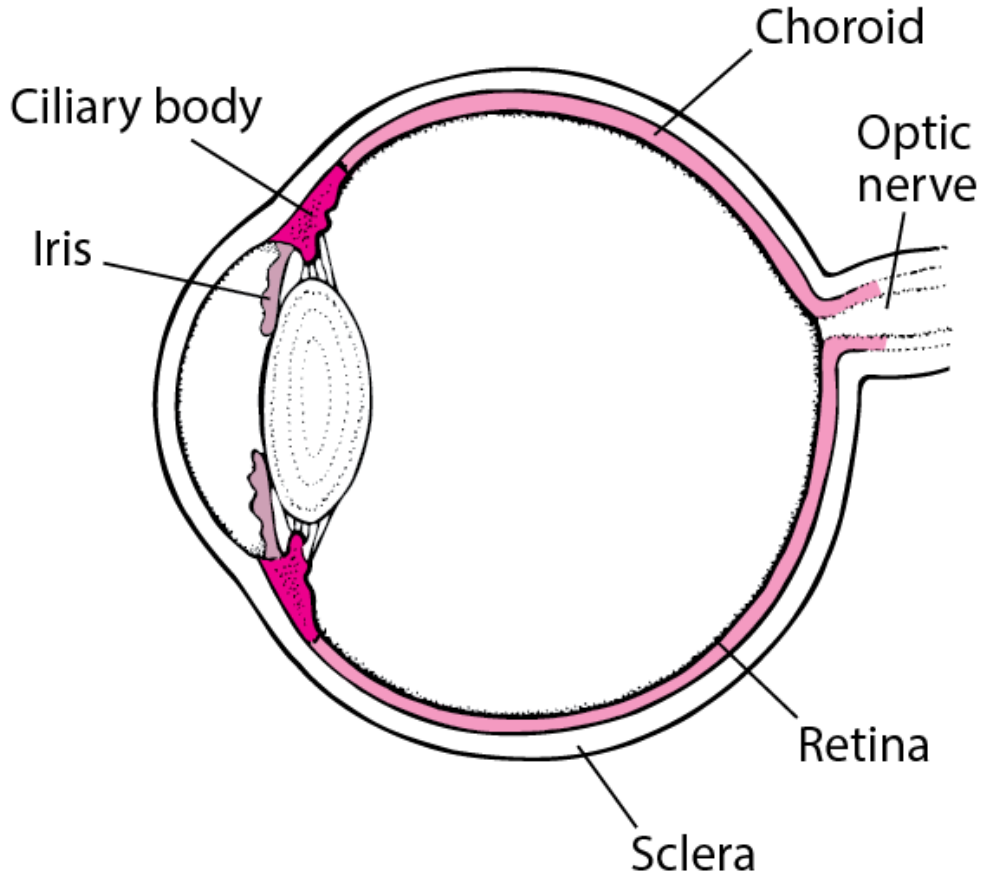
Glaucoma is not fully understood

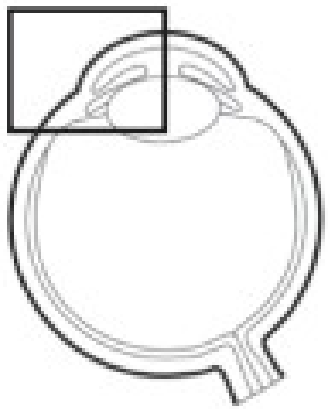
Susceptibility to glaucoma

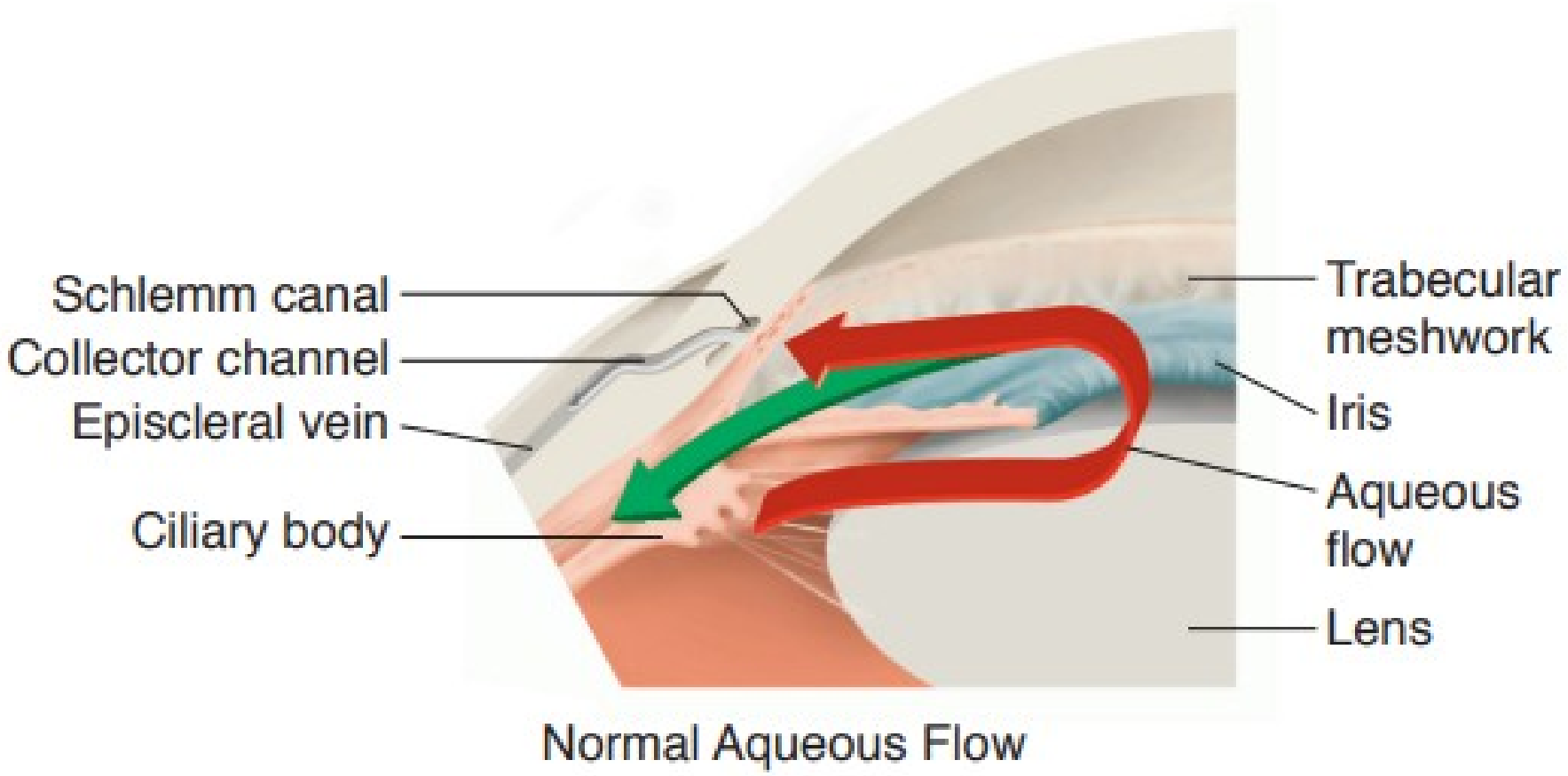
- determined by the **resilience of the optic nerve** to the multiple pathogenic mechanisms involved in the neuropathy
- progressive injury **may occur at low IOP** levels **whereas in other cases with higher pressures, injury never occurs.**
  - the optic nerve may continue to be damaged despite decreasing the IOP

Aqueous Humor Dynamics

- aqueous humor composition:
  - is **protein free** (optical clarity)
- production: **ciliary body** - 80 ciliary processes, rich supply of fenestrated capillaries
- 3.6 ml per day







Normal Aqueous Flow

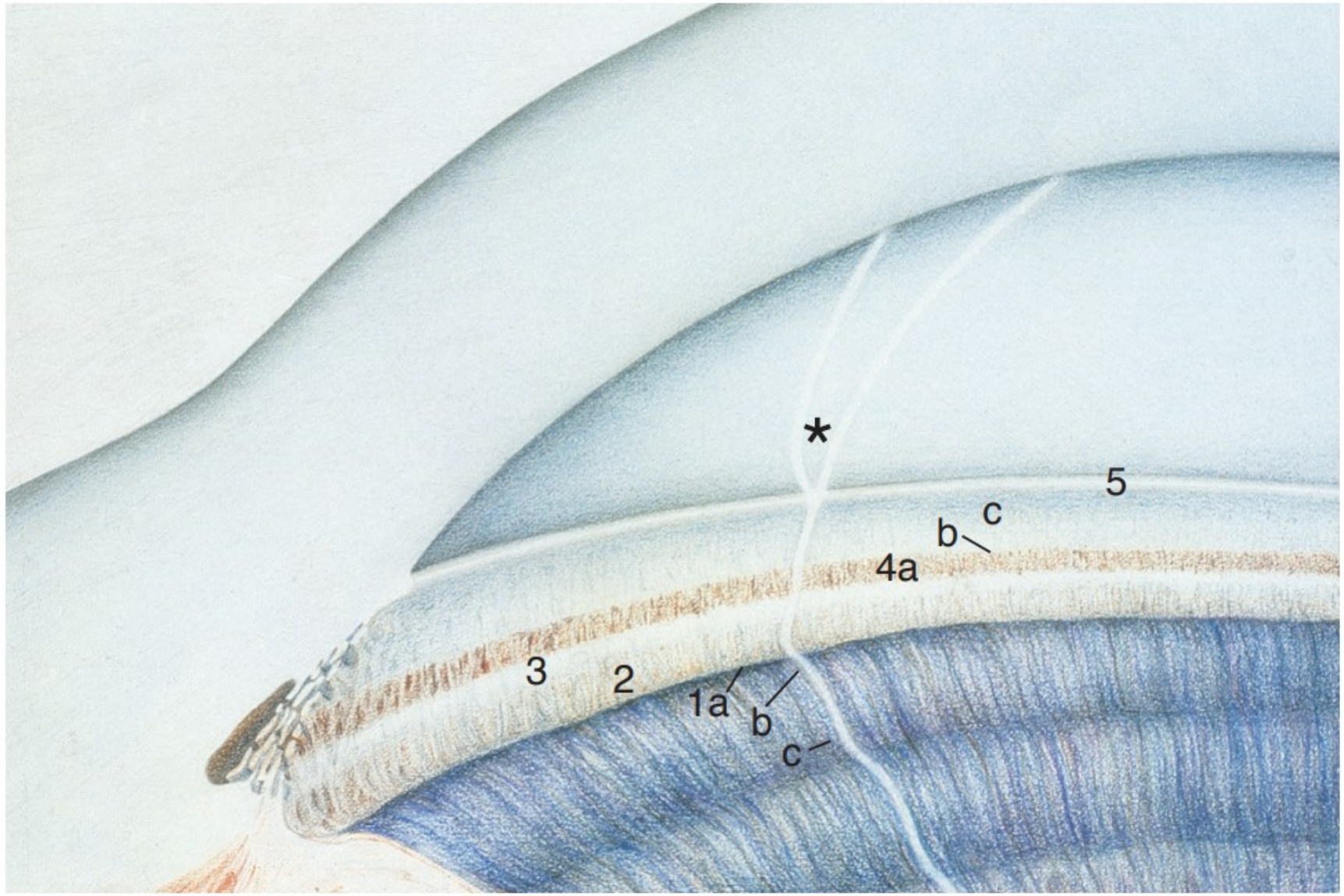


Figure 3-1 Gonioscopic appearance of a normal anterior chamber angle. *1,* Peripheral iris: *a,* insertion; *b,* curvature; *c,* angular approach. *2,* Ciliary body band. *3,* Scleral spur. *4,* Trabecular meshwork: *a,* posterior; *b,* mid; *c,* anterior. *5,* Schwalbe line. *Asterisk,* Corneal optical wedge.

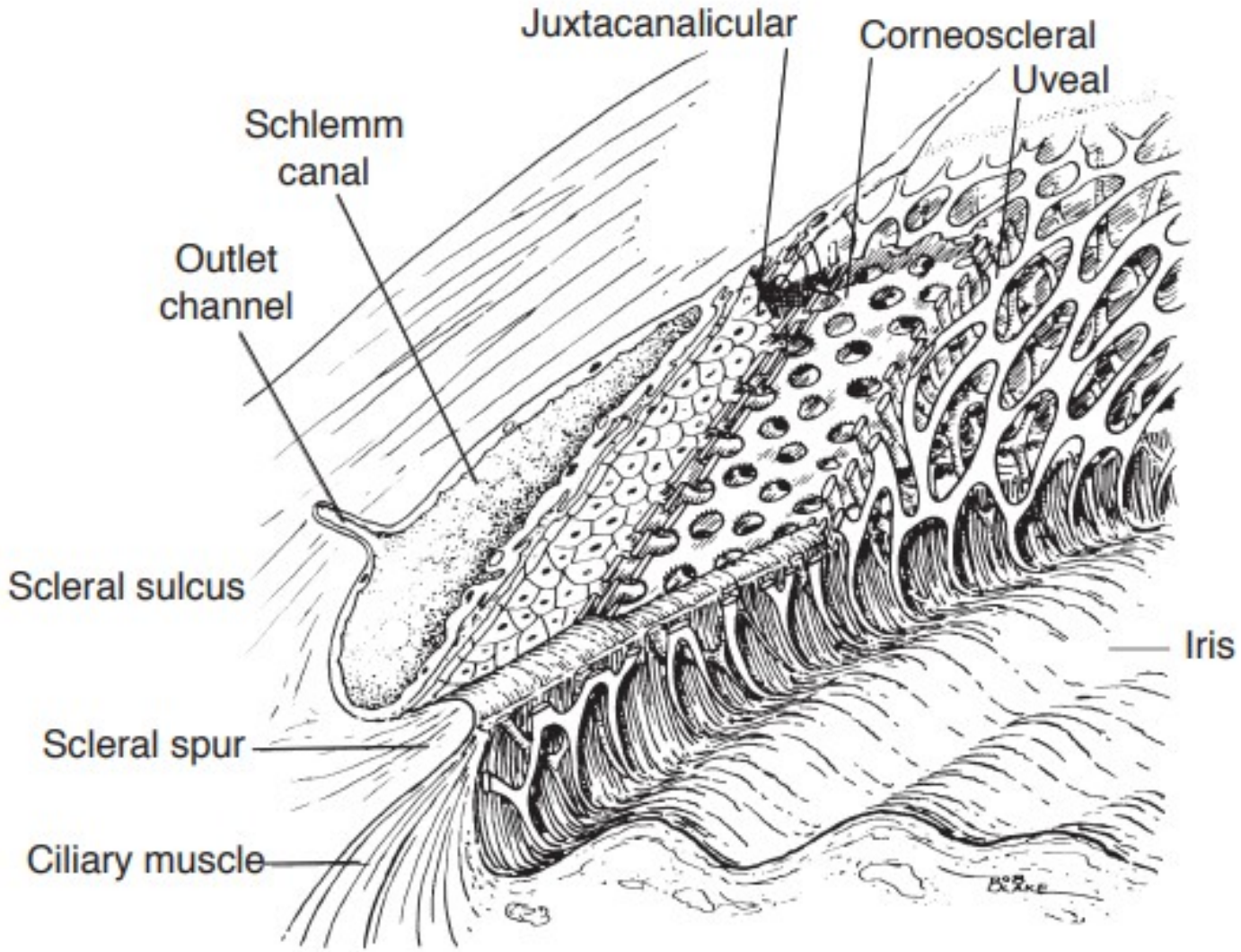
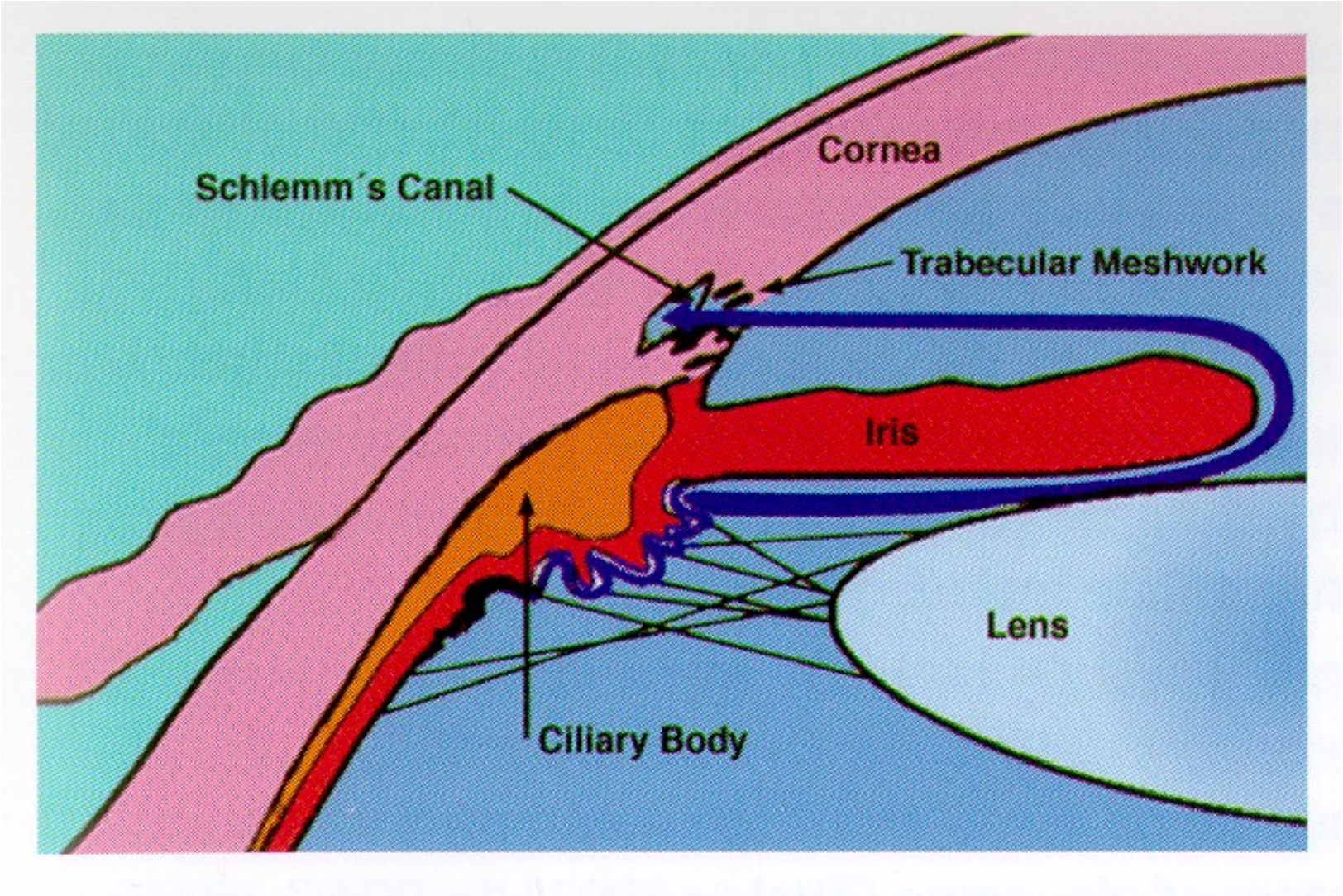


Figure 2-3 Three layers of the trabecular meshwork *(shown in cutaway views):* uveal, corneoscleral, and juxtacanalicular. *(Modified with permission from Shields MB.* Textbook of Glaucoma. *3rd ed. Baltimore: Williams & Wilkins; 1992.)*

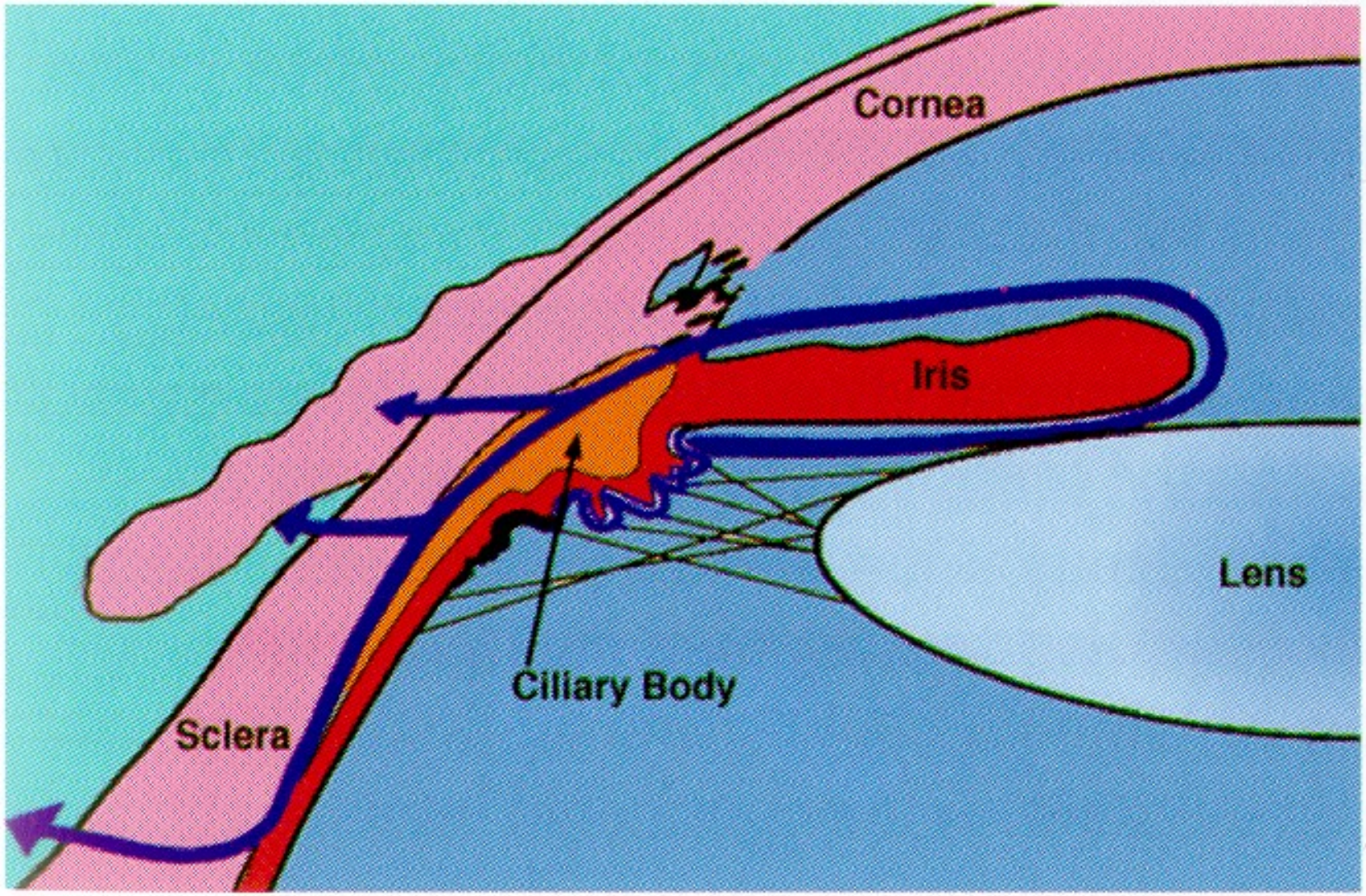
Aqueous Humor Dynamics

- Trabecular Outflow
  - pressure-sensitive outflow and functions as a one-way valve
- Uveoscleral Outflow
  - **up to 45%** of total aqueous outflow.
  - pressure-insensitive outflow
  - aqueous passage **from the anterior chamber into the ciliary muscle and then into the supraciliary and suprachoroidal spaces**
  - decreases with age and is reduced in patients with glaucoma
  - increased by cycloplegia, adrenergic agents, and prostaglandin analogues but decreased by miotics

