

**GLAUCOMA
&
CATARACT**

GLAUCOMA

from the Greek *glaukos*
which means „watery blue“

GLAUCOMA

- **one of the most common causes of irreversible blindness**
- **an incurable disease**

GLAUCOMA

in the Czech Republic

- **population 10 mil.**
- **glaucoma patients approximately 200 000 – 300 000**
- **600 glaucoma surgeries a year**
- **approximately every 20. patient in the ambulatory service has glaucoma**

TYPE OF GLAUCOMA

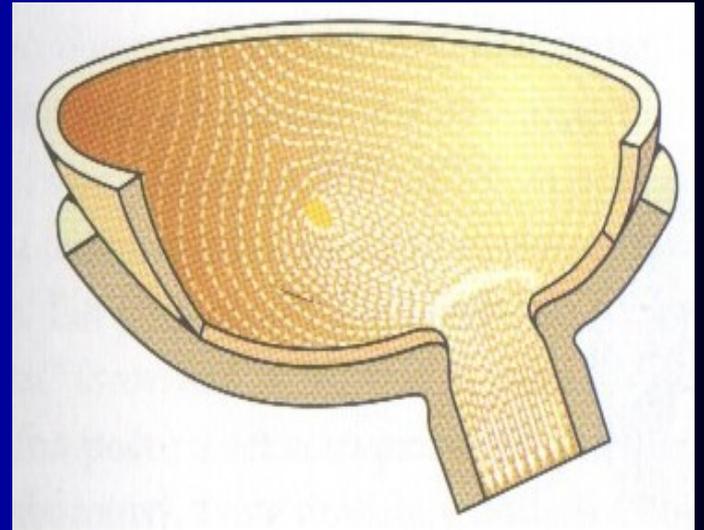
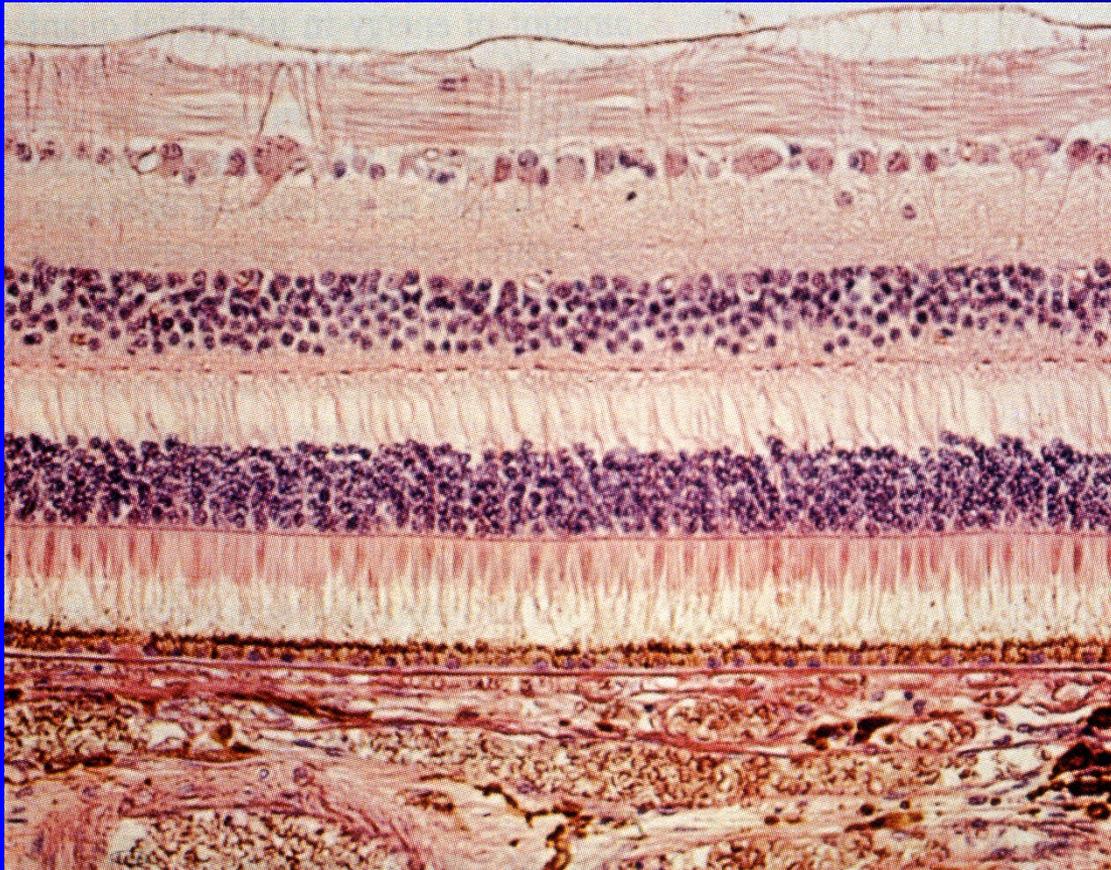
- **open angle glaucoma**
- **intraocular hypentension**
- **angle closure glaucoma**
- **normal tension glaucoma**

- In recent history glaucoma had been defined by having an intraocular pressure (IOP) above 21mmHg
- Later research indicated that the majority of people with IOPs above 21mmHg do not develop typical glaucomatous changes
- **Our modern concept of primary open angle glaucoma is a description of the constellation of signs frequently seen in „glaucoma“ that incorporate IOP, optic nerve appearance, and characteristic visual field changes**

- **A more modern definition for glaucoma is as follows: a pathologic condition in which there is a progressive loss of ganglion cell axons causing visual field damage that is related to IOP**
- **Currently, we look to evaluate the following components when making the diagnosis of glaucoma: history, presence or absence risk factors, IOP, optic nerve examination and visual field testing**