Trabecular outflow



Uveoscleral outflow



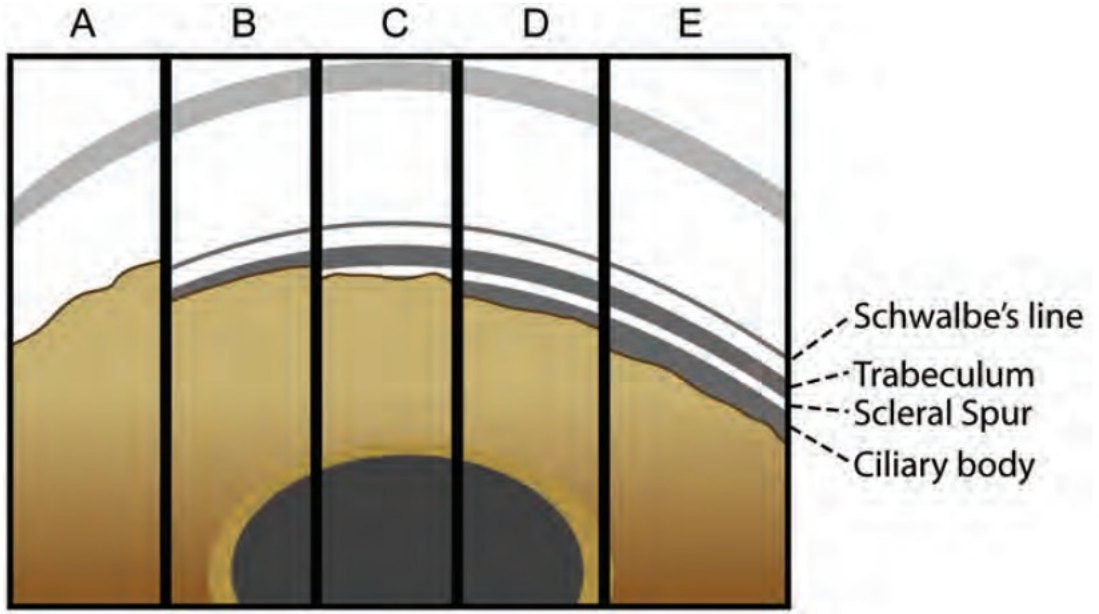
Part 3: Classification

Glaucoma classification

- Main classification
  - Open angle glaucoma
  - Angle closure gl.
  - Childhood gl.
- By cause
  - Primary, secondary
- By time
  - Acute
  - Chronic
  - Intermitent

Open angle gl.

- Primary (more common)
  - POAG – primary open angle gl.
  - NTG – normal-tension gl.
  - JOAG – juvenile open angle gl.
  - OHT – ocular hypertension
  - Glaucoma suspect
- Secondary
  - Pigmentary, pseudoexfoliation, uveitic…



Angle closure gl.

- Primary
  - **PACS** – primary angle closure suspect - narrow angle no nerve damage
  - **PAC** – primary angle closure - narrow angle, elevated IOP, no nerve damage
  - **PACG** – primary angle closure glaucoma - elevated IOP, nerve damage
  - **Primary angle closure without pupilary block** (plateau iris)
  - **Chronic angle closure** (angle permanently closed by PAS)
- Secondary
  - **With pupillary block**
    - Other mechanism than anatomical configuration (intumescent lens, secluded pupil..)
  - **Without pupillary block**
    - Pushing forward (choroideal tumor)
    - Pulling forward (NV glaucoma)

Childhood gl.

- PCG
  - presents within the first few years of life
- Glaucoma associated with congenital anomalies
  - Associated with local (aniridia) or systemic (neurofibromatosis..) disorders
- Secondary glaucoma in infants and children
  - Inflamation, retinoblastoma, trauma..

Terminology: absolute glaucoma

- Any type of glaucoma at its terminal phase – practical or total blindness
- Main goal of therapy = **pain elimination**
  - Cyclocryo/photocoagulation
  - Retrobulbar alcohol application – sensitive inervation block
  - Enucleation

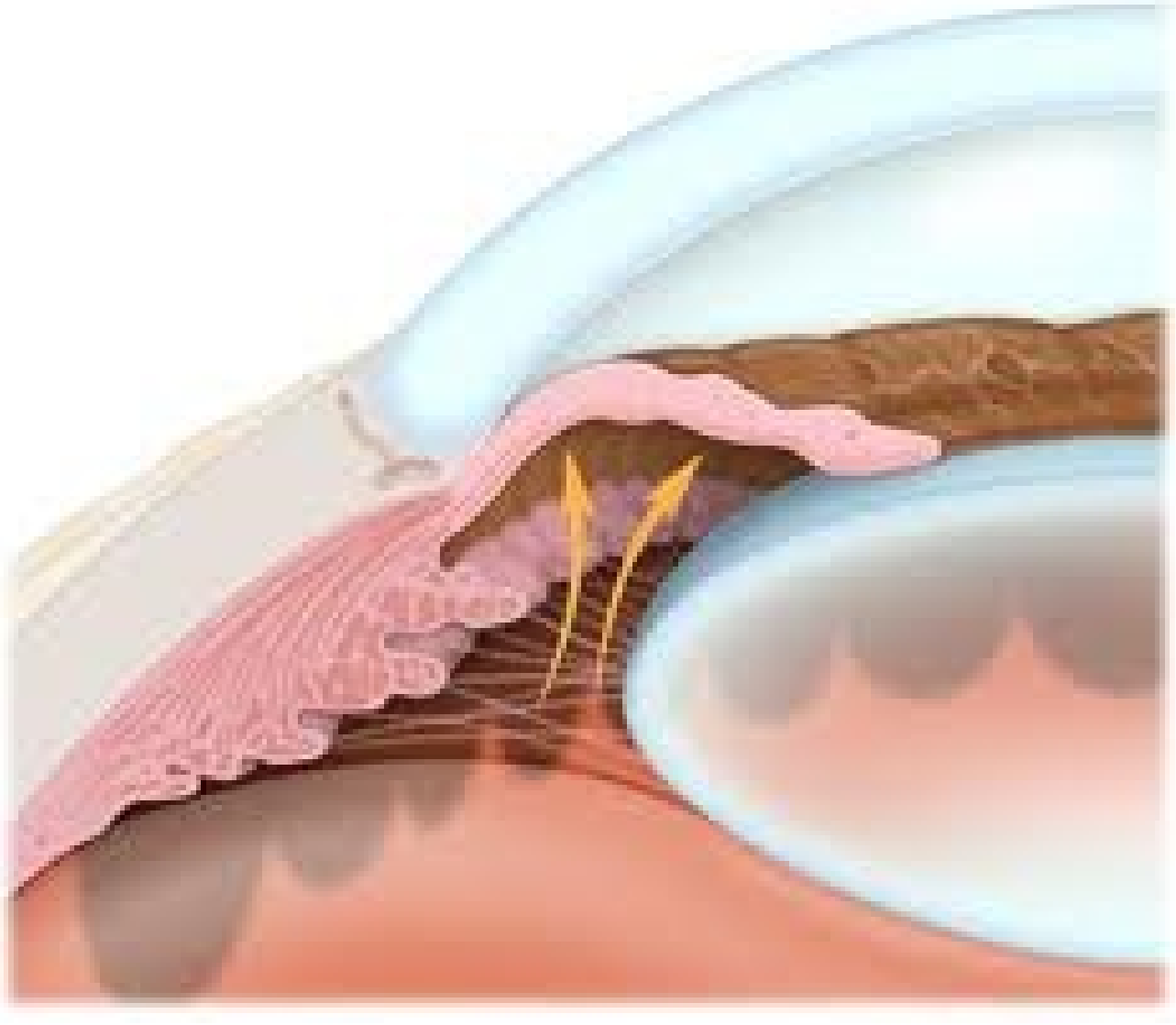
Part 4: Emergency cases: acute angle closure + malignant glaucoma

ACUTE ANGLE CLOSURE

Pupillary block

- the most common mechanism leading to **acute angle-closure** (glaucoma)
  - the flow of aqueous humor from the posterior chamber to the anterior chamber is. **obstructed by a functional block between the pupillary portion of the iris and the lens**
  - **Iris root is then pushed against trabecular meshwork**
- Risk factors:
  - Narrow angle, hypermetropia, age related lens swelling (cataract)
  - Mydriasis
    - Nighttime (less light)
    - Emotions

Pupillary block



Pupillary block

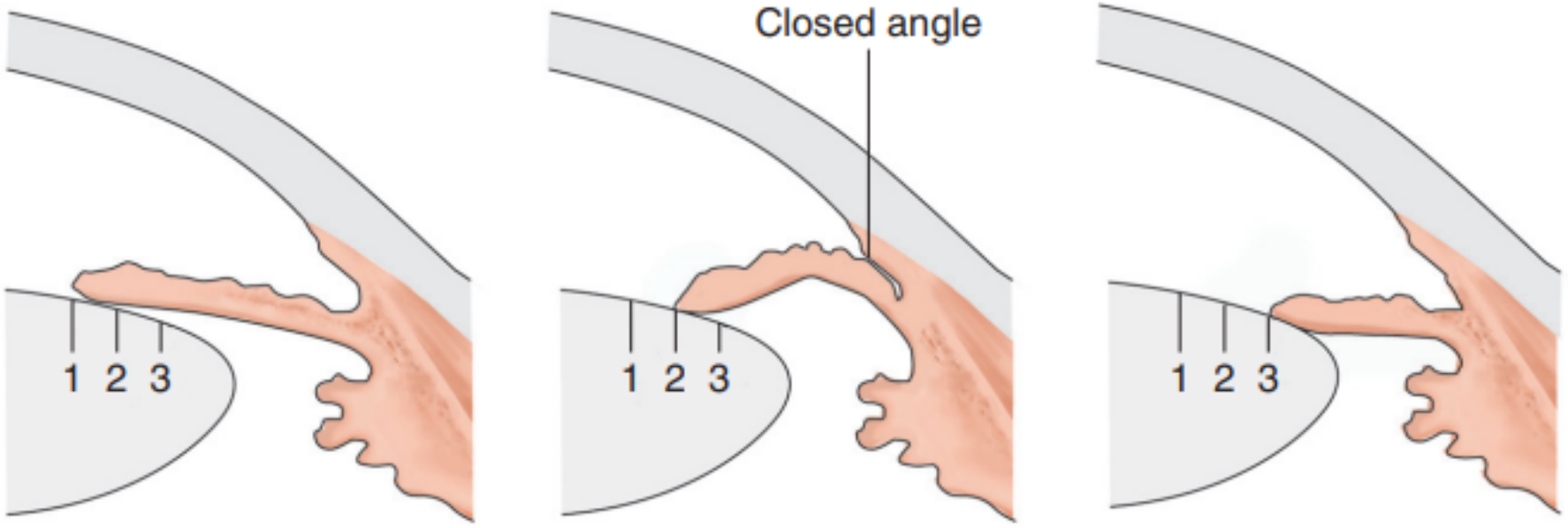


Figure 1-1 *1,* The pupil is constricted and the angle is open. *2,* The pupil is in the mid-dilated position. Pupillary block is maximal in this position and, as a result, the iris is bowed anteriorly and the angle narrows. *3,* The pupil is completely dilated, and pupillary block is diminished, with a return to a flatter iris configuration. If full-blown angle closure occurs, the iris may stay in the mid-dilated position until the angle-closure attack is broken. *(Illustration by Cyndie C. H. Wooley.)*

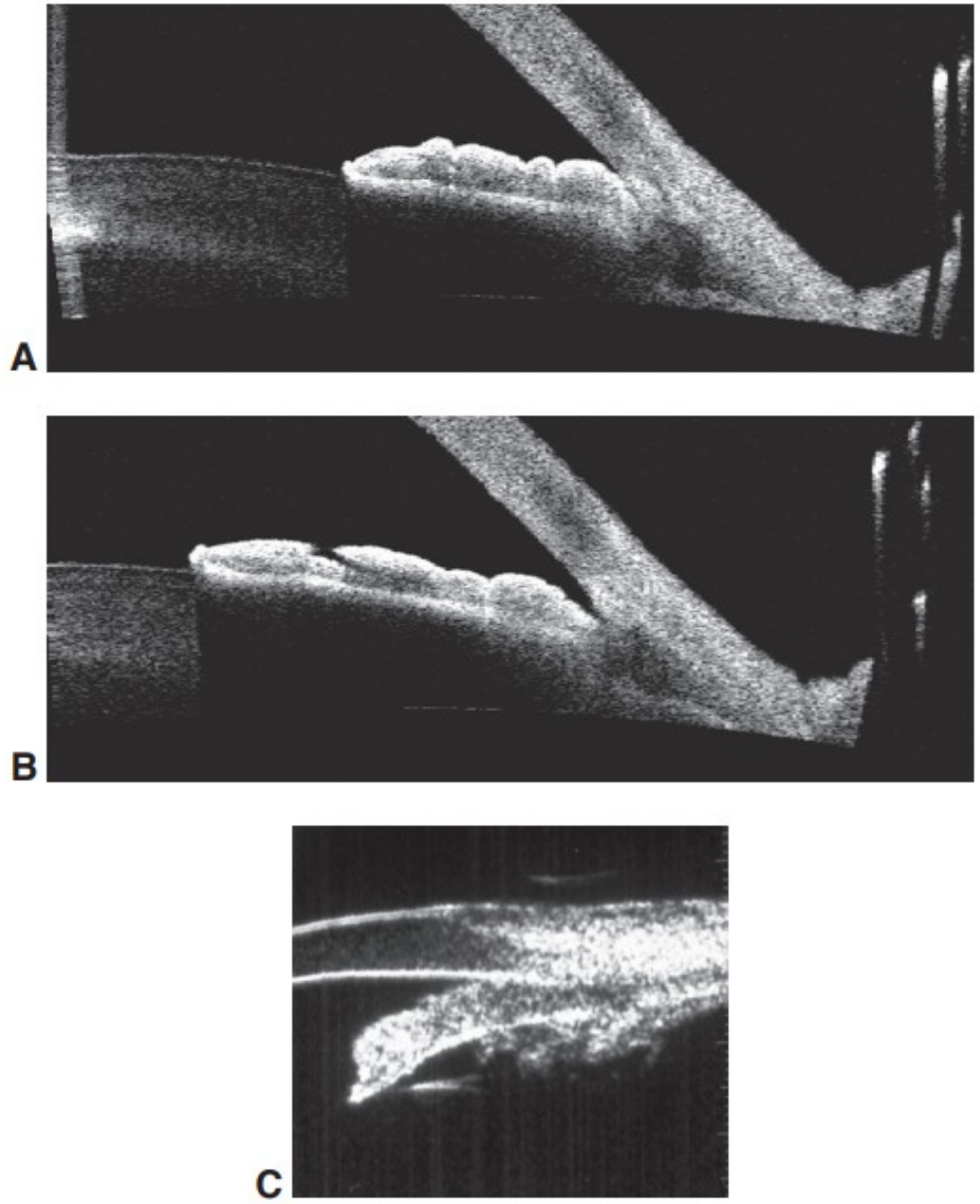
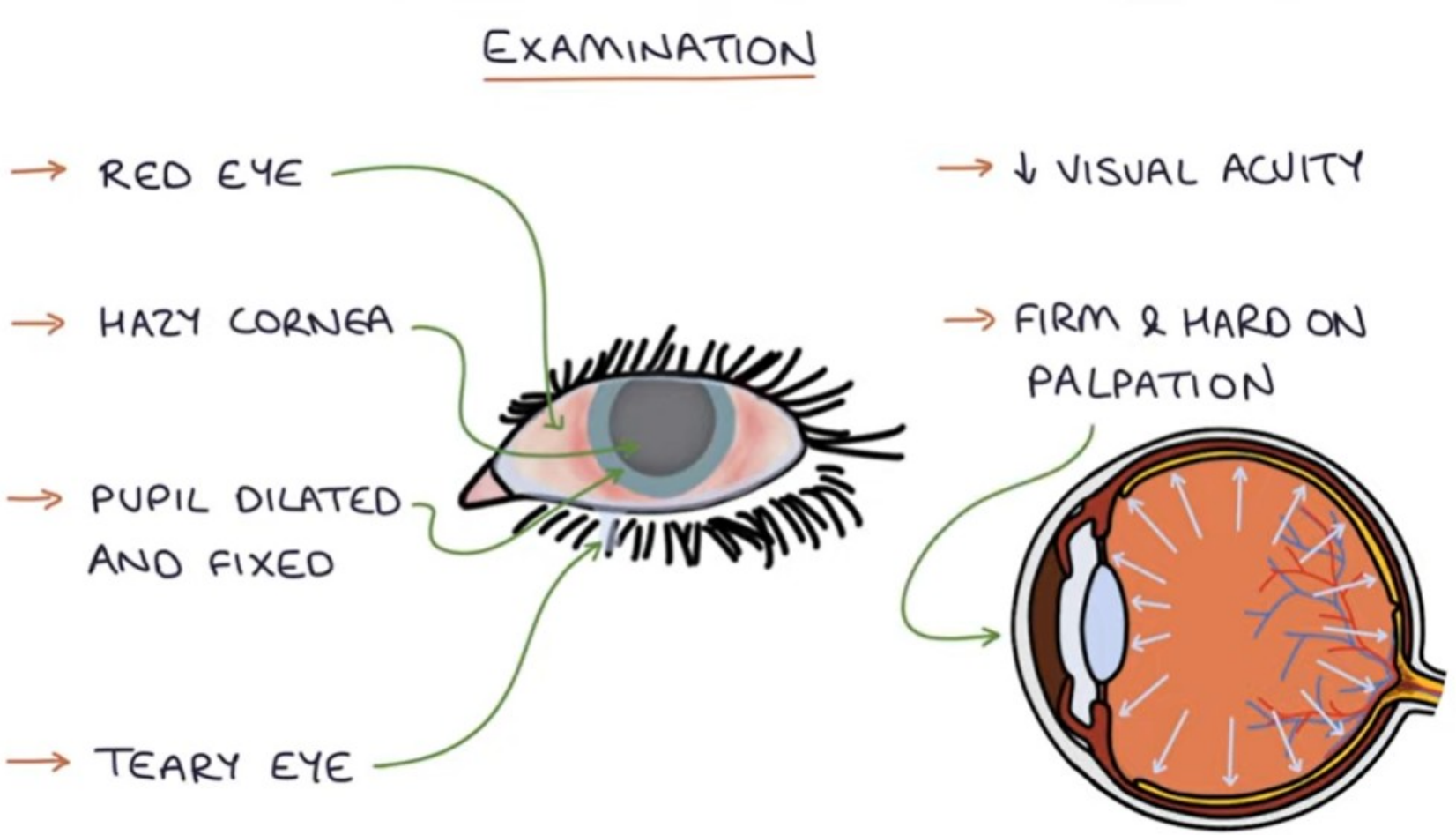


Figure 5-1 Ultrasound biomicroscopy (UBM) of a narrow angle. **A,** Angle closure is evident when the angle is imaged with lights off. **B,** The same angle is much more open when it is imaged with lights on. **C,** UBM of a narrow angle due to plateau iris. *(Parts A and B courtesy of Yaniv Barkana, MD; part C courtesy of Wallace L. M. Alward, MD.)*

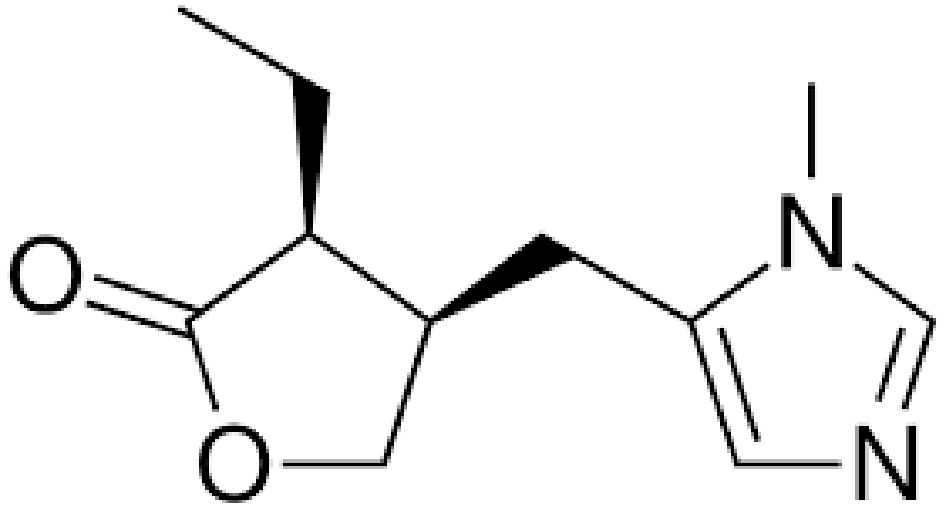
Acute angle closure - signs

- Unilateral (usually)
- IOP (usually) over 60 mmHg



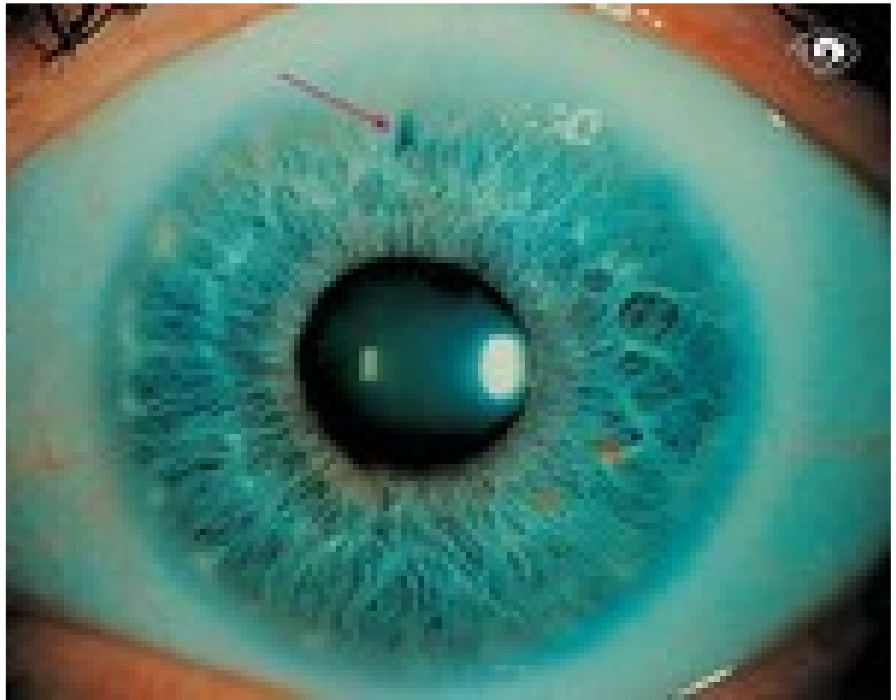
Acute angle closure – primary care

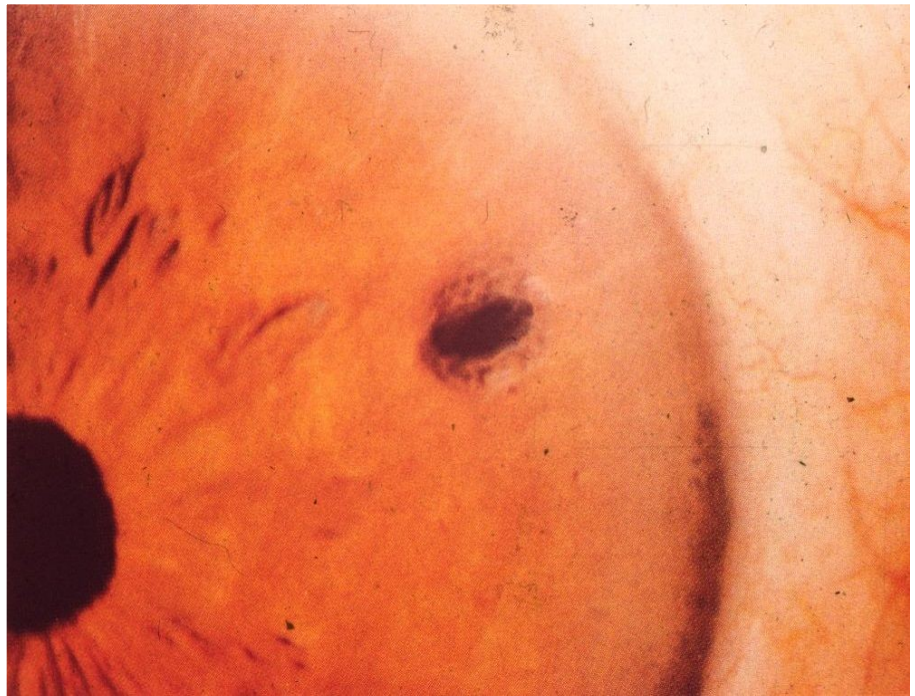
- Miotics
- Other local antiglaucomatics
- Systemic therapy:
  - Osmotics
  - Carbonanhydrase inhibitors
  - Analgetics
  - Antiemetics



Acute angle closure – secondary care

- Laser iridotomy (Nd:YAG laser)
  - (neodymium-doped yttrium aluminum garnet)
  - Little hole in the iris periphery
  - Help to equal the pressures between posterior and anterior eye segment
- Cataract extraction

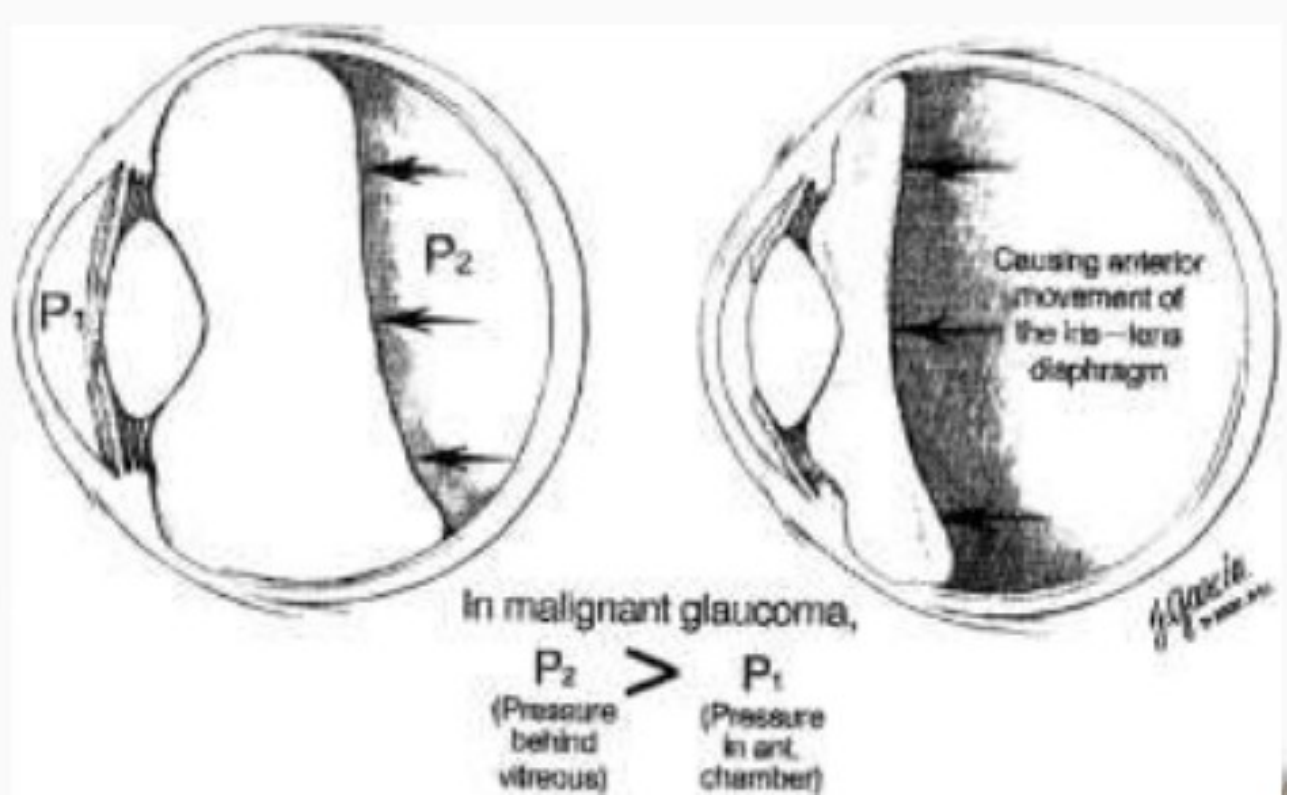


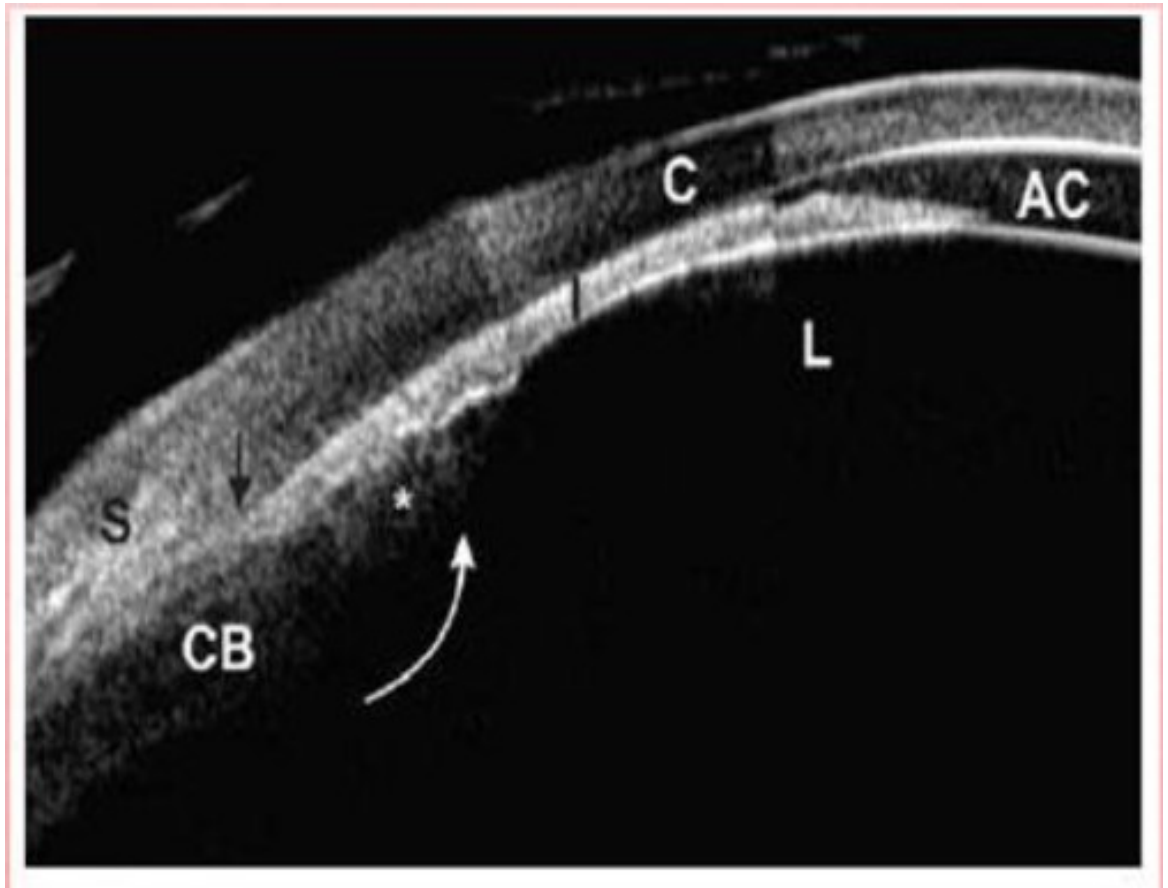


Laser iridotomy video

- https://www.youtube.com/watch?v=pNpzdYA3TqI

Special case: Malignant glaucoma





Part 5: Examination

Examination in glaucoma

- History
- Slit lamp examination
  - gonioscopy
- IOP measurement
- Perimetry
- Imaging
  - OCT RNFL
  - Ganglion cells
  - HRT

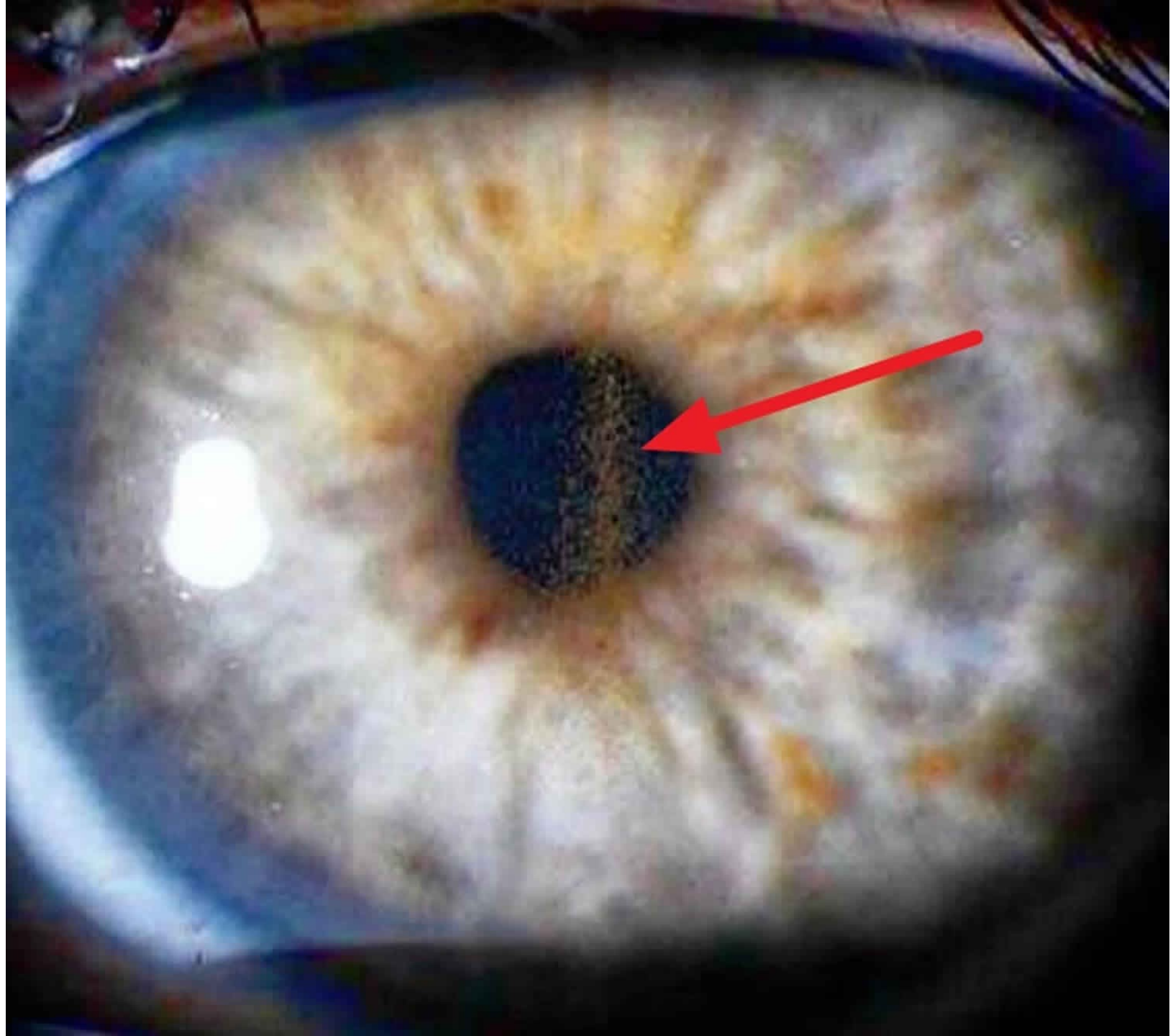
Medical history in glaucoma

- Typically no symptoms for chronic glaucoma in early stages
- Risk factors:
  - age, family history, high IOP, hyperopia, DM, previous eye injury, thin cornea, race
- Important in medical history
  - Past ocular surgery
  - Refractive error
  - General medical history (corticosteroid use – steroid induced gl.)
  - Past medical history (DM, AB, AI, heart diseases, raynauds phenomenon)
  - Glaucoma in family

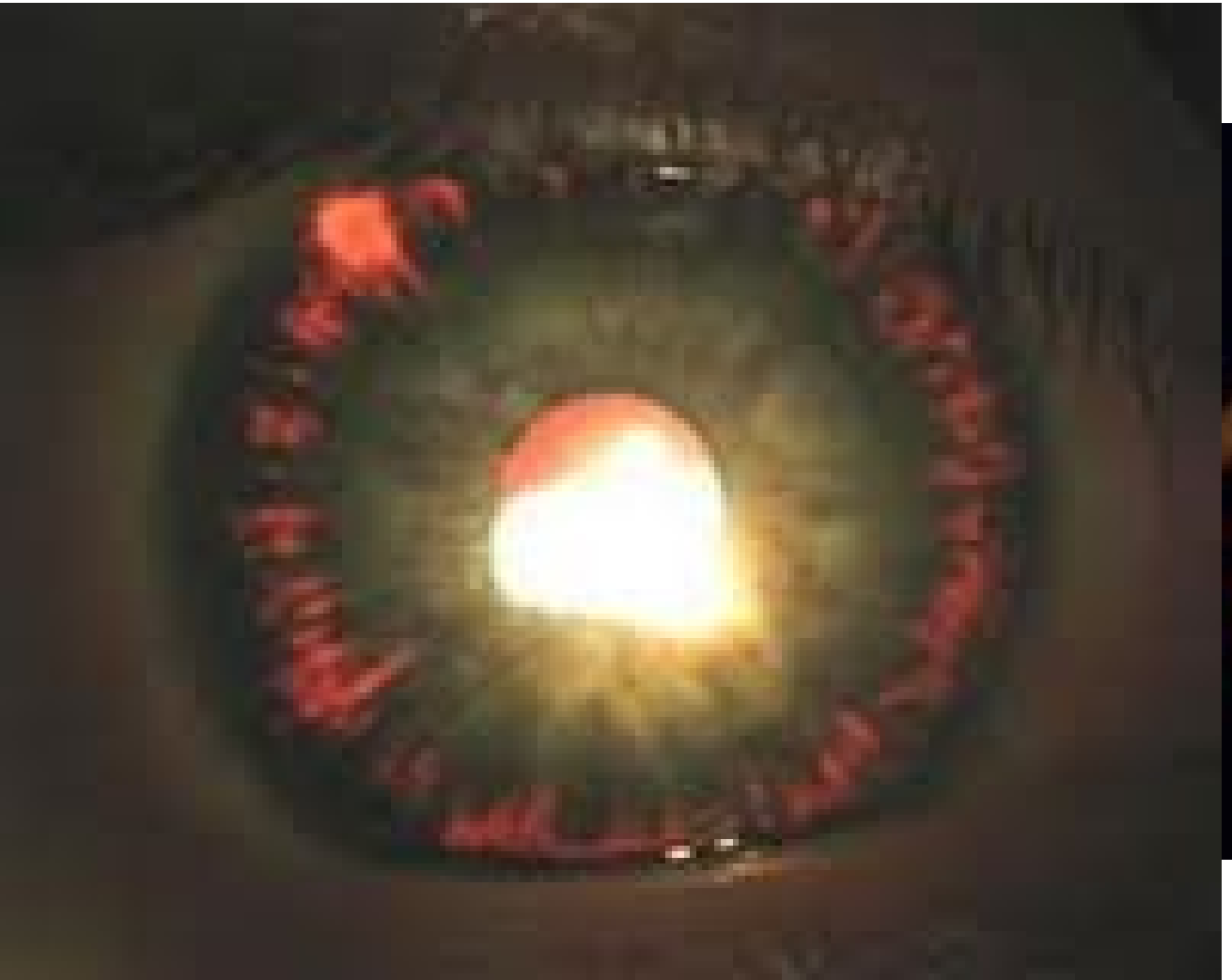
Slit lamp examination

- External adnexae (lashes)
- Pupils – may differ in size
- Conjunctiva – hyperaemia, scarring due to decreased tear production..
- Cornea – epithelopathy (mediacal toxicity), microcystic oedema (IOP), Kruckenbergs spindle (pigmentary gl.), precipitates (uveitic gl.)
- AC – van Herick method (width)
- Iris – translumination defects (pigmentary gl), ectropion uveae, rubeosis iridis..
- Lens – intumescent cataract, pseudoexfoliation, subluxation…
- Fundus – optic nerve head, retinal haemorrhages, masses…

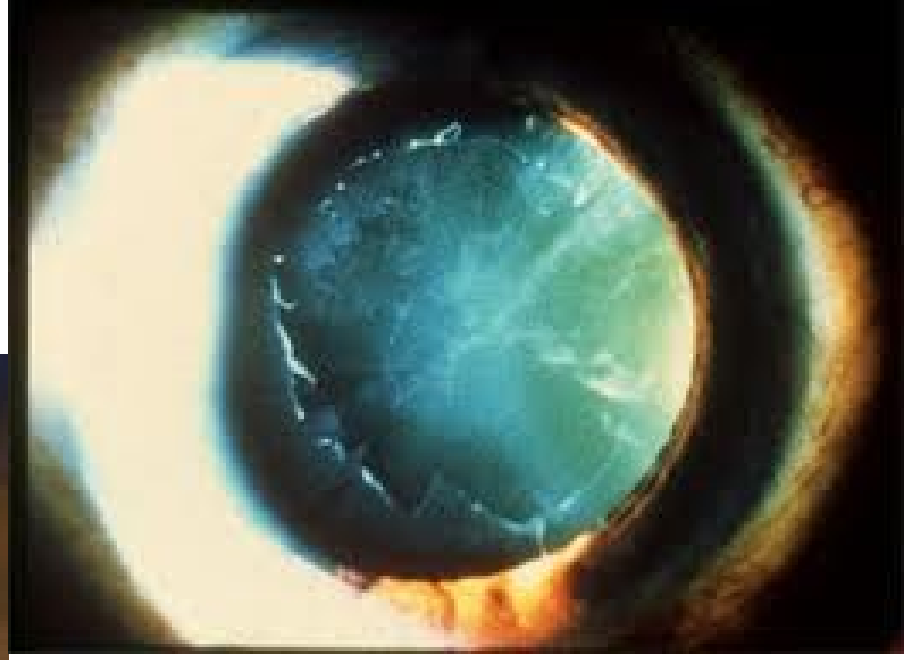
Fig 2: Hypertrichosis in a patient on bimatoprost in Left eye



Pigmentary glaucoma (secondary open angle)



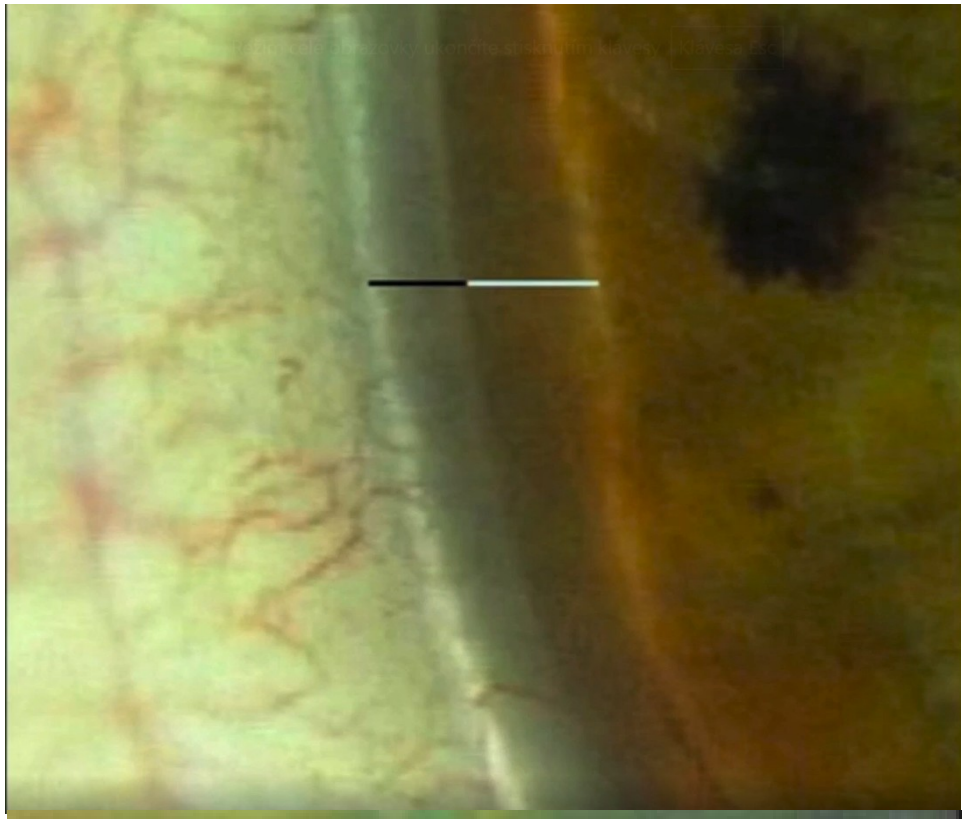
PEX glaucoma (secondary open angle)

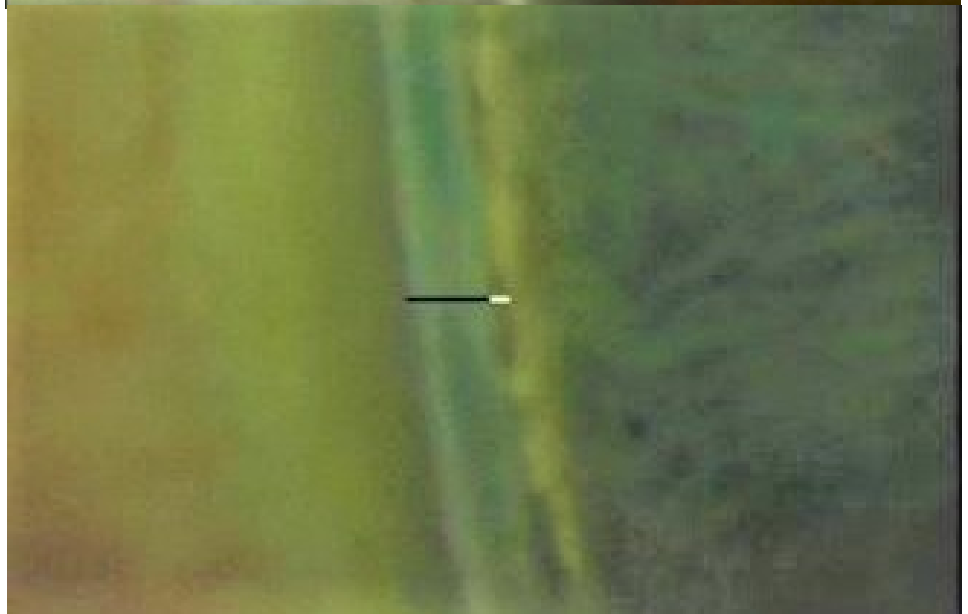


Neovascular gl. (secondary angle closure)

Van Herick grading

AC Depth	Grade
≥ cornea	4
¼ - ½ cornea	3
¼ cornea	2
< ¼ cornea	1
Dangerously narrow	Slit



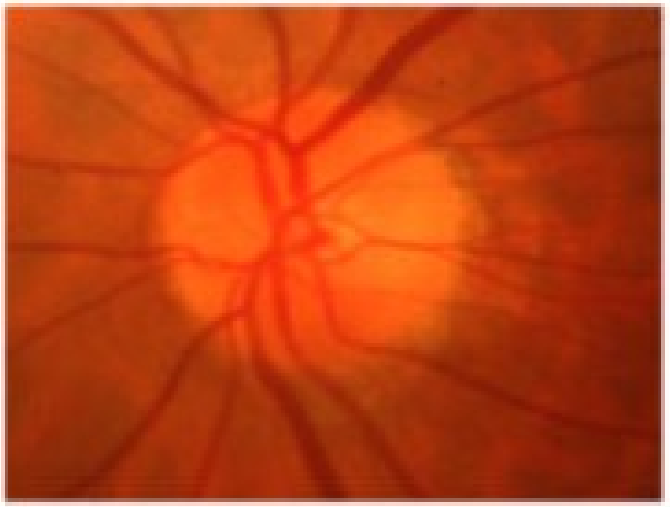


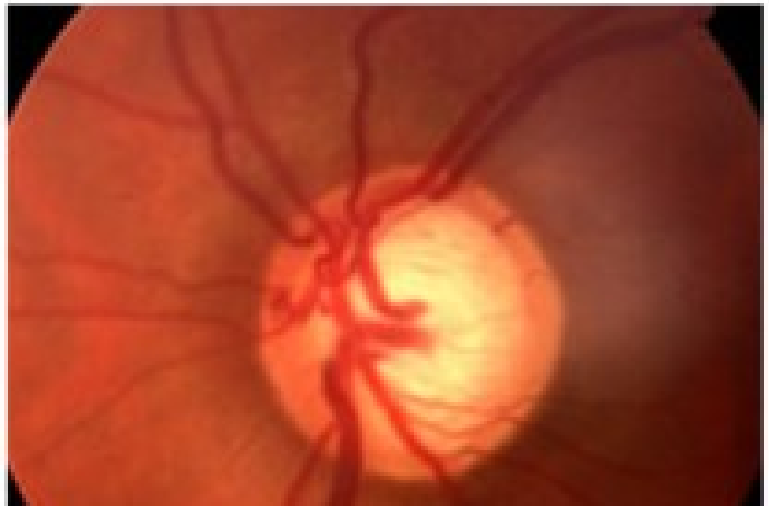
Under ¼ = high risk of angle closure

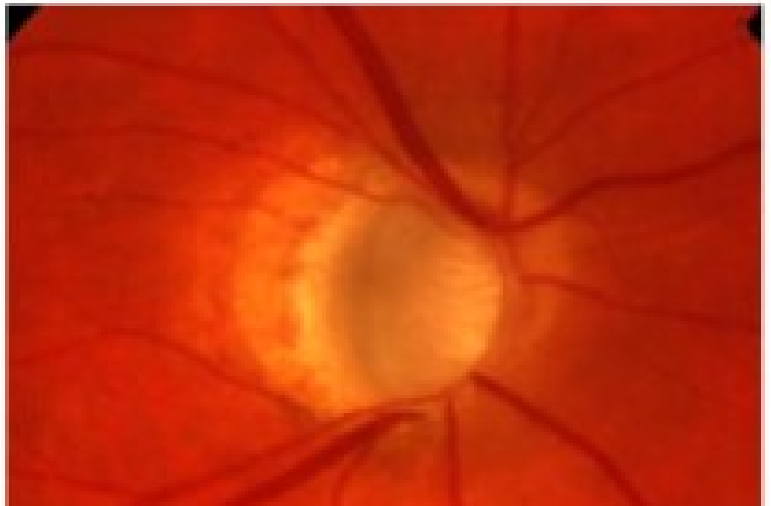
Slit lamp examination

Signs of glaucoma atrophy of ONH:

- Excavation of papilla of ONH
- Nasalization (nasal shift of vessels)
- Peripapillary choroidal atrophy
- Disc hemorrheage

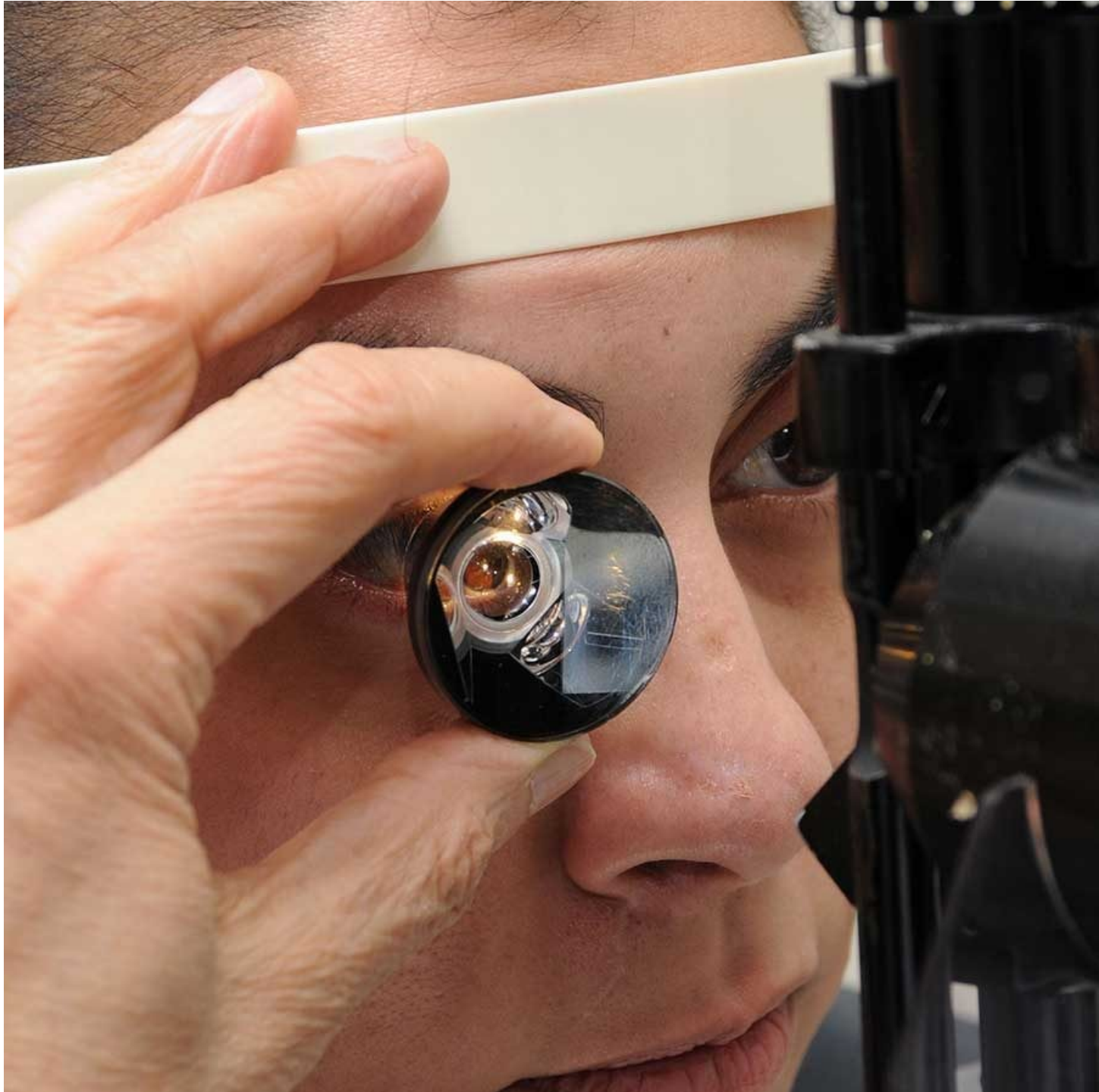


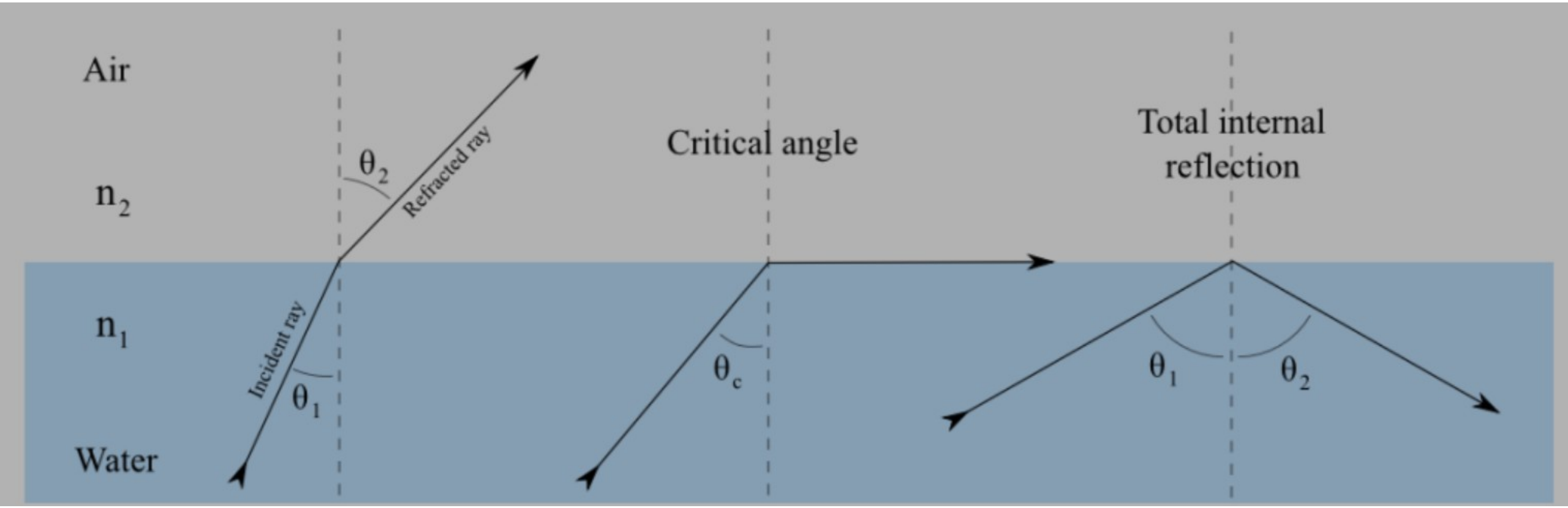


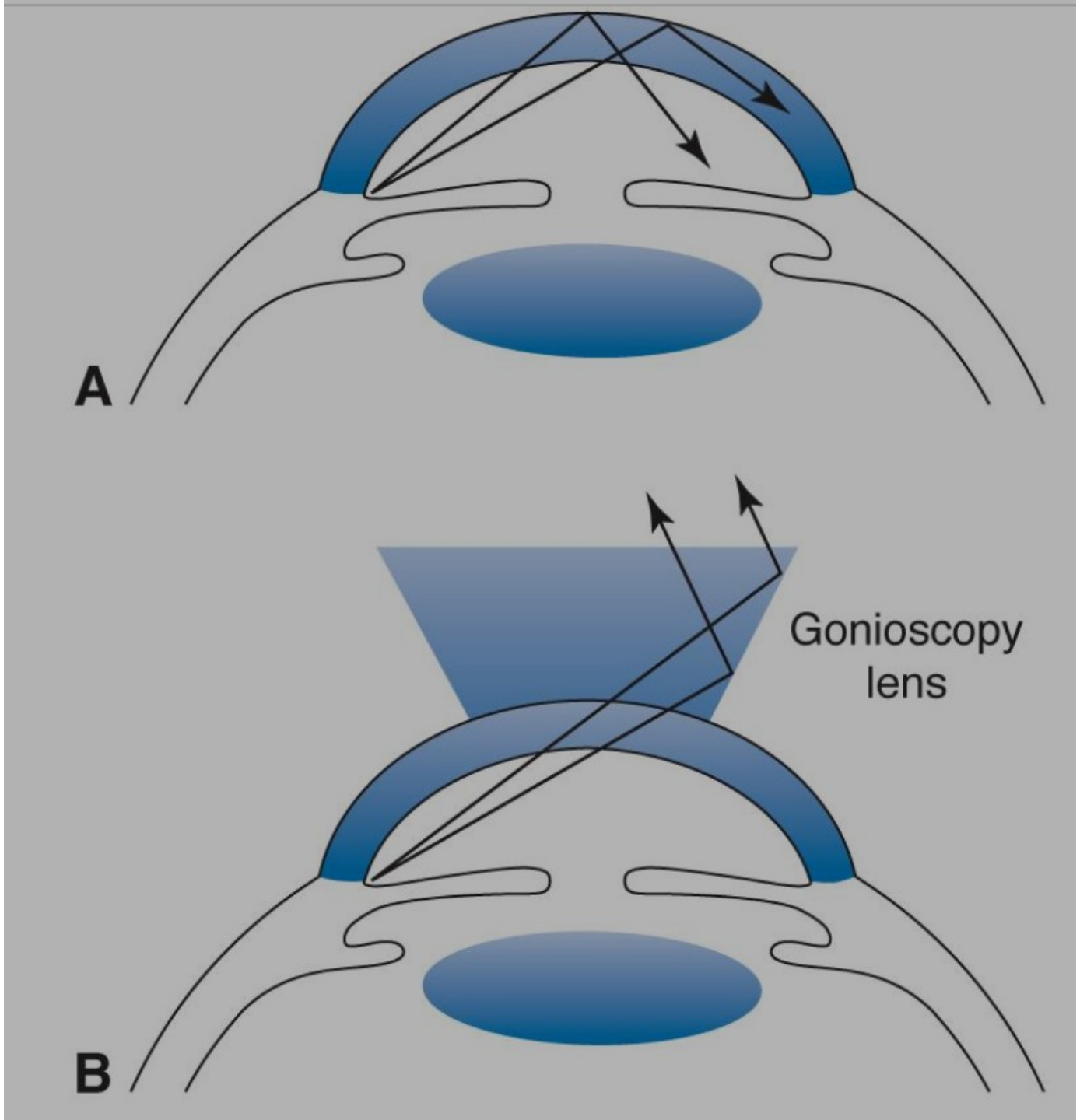


Gonioscopy

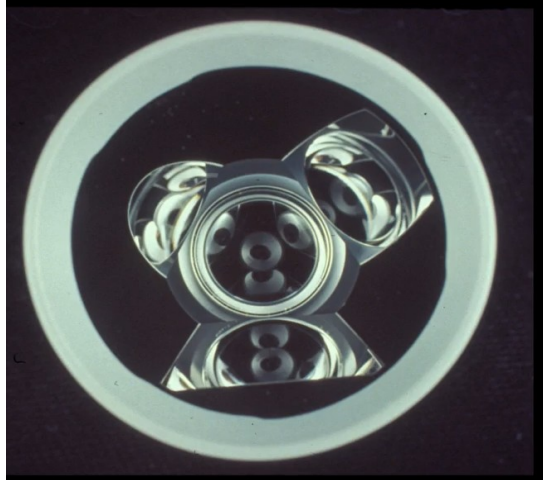
- Visualisation of the anterior chamber angle



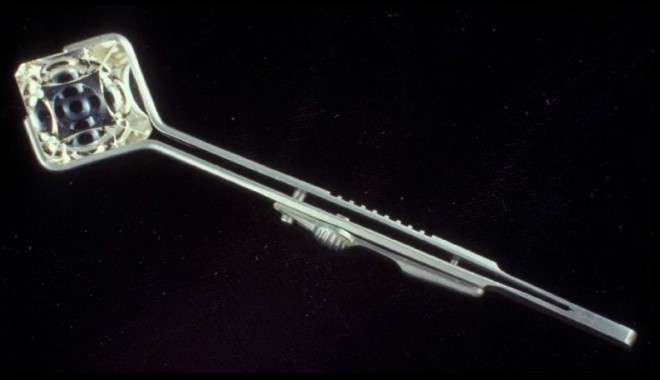

Air
n_2
n_1
Water
θ_2
Refracted ray
Incident ray
θ_1
Critical angle
θ_c
Total internal reflection
θ_1
θ_2


A
Gonioscopy
lens
B

Indirect Gonioscopy Lenses



Goldmann-style



Zeiss-style

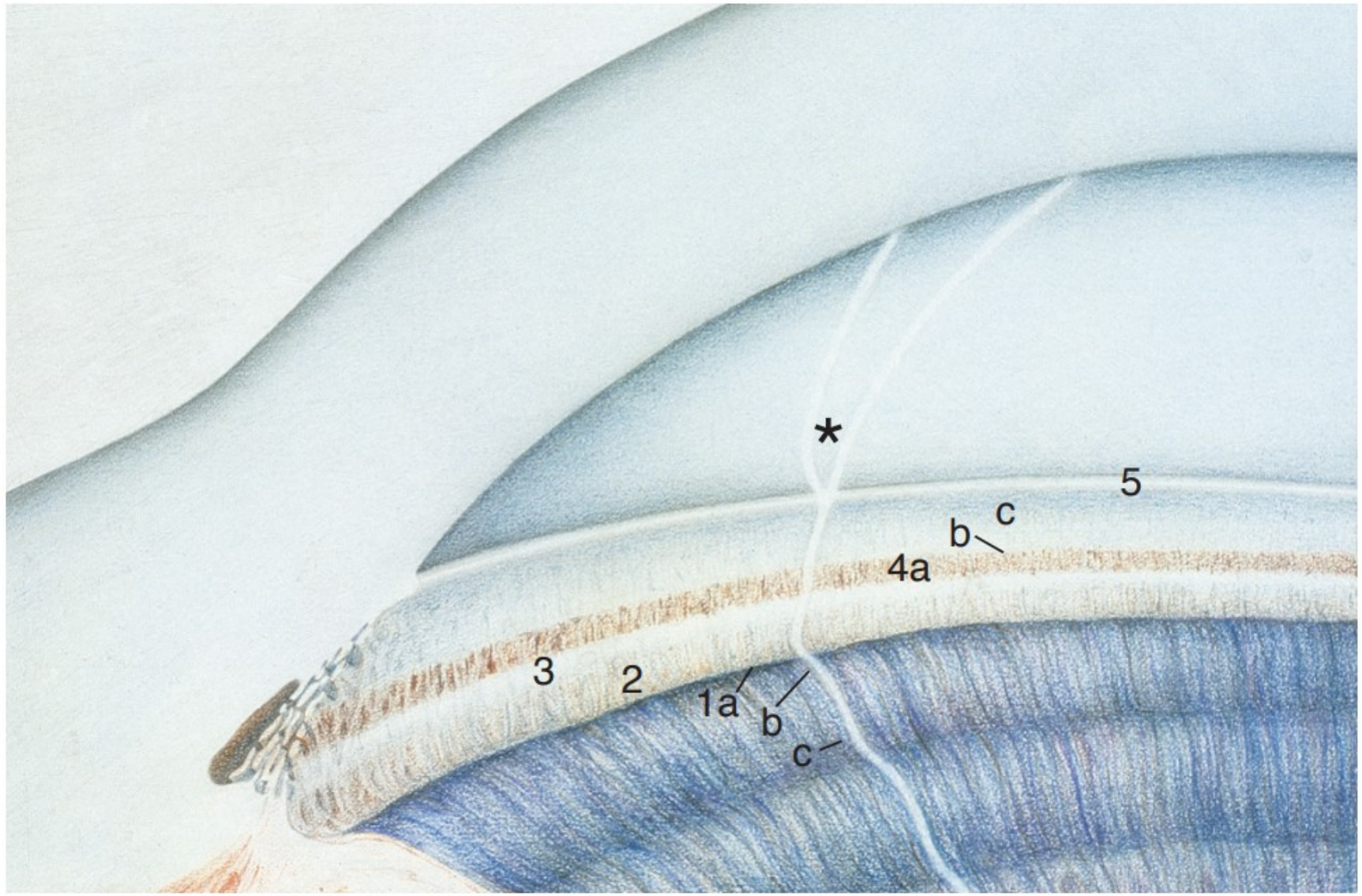


Figure 3-1 Gonioscopic appearance of a normal anterior chamber angle. *1,* Peripheral iris: *a,* insertion; *b,* curvature; *c,* angular approach. *2,* Ciliary body band. *3,* Scleral spur. *4,* Trabecular meshwork: *a,* posterior; *b,* mid; *c,* anterior. *5,* Schwalbe line. *Asterisk,* Corneal optical wedge.

Spaeth grading system

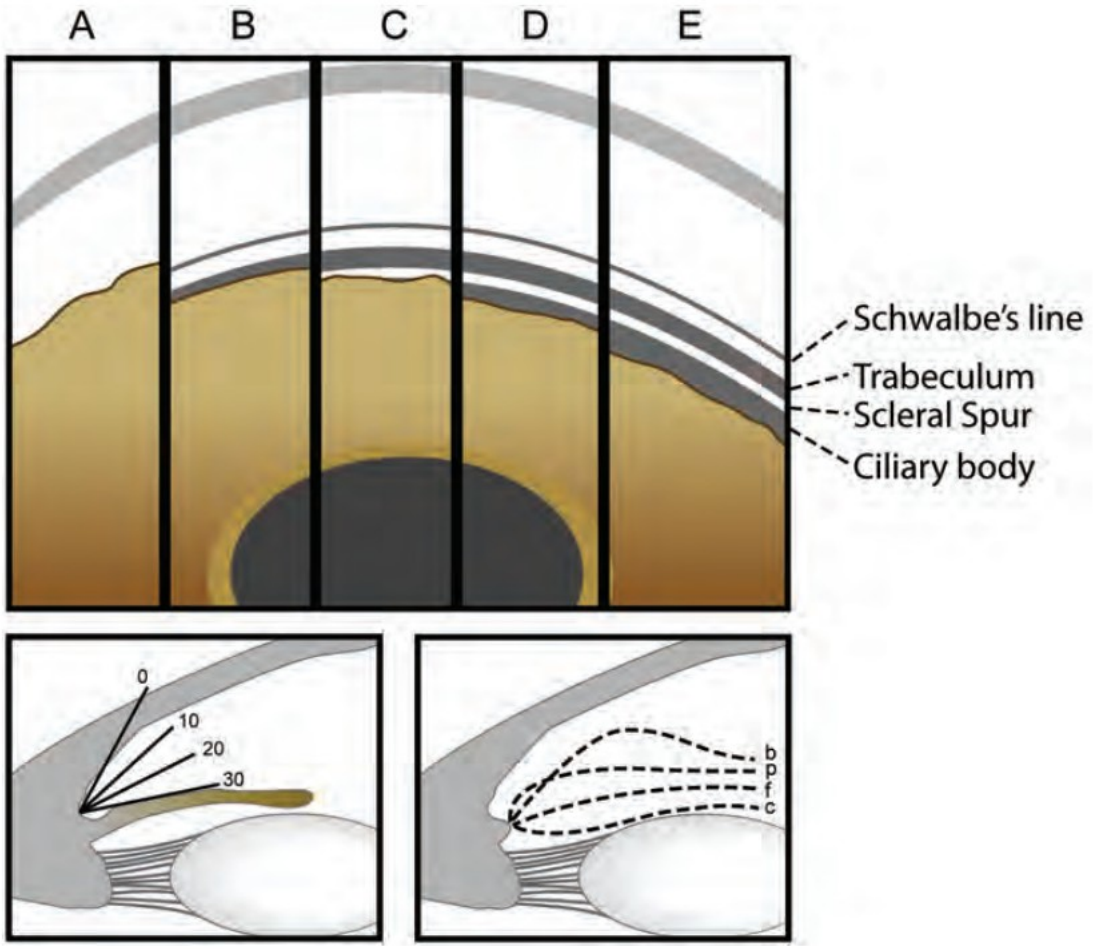


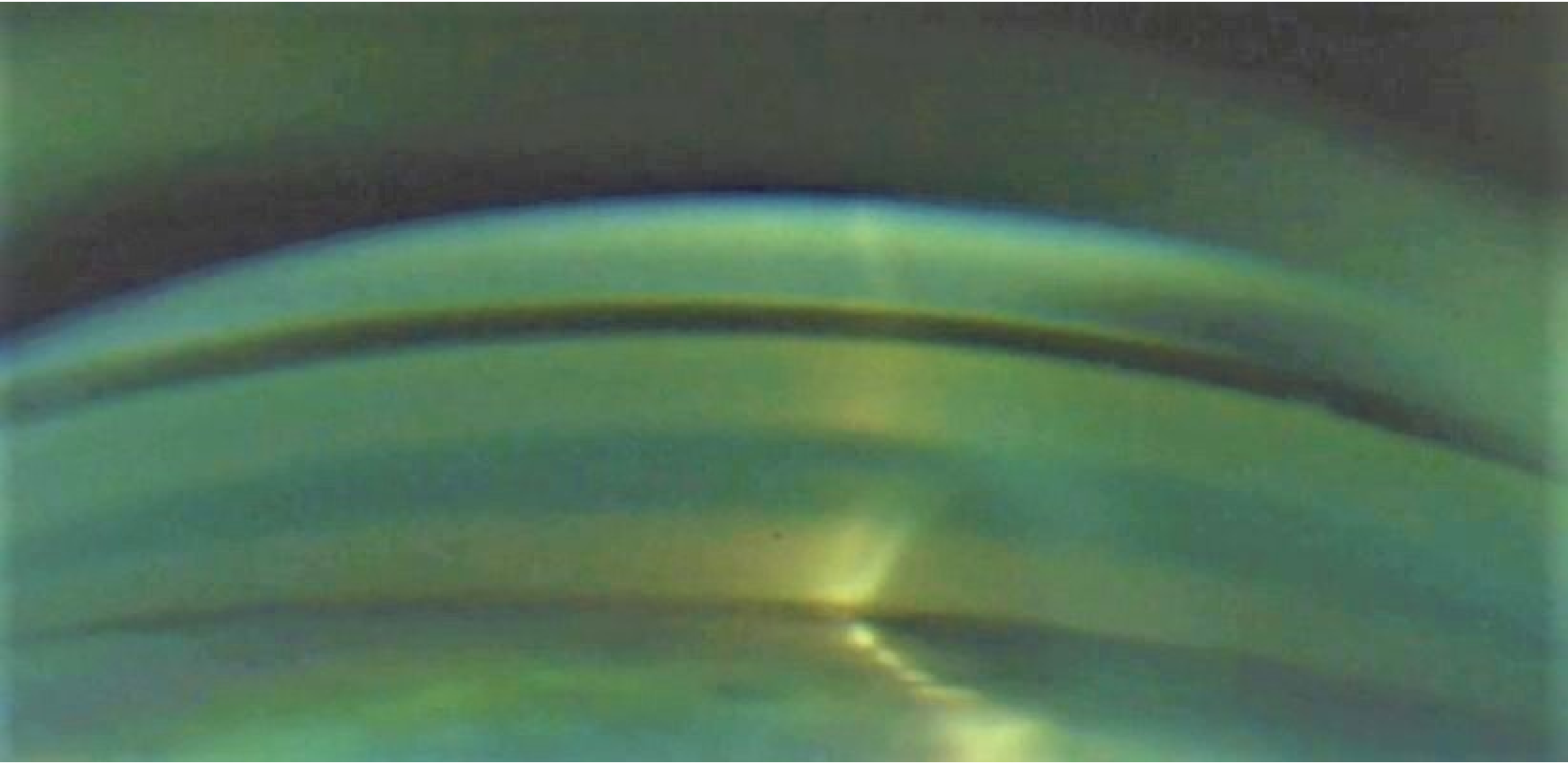
FIGURE A.14.1. Spaeth angle classification.

TABLE 4. SPAETH GONIOSCOPIC GRADING SYSTEM*

Iris Insertion	Angular Approach	Peripheral Iris		Pigmentation of Trabecular Meshwork
A Anterior to Schwalbe's line	0° to 50°	**r** regular	**f** flat	**0** no pigment
B Between Schwalbe's line and scleral spur		**s** steep	**b** bowed anteriorly	**1+** minimal
C Scleral spur visible			**p** plateau iris	**2+** mild
D Deep with ciliary body visible		**q** queer	**c** concave	**3+** moderate
E Extremely deep with >1 mm of ciliary body visible				**4+** intense

** Evaluating iris insertion, angular approach, peripheral iris configuration, and degree of trabecular meshwork pigmentation.*

Pigmentary glaucoma: E60c 4+ ptm



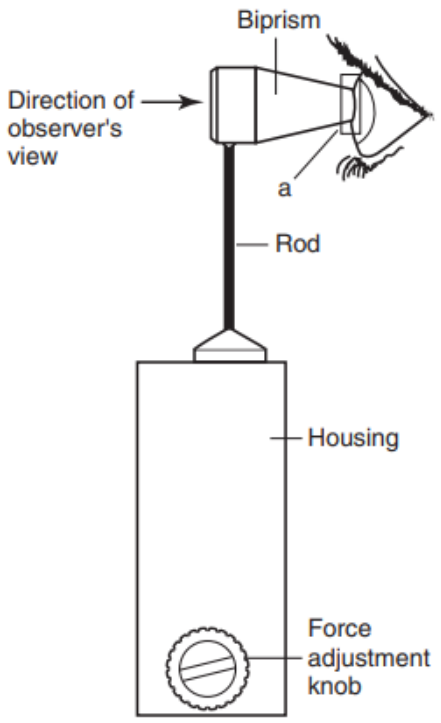
IOP MEASUREMENT - „NORMAL“ IOP?

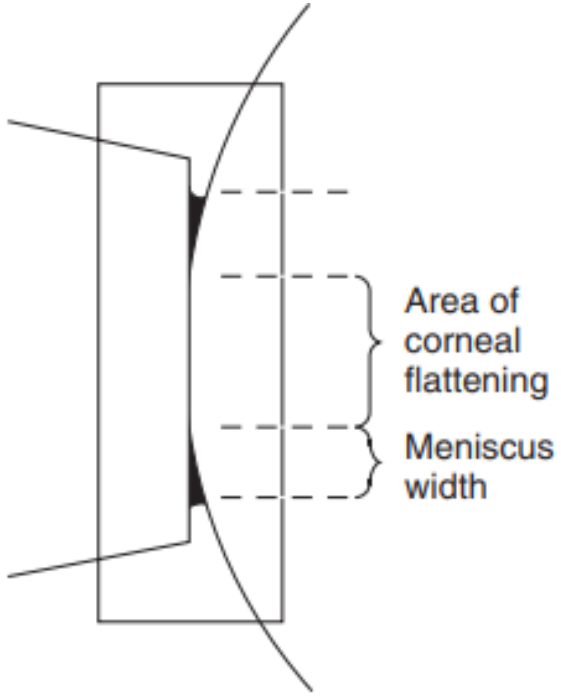
- in the general population of Europe: approximately 15.5 mm Hg, with a standard deviation of 2.6 mm Hg
- Circadian variation: IOP varies by 2–6 mm Hg over a 24-hour period, peak is indvidual, often in the morning
- High IOP is often first sign of glaucoma
- factors that may increase intraocular pressure:
  - Playing a wind instrument, Valsalva maneuver, Blepharospasm, Corticosteroids…
- Factors that may decrease intraocular pressure
  - Pregnancy, alcohol, cannabis, aerobic exercise…

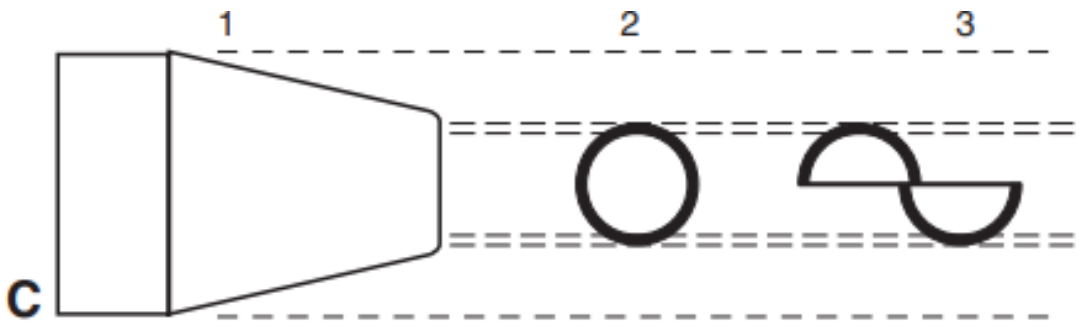
IOP measurement

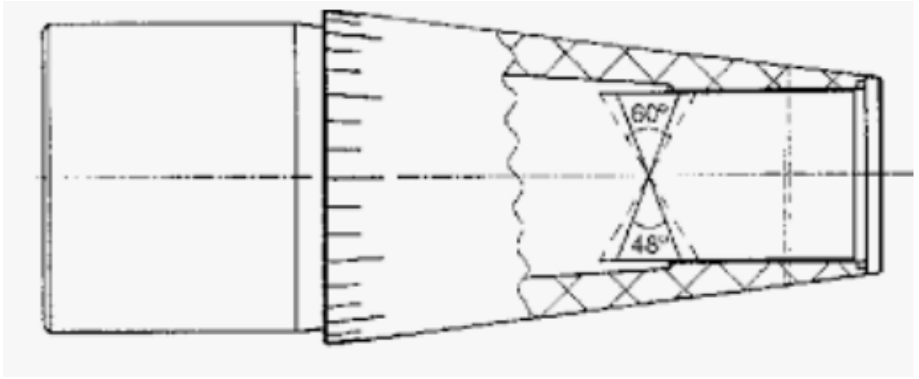
European Glaucoma Society
Innovation, Education, Communication, Implementation

- Goldmann applanation tonometer
  - the most widely used method
  - Imbert-Fick principle: pressure inside an ideal dry, thin-walled sphere equals the force necessary to flatten its surface divided by the area of the flattening
  - Circular menisus is converted into 2 semicircles by the prism









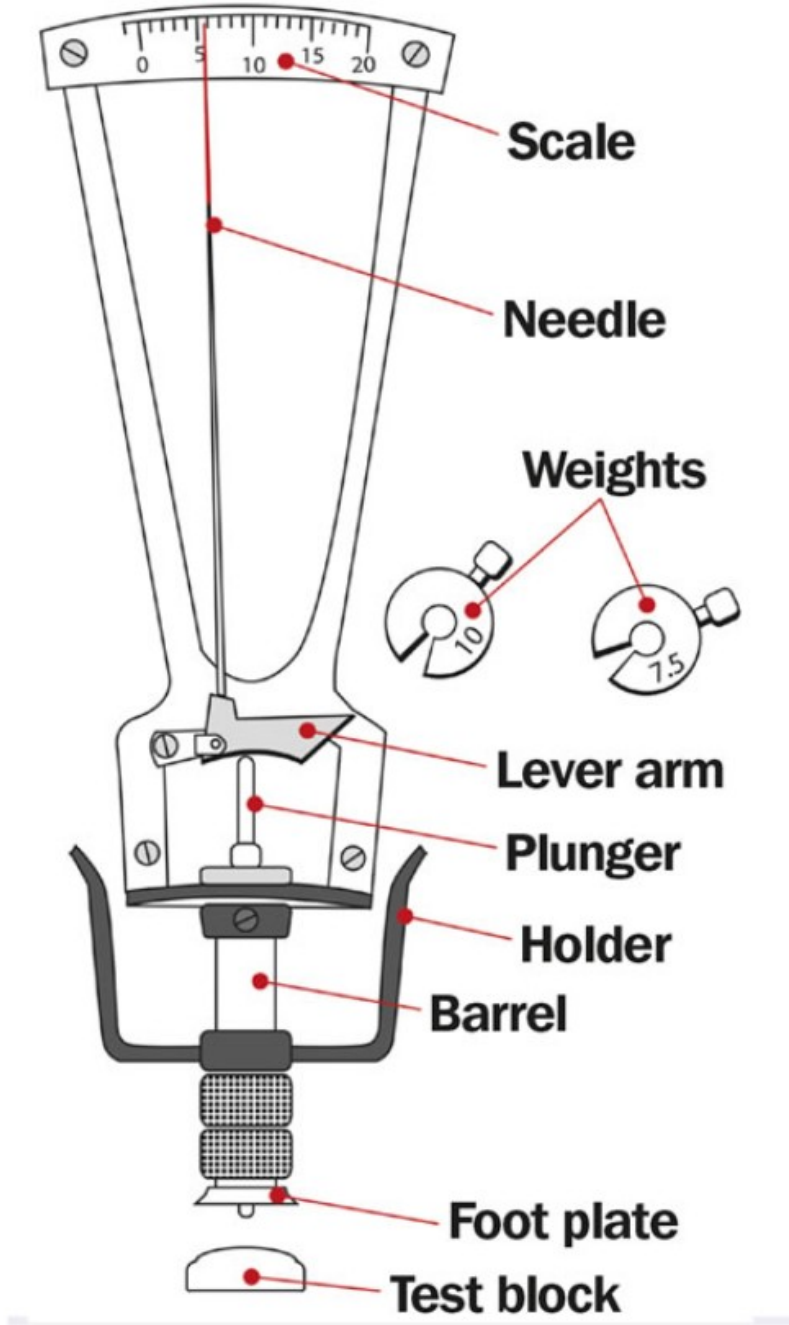
Aplanation tonometry - video

- https://www.youtube.com/watch?v=KOHe9wzM4ns&embeds_euri=https%3A%2F%2Fhubblecontent.osi.office.net%2F&source_ve_path=MjM4NTE&feature=emb_title&ab_channel=EyeDoc

IOP measurement

- Noncontact (air-puff) tonometers
  - measuring the force of air required to indent the cornea to a fixed point
  - Pachymetry
  - Corneal hysteresis
  - Advantage: no risk of infection, no need of local anesthaesia
  - Disadvantage: less accurate
- Schiøtz tonometry
  - The amount of indentation is read on a linear scale on the instrument and converted to mm Hg by a calibration table
  - Due to a number of practical and theoretical problems, Schiøtz tonometry is now **rarely used in the developed world**.


NIDEK


0
5
10
15
20
Scale
Needle
Weights
10
7.5
Lever arm
Plunger
Holder
Barrel
Foot plate
Test block

Perimetry

- Kinetic perimetry
  - Older method, still used in terminal cases
- Static (computer) perimetry
  - More accurare
  - Absolute/relative scotomas
  - Usually takes several tries to learn
  - Indicates false positive, false negative responses and fixation loss
  - Special glucoma indexes and evaluation (GHT, MD..) to map the progression

OD
full field
120p

Eye: Right

Name: DOB:
ID:

Full Field 120 Point Screening Test

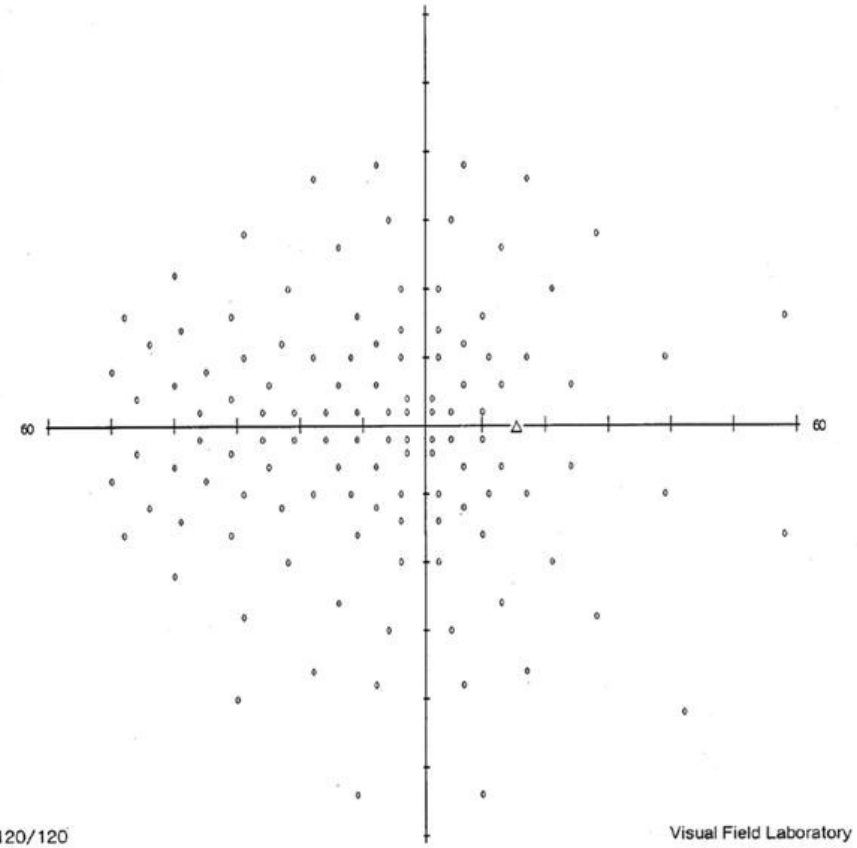
Fixation Monitor: Gaze/Blind Spot
Fixation Target: Central
Fixation Losses: 0/13
False POS Errors: 0/11
False NEG Errors: 0/11
Test Duration: 04:26

Stimulus: III, White
Background: 31.5 ASB
Strategy: Three Zone
Test Mode: Age Corrected

Pupil Diameter: 6.2 mm
Visual Acuity:
RX: DS DC X

Date: 05-16-2008
Time: 10:26 AM
Age:

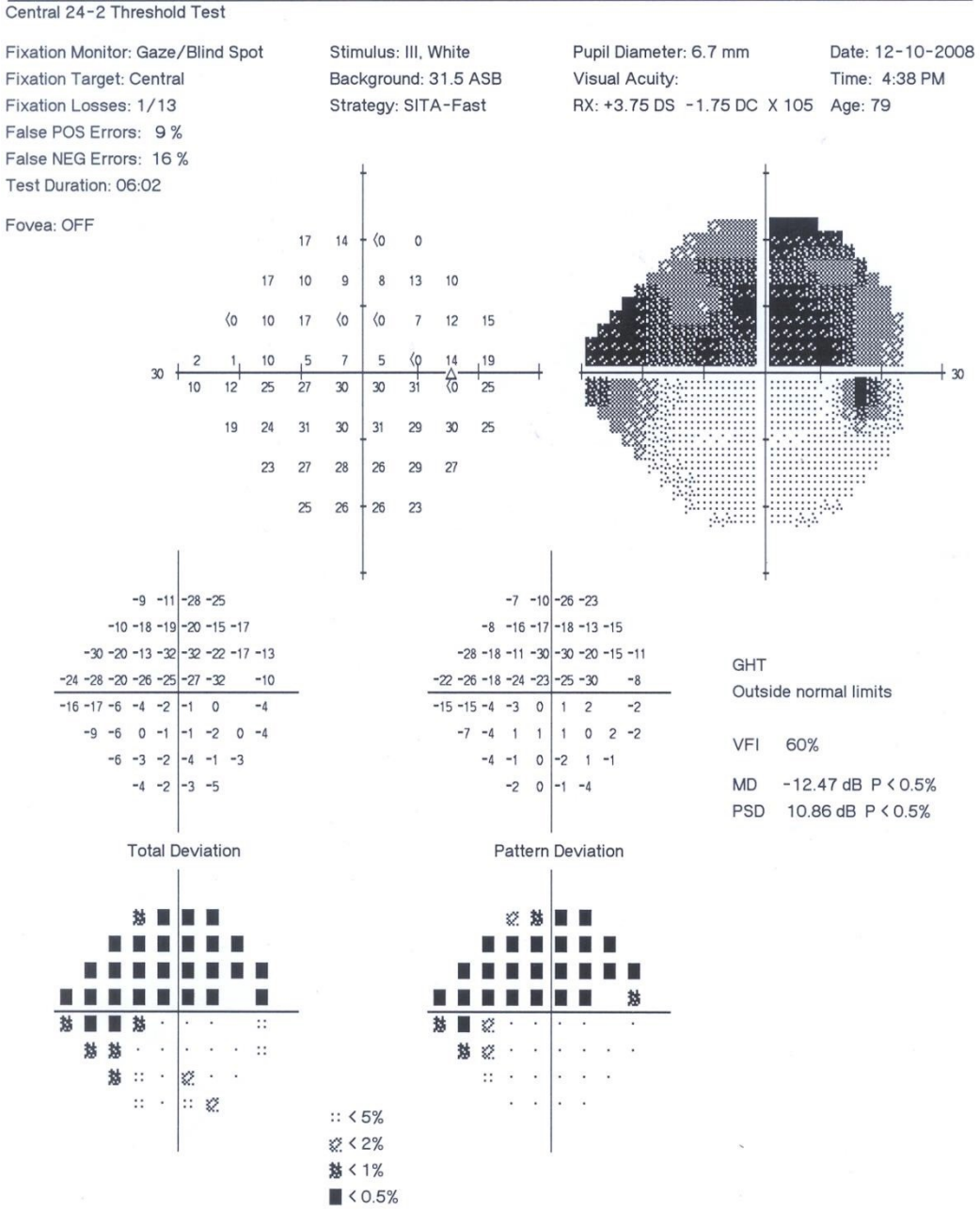
Central Reference: 32 dB
Peripheral Reference: 32 dB



o Seen 120/120
x Defect 0/120
▪ Not Seen 0/120
△ Blind Spot

Visual Field Laboratory
University of Iowa
College of Medicine
Iowa City, IA
(319) 356-1611

OD threshold 24-2

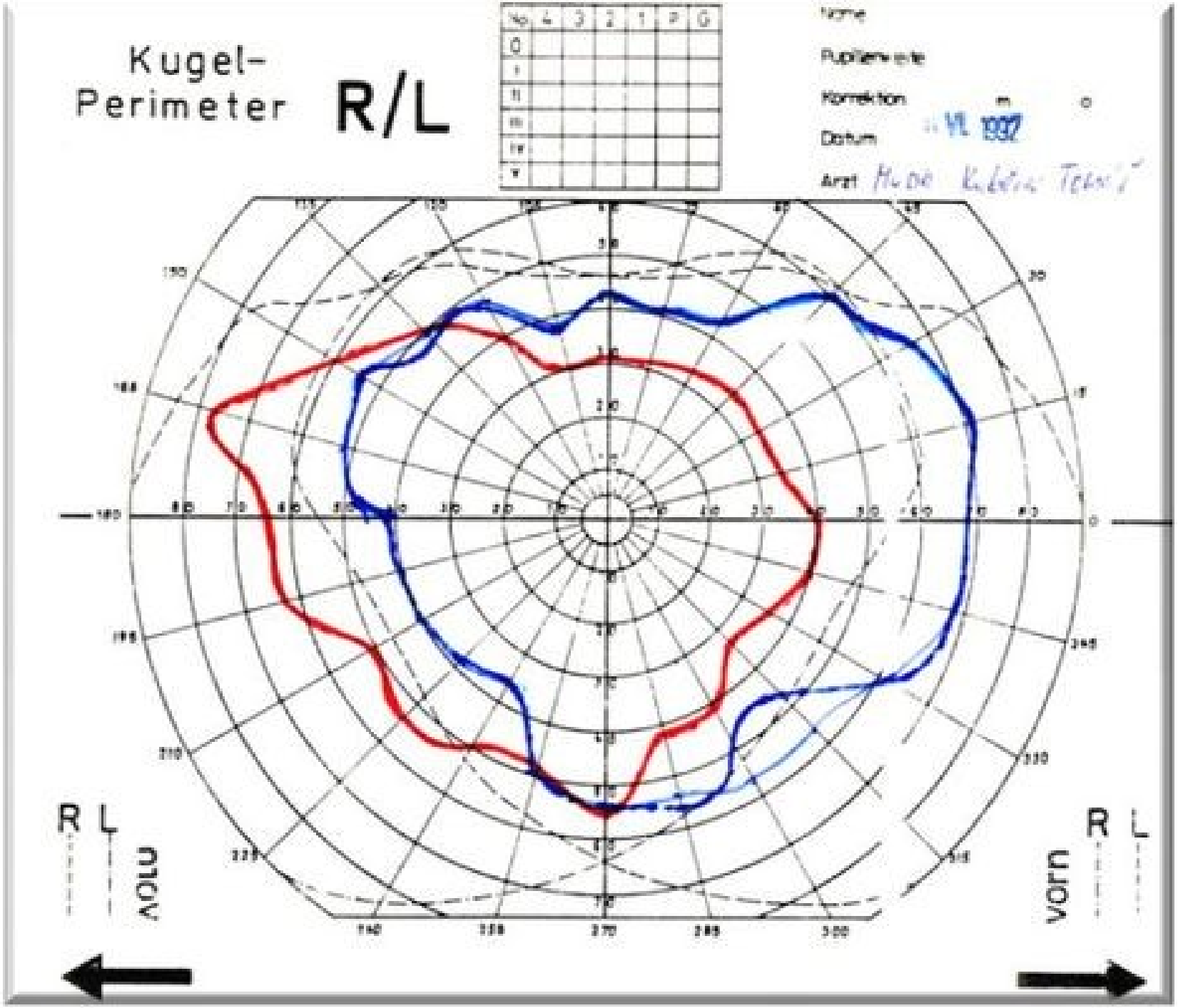


BLIND SPOT

RELATIVE SCOTOMA

ABSOLUTE SCOTOMA

NORMAL SENSITIVITY

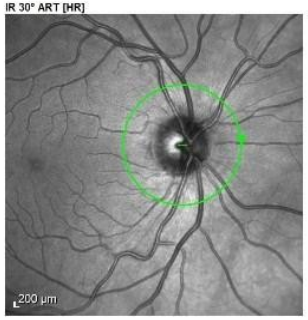

Kugel-
Perimeter
R/L
Name
Pupillenweite
Korrektion
Datum
Arzt
R L
AOLU
vorn
R L

Imaging

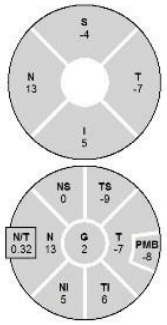
Patient ID: ---
Diagnosis: ---
Exam.: 24.10.2012
Comment: ---

OD

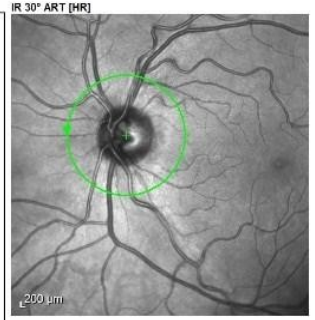
IR 30° ART [HR]



Asymmetry
OD - OS

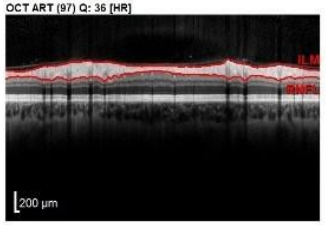


IR 30° ART [HR]

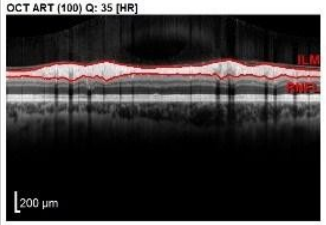


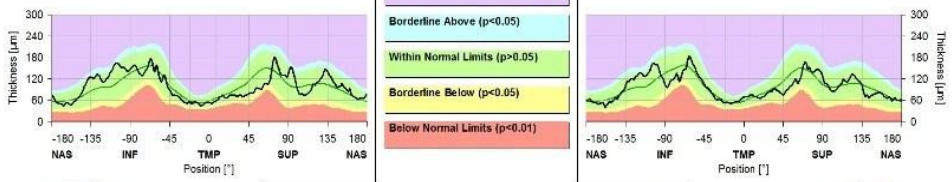
OS

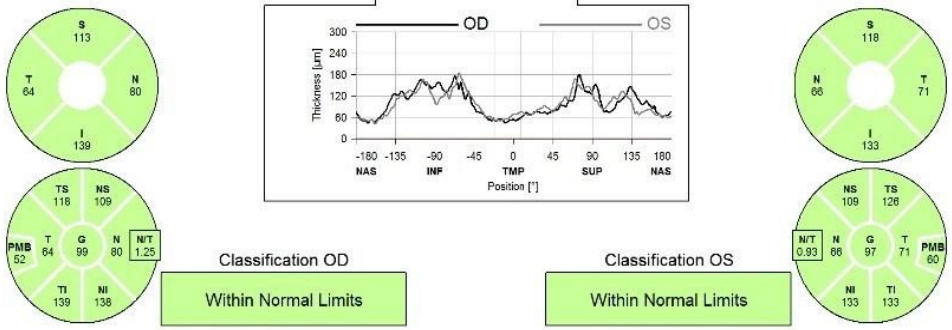
OCT ART (97) Q: 36 [HR]



OCT ART (100) Q: 35 [HR]







Classification OD

Within Normal Limits

Classification OS

Within Normal Limits

Notes:

Date: 9.11.2015 Signature:

Software Version: 5.8.3 *www.HeidelbergEngineering.com* *Axonal Single Exam Report OU with FoDi™*

Oční ordinace MUDr. Tomáš Kuběna, s.r.o.
U zimního stadionu 1758, 760 01 Zlín, tel. 57 74 38 180
e-mail: tomas@kubena.cz http:// www.kubena.cz

HEIDELBERG ENGINEERING

Patient:
Pat-ID:
DOB:
Gender: female
Examination:
Ethnicity: (Caucasian)

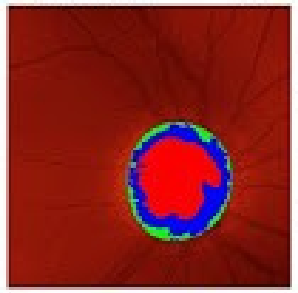
Quality: Excellent (SD 8 µm)
Focus: -2.00 dpt
Operator: ---

Initial Report

Quality: Excellent (SD 10 µm)
Focus: -1.00 dpt
Operator: ---

OD OS

Disc Size: 2.70 mm² (large)



CUP

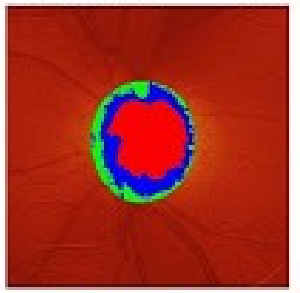
Linear Cup/Disc Ratio [ ]

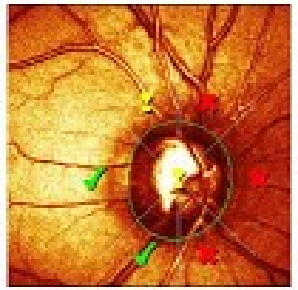
0.70 ✓	Asymmetry ✓ 0.02	0.68 ✓
p = 0.14	p = 0.32	p = 0.18

Cup Shape Measure [ ]

-0.09 ✓	Asymmetry ✓ 0.06	-0.15 ✓
p = 0.1	p = 0.15	p = 0.42

Disc Size: 2.69 mm² (large)





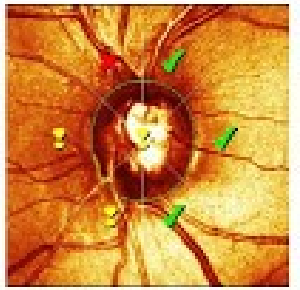
RIM

Rim Area [mm²]

1.37 ?	Asymmetry ✓ -0.07	1.44 ?
p = 0.003	p = 0.36	p = 0.01

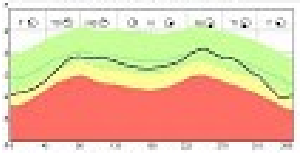
Rim Volume [mm³]

0.34 ✓	Asymmetry ✓ -0.06	0.42 ✓
p = 0.12	p = 0.18	p = 0.38



MRA: Outside normal limits

MRA: Outside normal limits

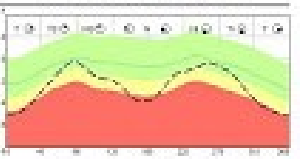


RNFL Profile

RNFL

Height Variation Contour [mm]

0.45 ✓	Asymmetry ✓ -0.03	0.48 ✓
p > 0.5	p = 0.2	p > 0.5

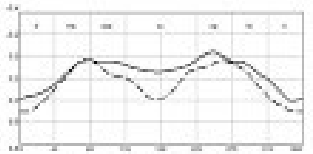


RNFL Profile

Mean RNFL Thickness [mm]

0.30 ✓	Asymmetry ✓ -0.01	0.31 ✓
p > 0.5	p = 0.3	p > 0.5

Inter-Eye Asymmetry	9 %

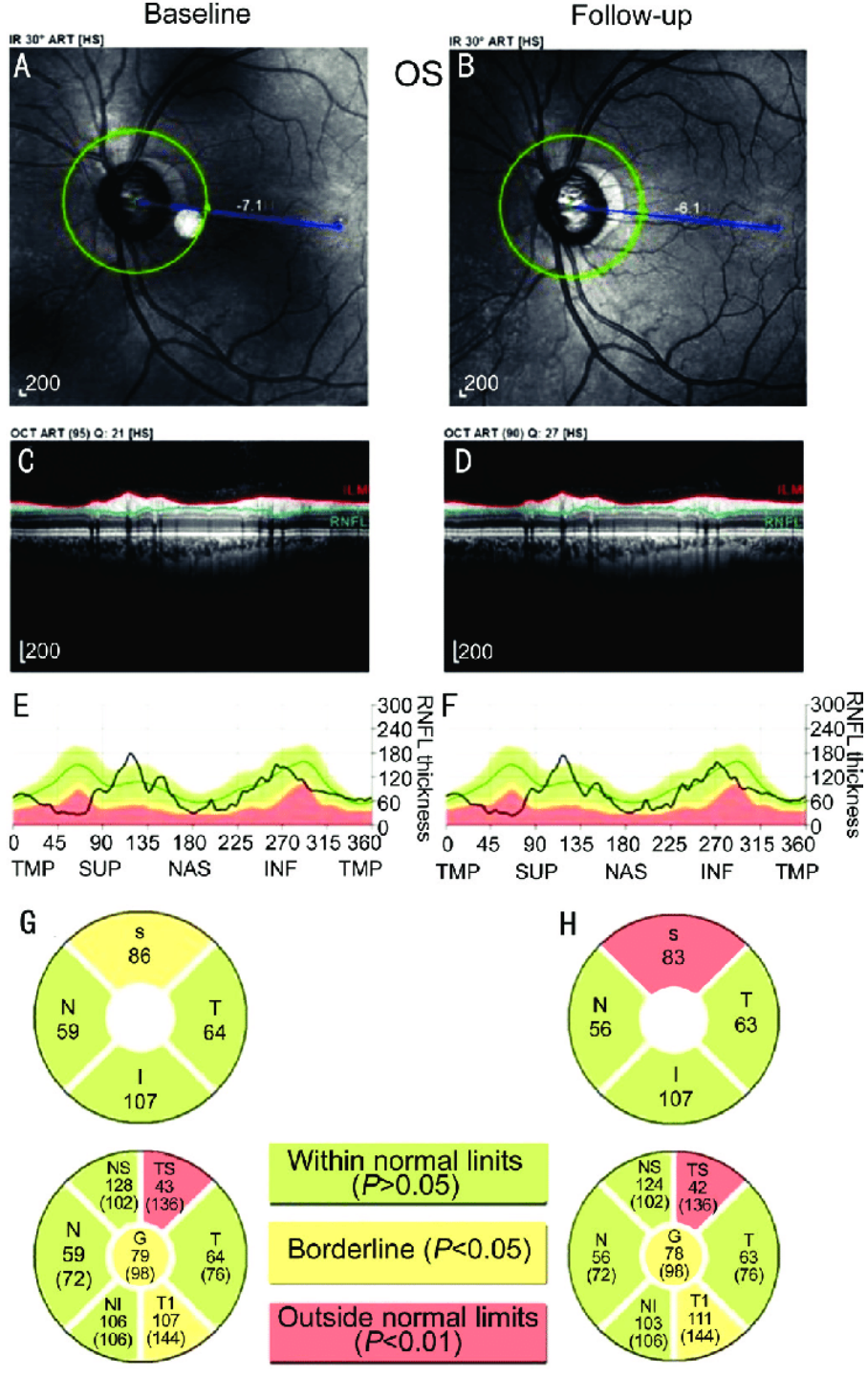


Combined RNFL Profile

Comments:

Signature:
Date: 20.12.2010

Software Version: 3.2.0.0
www.HeidelbergEngineering.com


Baseline
Follow-up
OS
A
B
C
D
E
F
G
H
IR 30° ART [HS]
OCT ART (95) Q: 21 [HS]
OCT ART (90) Q: 27 [HS]
200
ILM
RNFL
-7.1
-6.1
RNFL thickness
300
240
180
120
60
0
0 45 90 135 180 225 270 315 360
TMP SUP NAS INF TMP
s 86
N 59
T 64
I 107
NS 128 (102)
TS 43 (136)
G 79 (98)
NI 106 (106)
T1 107 (144)
N 59 (72)
T 64 (76)
s 83
N 56
T 63
I 107
NS 124 (102)
TS 42 (136)
G 78 (98)
NI 103 (106)
T1 111 (144)
N 56 (72)
T 63 (76)
Within normal limits (P>0.05)
Borderline (P<0.05)
Outside normal limits (P<0.01)

Part 6: Therapy

Therapy = lowering IOP

- **Pharmacotherapy**
  - Antiglaucomatics
  - Neuroprotectin (Citikolin)
- **Surgery**
- **Laser therapy**

- Therapy selection depends on glaucoma type:
- Open angle
  - Pharmacotherapy
  - Surgery
- Angle closure
  - Surgery
  - Pharmacotherapy (pilocarpine)

Antiglaucomatics

- For local use
  - Monotherapy/combined therapy (**up to 4**)
- For systemic use
  - Carbonanhydrase inhibitors
    - decrease of aqueous humor production
    - CI: kidney/liver failure, gravidity
  - Osmotics
    - Vitreuous dehydratation – leads to retraction of iridocorneal diaphragma backwards – anterior chambre deepening)
    - CI: heart/kidney failure

Antiglaucomatics

- Prostaglandins
  - **Drug of first choice**
  - Used once a day (evening), long effect, best compliance, 30% IOP decrease
  - Mechanism – **higher outflow through uveoscleral pathway**
  - Contraindication: inflamation, surgery…

Antiglaucomatics

- Beta-blockers (nonselective)
  - Mechanism: **decrease of aqueous humor production** (vasoconstriction – beta 1 and 2 rcp)
  - Contraindications: arrhythmia, COPD, AB
  - 1-0-1

- Beta-1 selective betablockers

Antiglaucomatics

- Alpha-2 selective agonists
  - **decrease of aqueous humor production** (vasoconstriction in ciliary body), increase of uveoscleral outflow
  - CI: IMAO use, children

Antiglaucomatics

- Parasymphatomimetics (pilokarpine)
  - **Increase of a.h. outflow by contracting ciliary body**
  - **Increase of a.h. outflow by „angle opening“ (miosis)**
  - CI: uveitis, bradycardia, hypotension, recent heart attack, gastrintestinal ulcers, epilepsy, parkinson disease

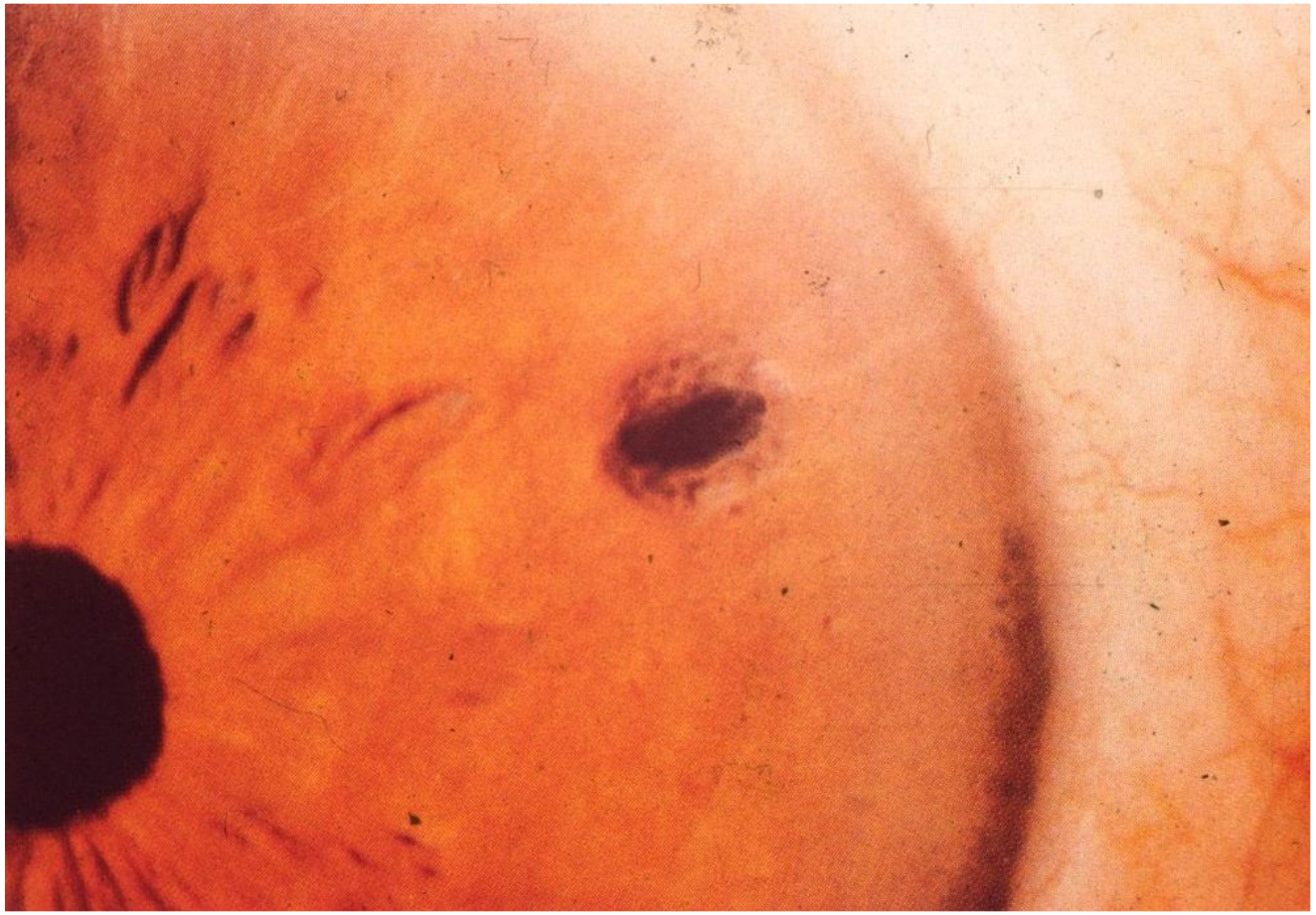
Antiglaucomatics

- Carboanhydrase inhibitors
  - **decrease of aqueous humor production** (CA is an enzyme in ciliary body processes)
  - CI: cornea diseases (endothelial cells decrease)

Antiglaucomatics

- RHO kinase inhibitors
  - New drugs, targeting TM
  - Unavailable in CZ

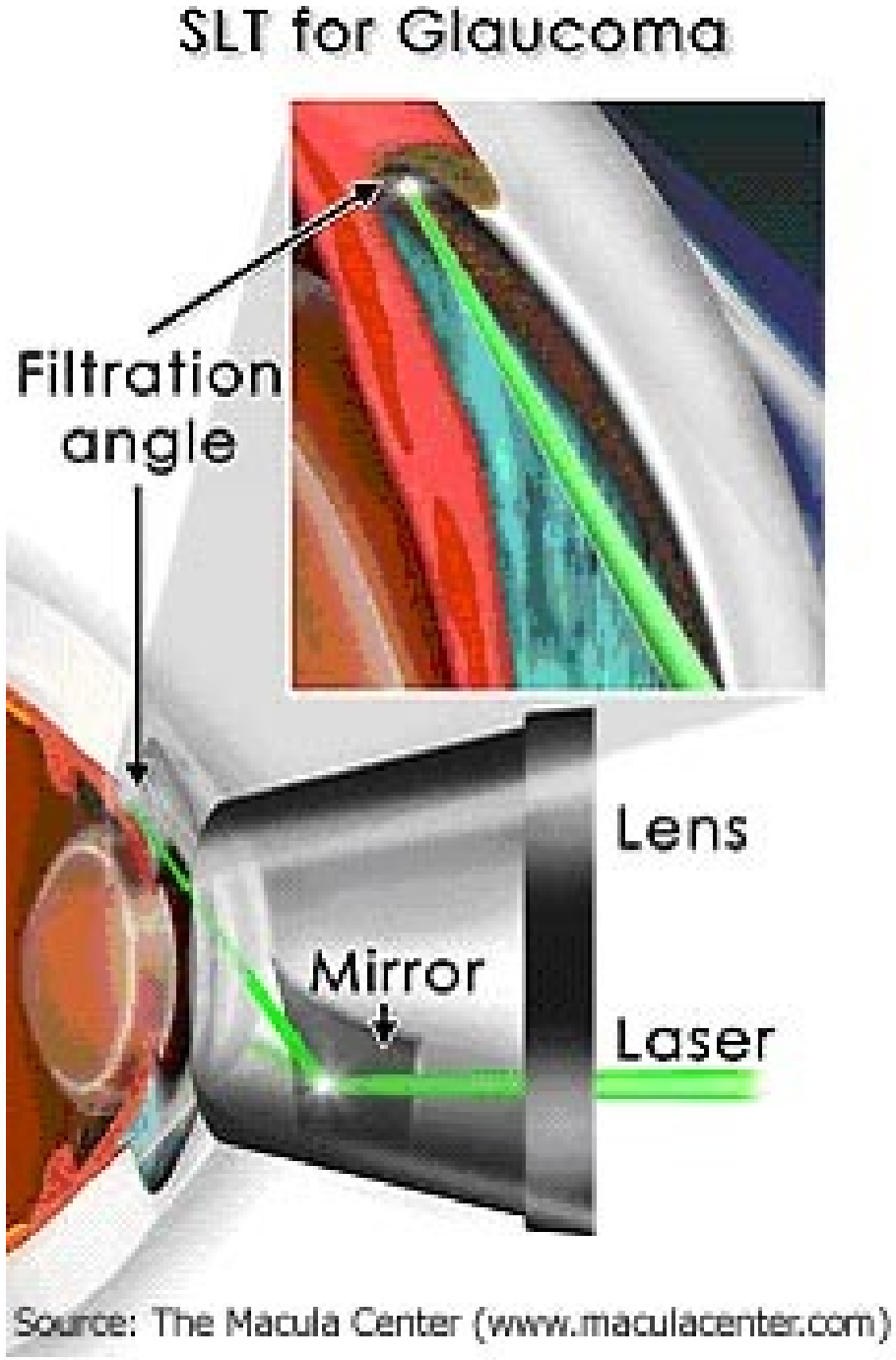
LASER THERAPY



LASER IRIDOTOMY

Laser trabeculoplasty

- Argon laser
- 50-100 strikes into the trabeculum in order to make it more permeable for a.h.
  - A space between the strikes is left intact so it opens a little

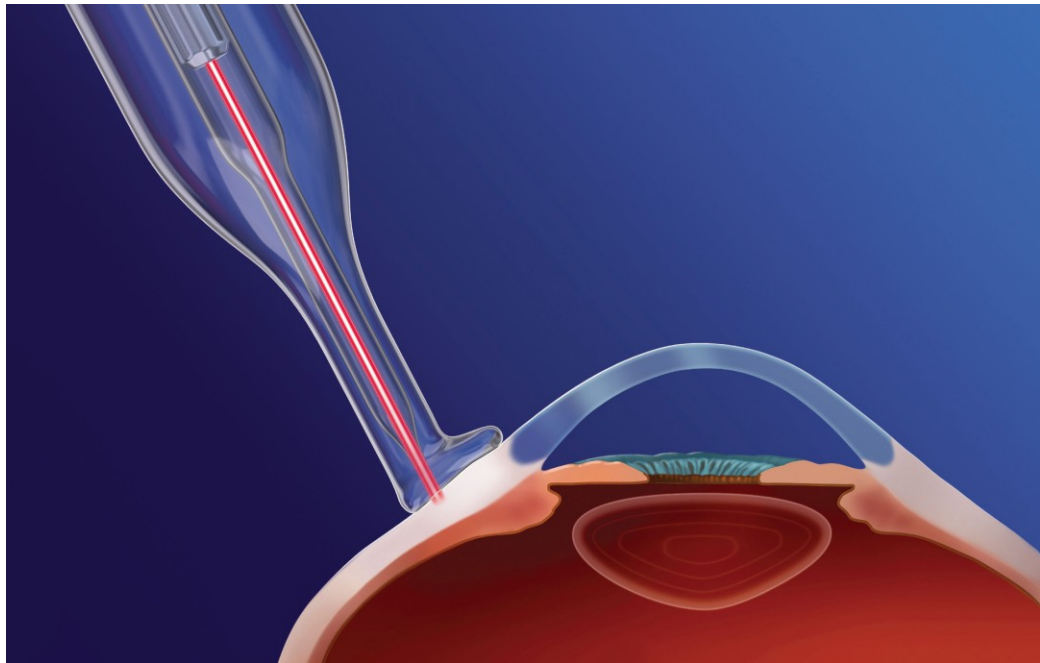


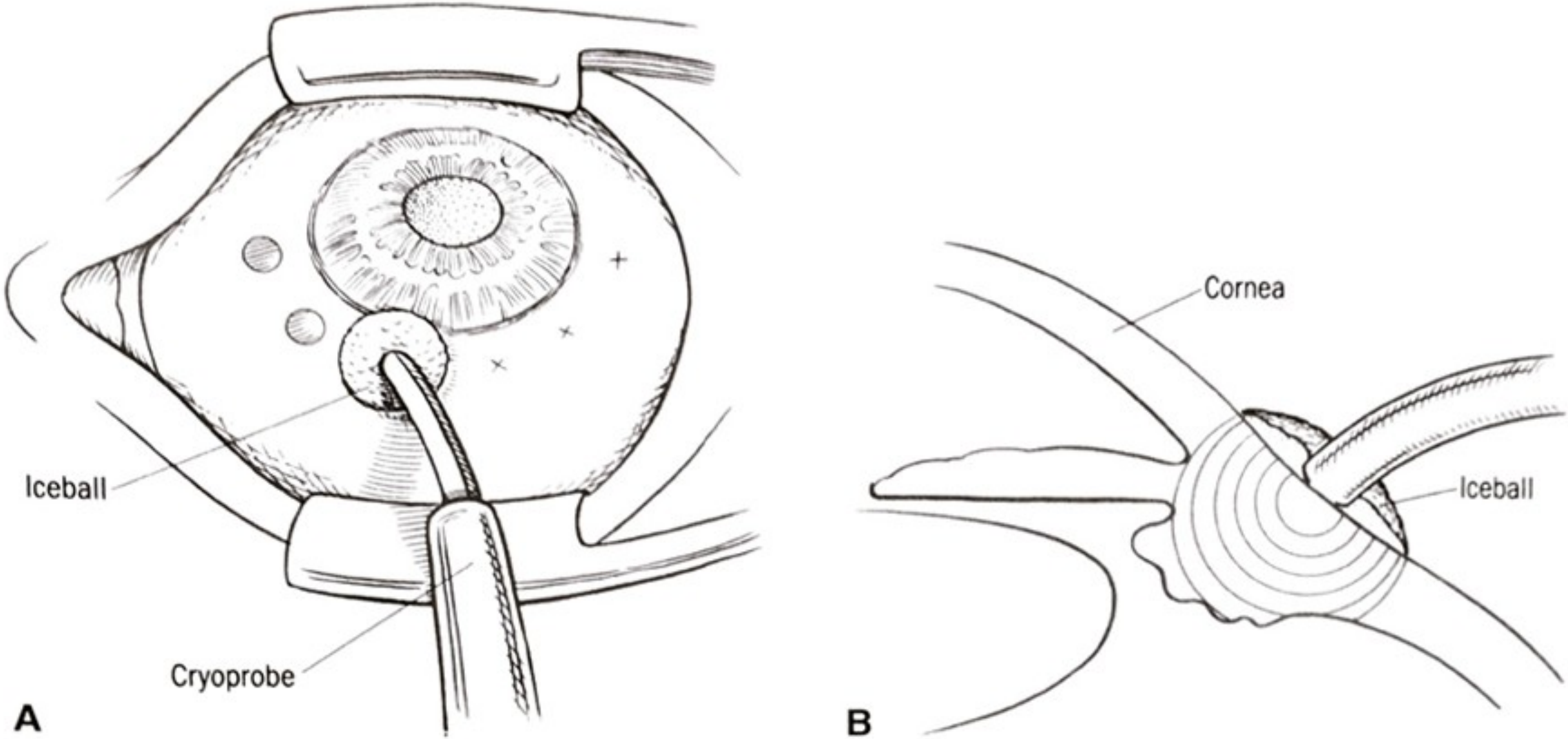
Cyclophotocoagulation

- a laser procedure that helps lower the eye pressure by targeting the part of the eye that produces fluid (ciliary processes)
  - Destroying part of the ciliary body by laser coagulation
  - Transscleral apliccation of laser beam
  - Indicated in most advanced cases with poor prognosis of vision

- Cyclocryocoagulation
  - Even stronger

- Retrobulbar alcohol application
  - Terminal cases



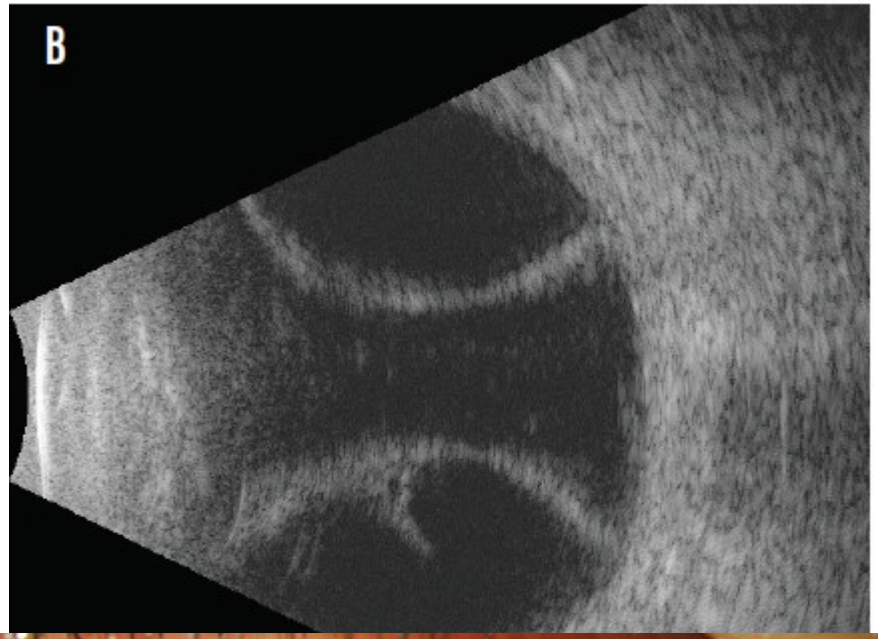

Iceball
Cryoprobe
A
Cornea
Iceball
B

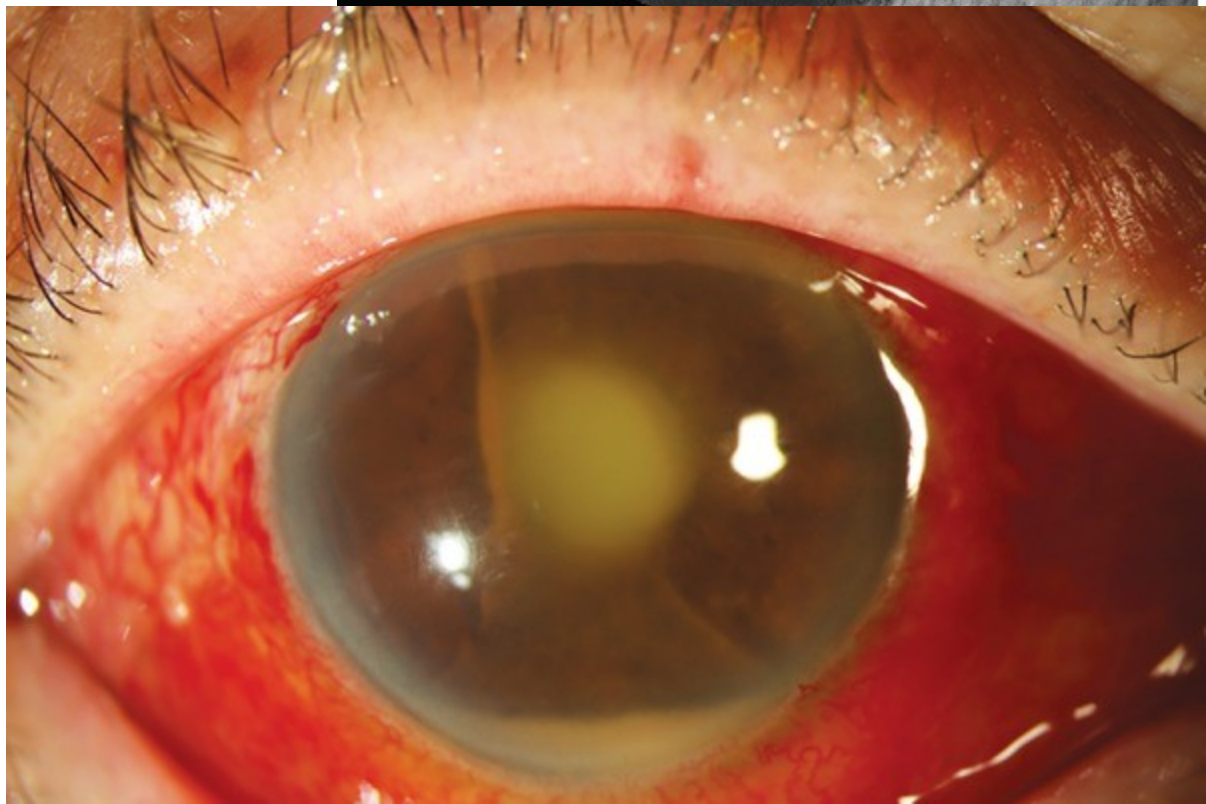
Cyklocryocoagulation - video

- https://www.youtube.com/watch?v=D5CRcJO3U9M

Surgery

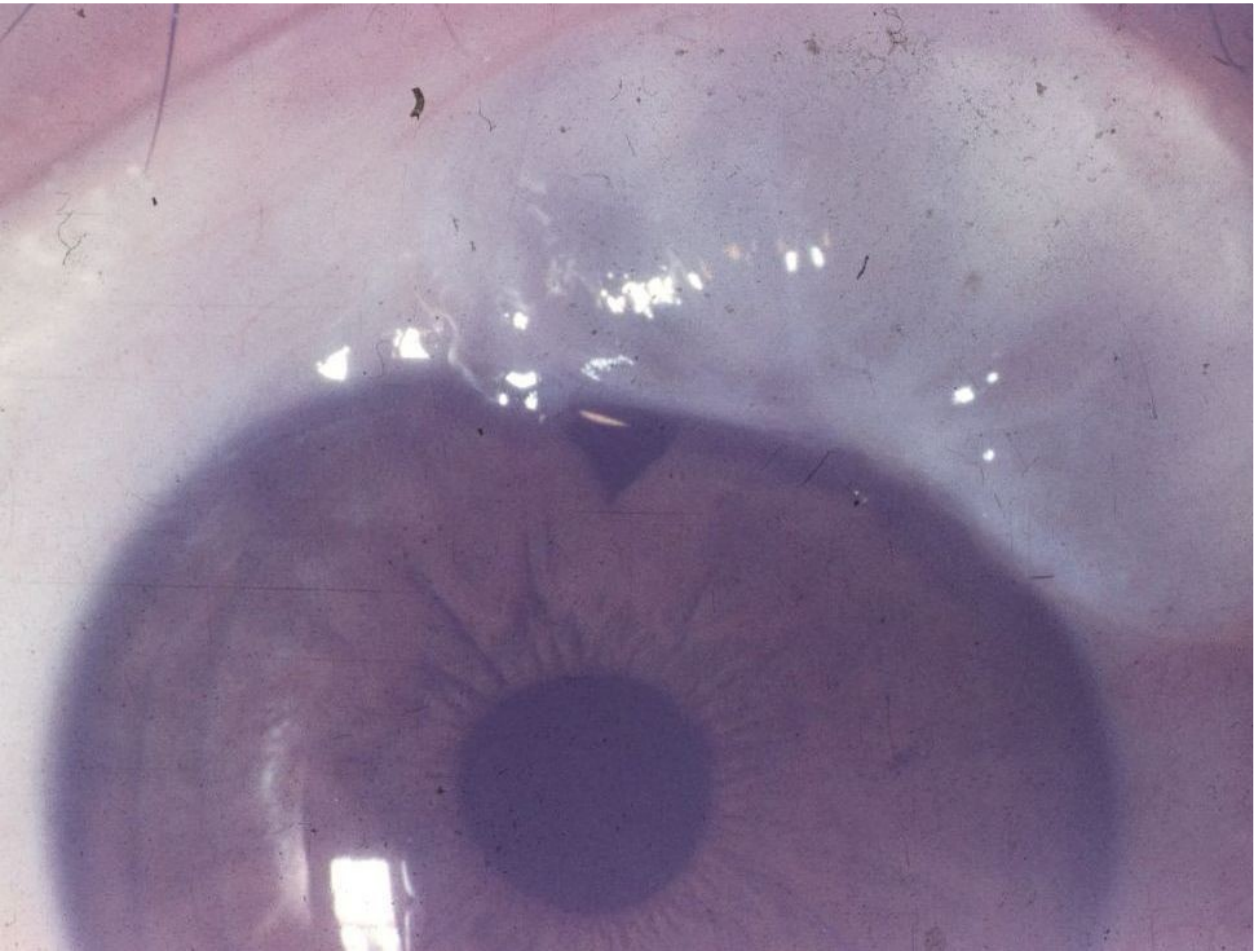
- Classical filtration surgery
  - Trabeculectomy
  - Filtration implants
  - Deep sclerectomy (non penetrating)
- MIGS
  - High safety profile
  - Minimal disruption of normal anatomy
  - Ab interno approach

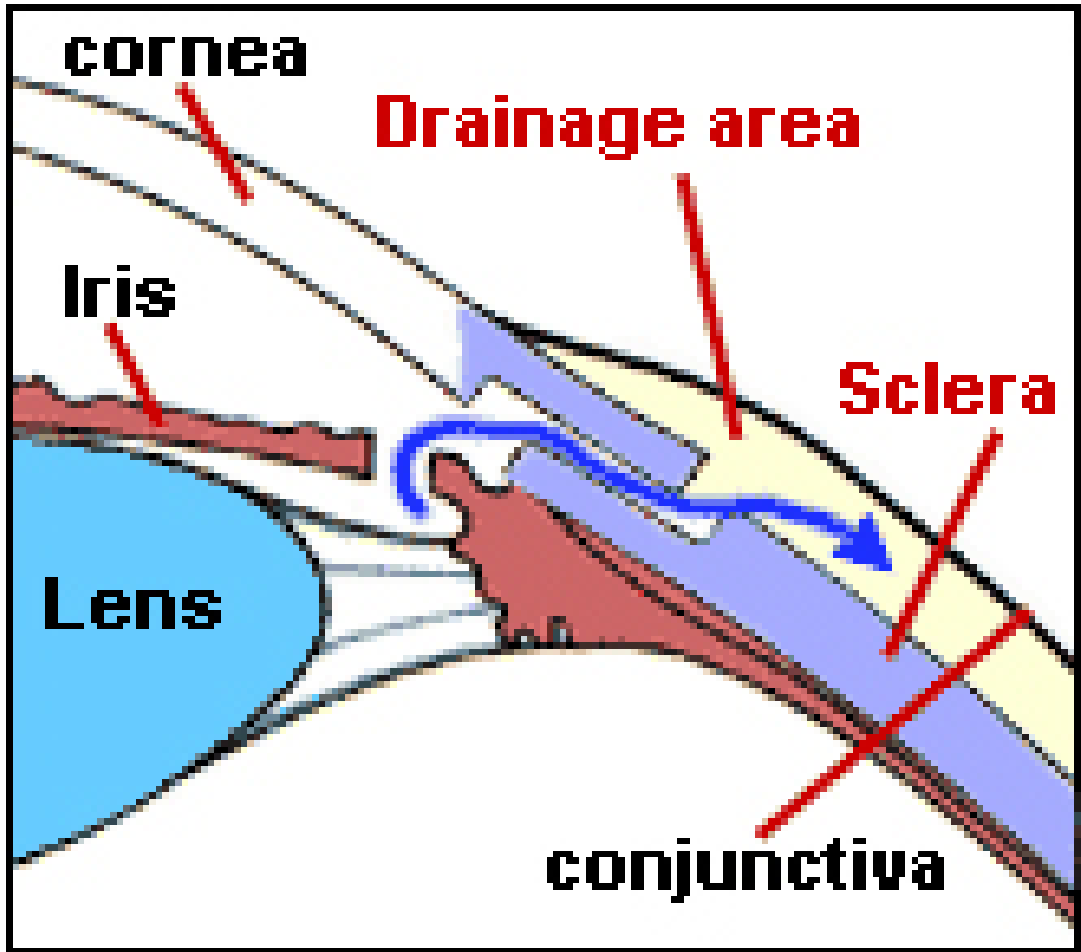




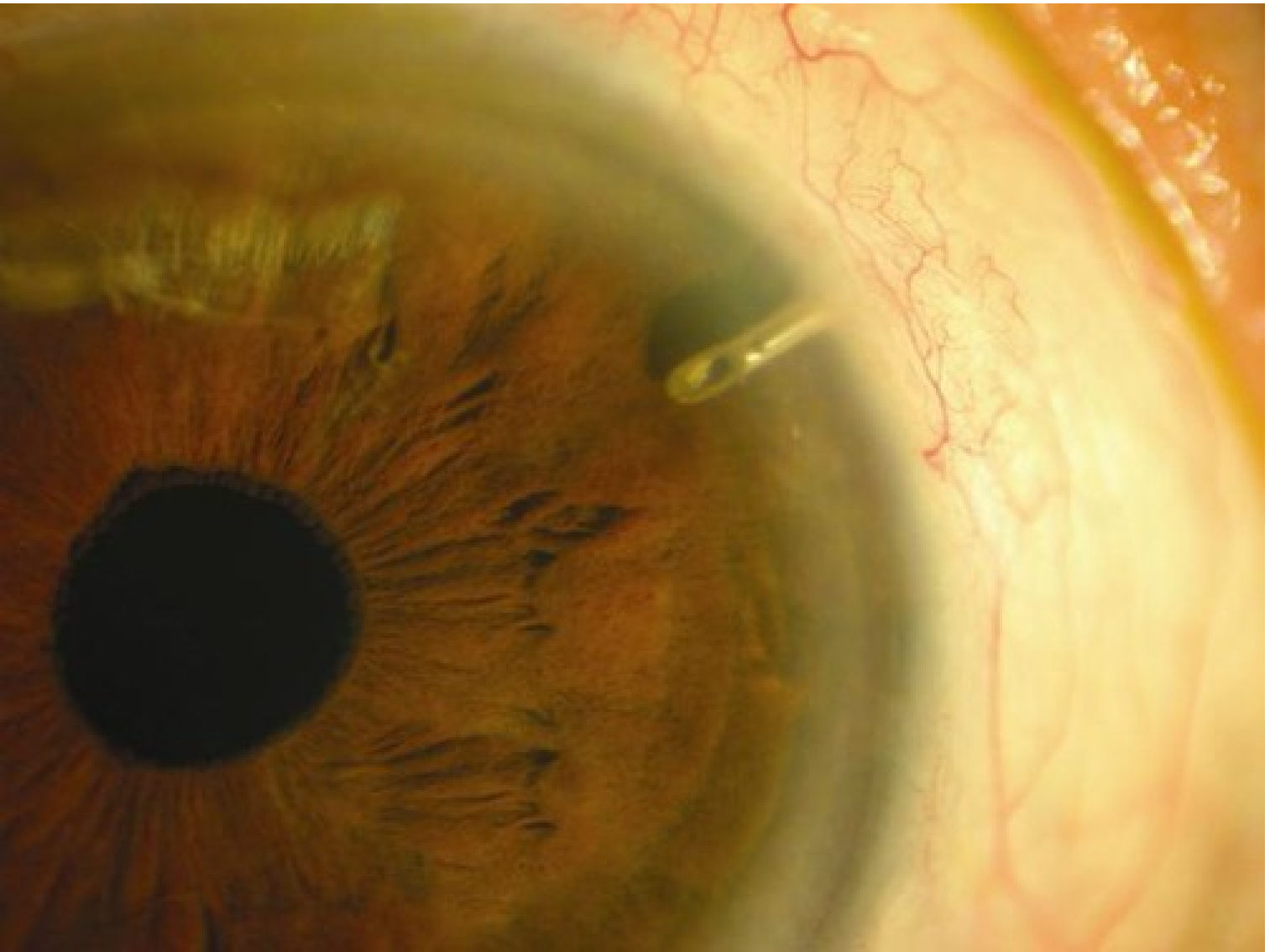
Trabeculectomy

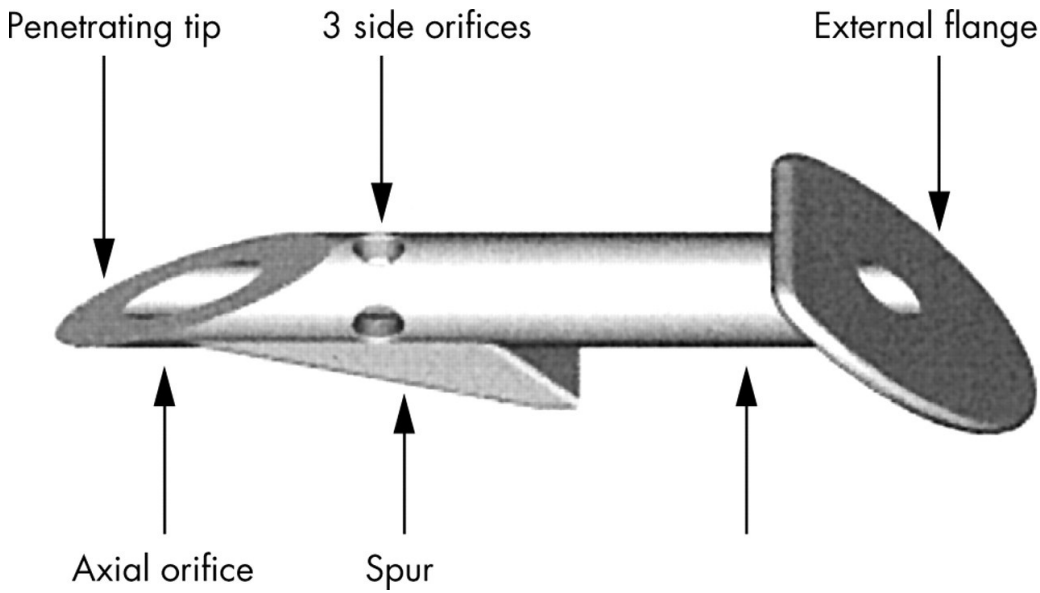
- Main goal is to make arteficial pathway for the a.h. outside of the eye





Express implant



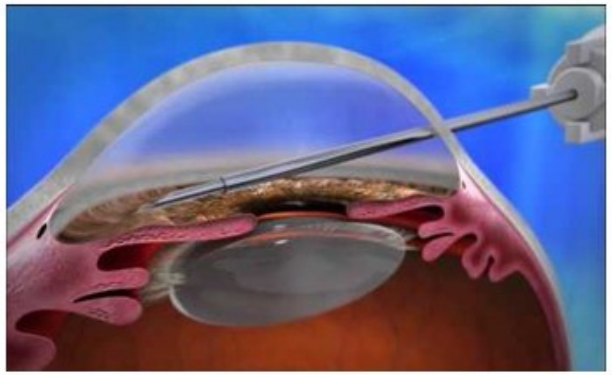


Express implant - video

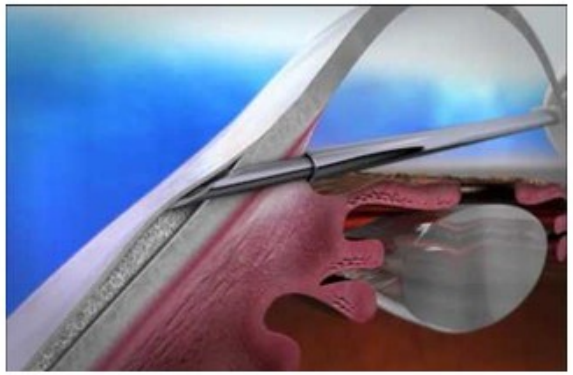
- https://www.youtube.com/watch?v=Eay9oxuCosM&ab_channel=Dr.Adri%C3%A1nHern%C3%A1ndezMart%C3%ADnez

MIGS – Xen implant

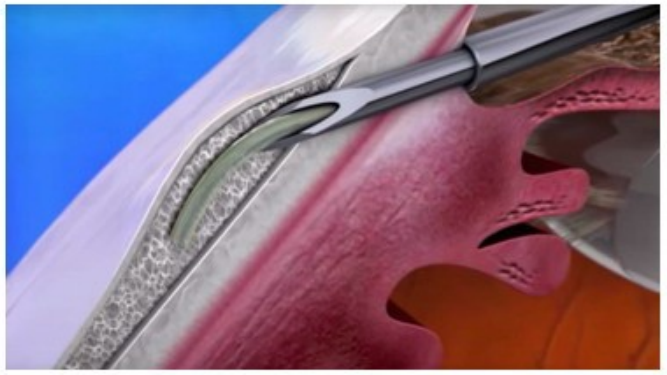
Simple Steps of Implanting XEN Glaucoma Tube at PVSC



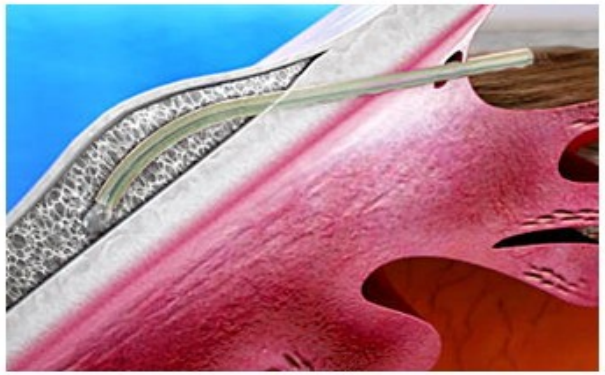
Step 1: The XEN injector is passed through the Anterior Chamber



Step 2: The XEN injector is passed through the Sclera into the Subconjunctival space

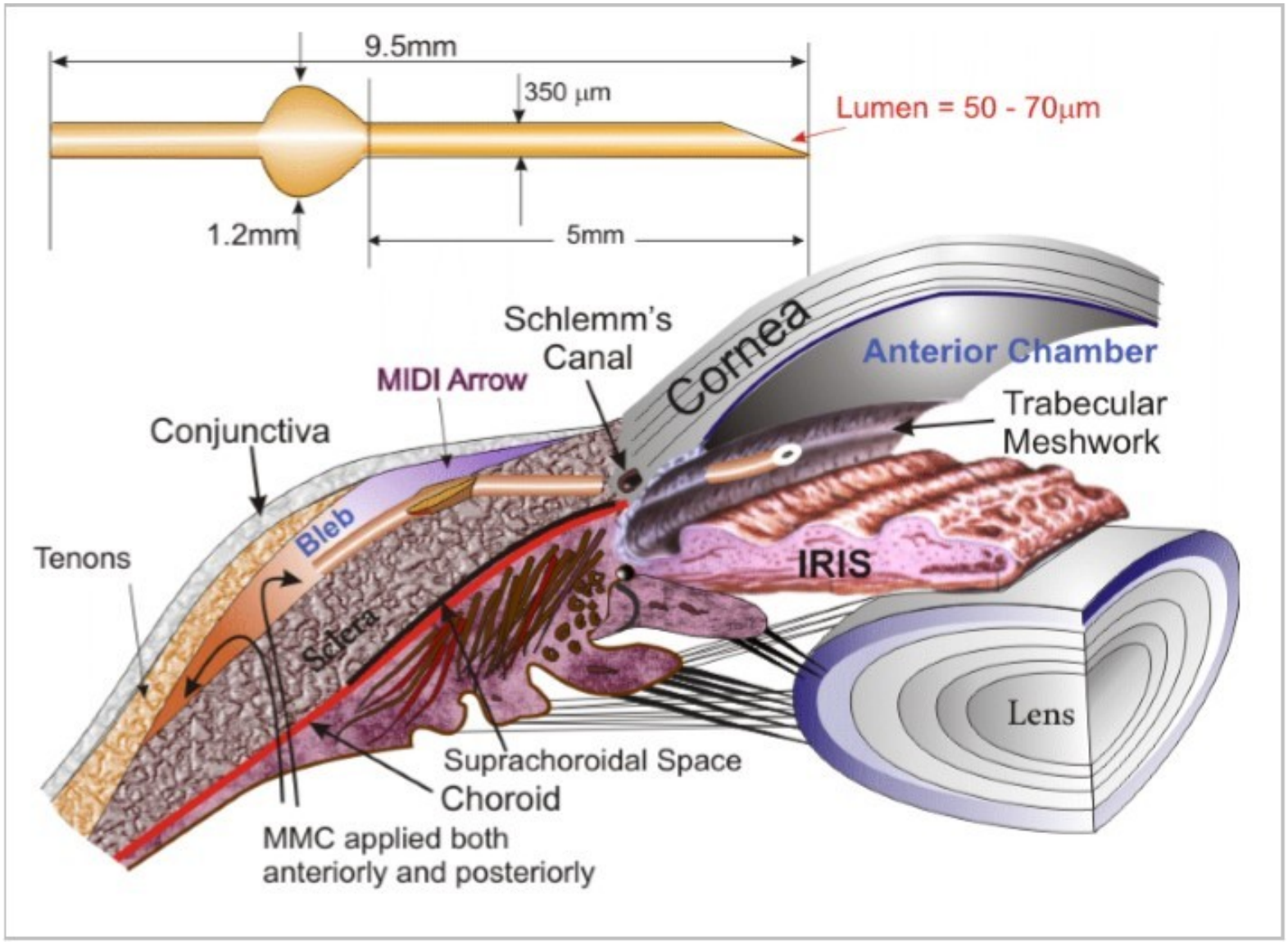


Step 3: The XEN Tube is pushed into the Subconjunctival Space to connect it to the Anterior Chamber



Final The XEN Tube is in proper position draining the Anterior Chamber fluid into the Subconjunctival space

MIGS – Preserflo implant



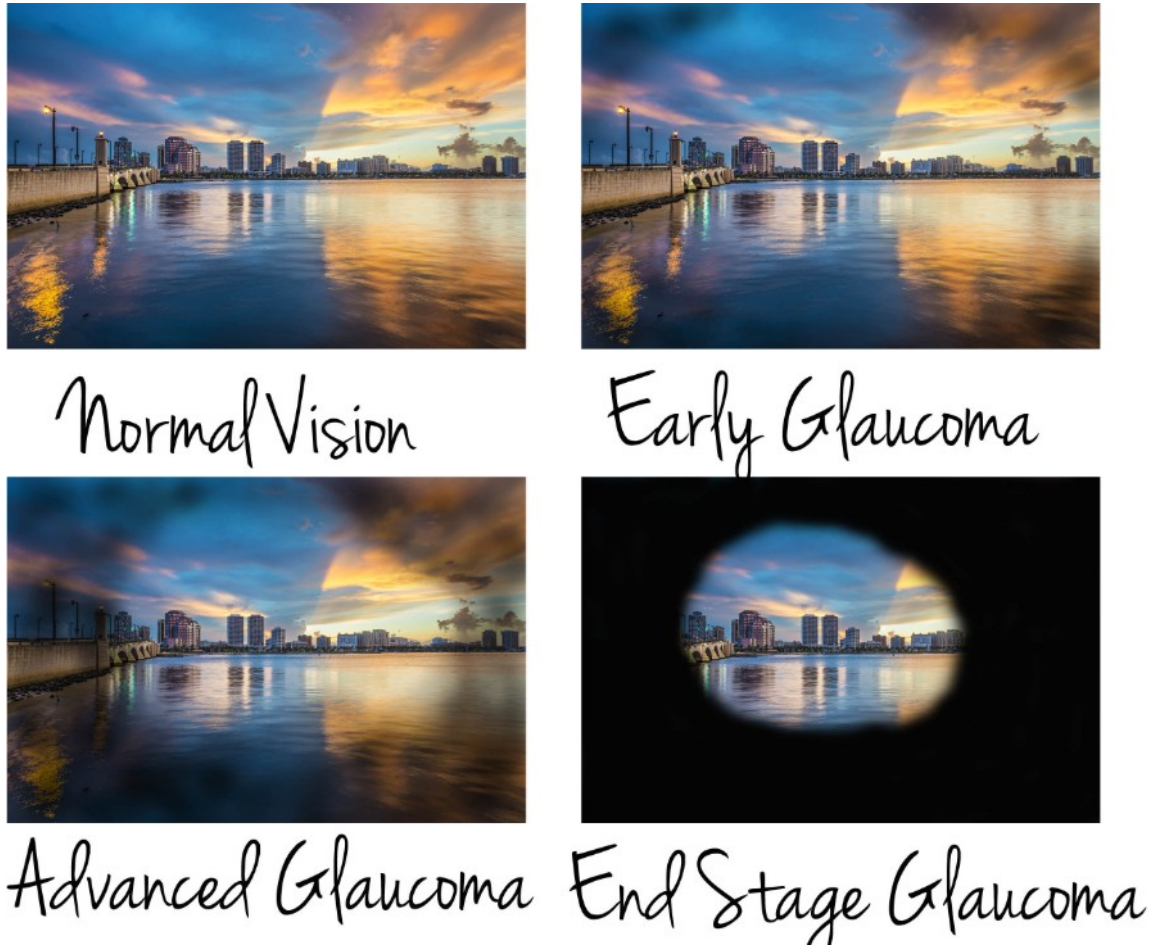
Part 7: glaucoma essentials

GLAUCOMA ESSENTIALS

- **Glaucoma ≠ elevated IOP!!**
- **BUT**, glaucoma is usually associated with high IOP (x normal tension glaucoma)
- Late symptoms onset
- Affects 60.5 million people worldwide

GLAUCOMA ESSENTIALS

- accounts for 8% of all cases of blindness and **is the leading cause of irreversible blindness worldwide**
- Early detection is essential
  - Educate patients with positive family history



GLAUCOMA ESSENTIALS

Thank you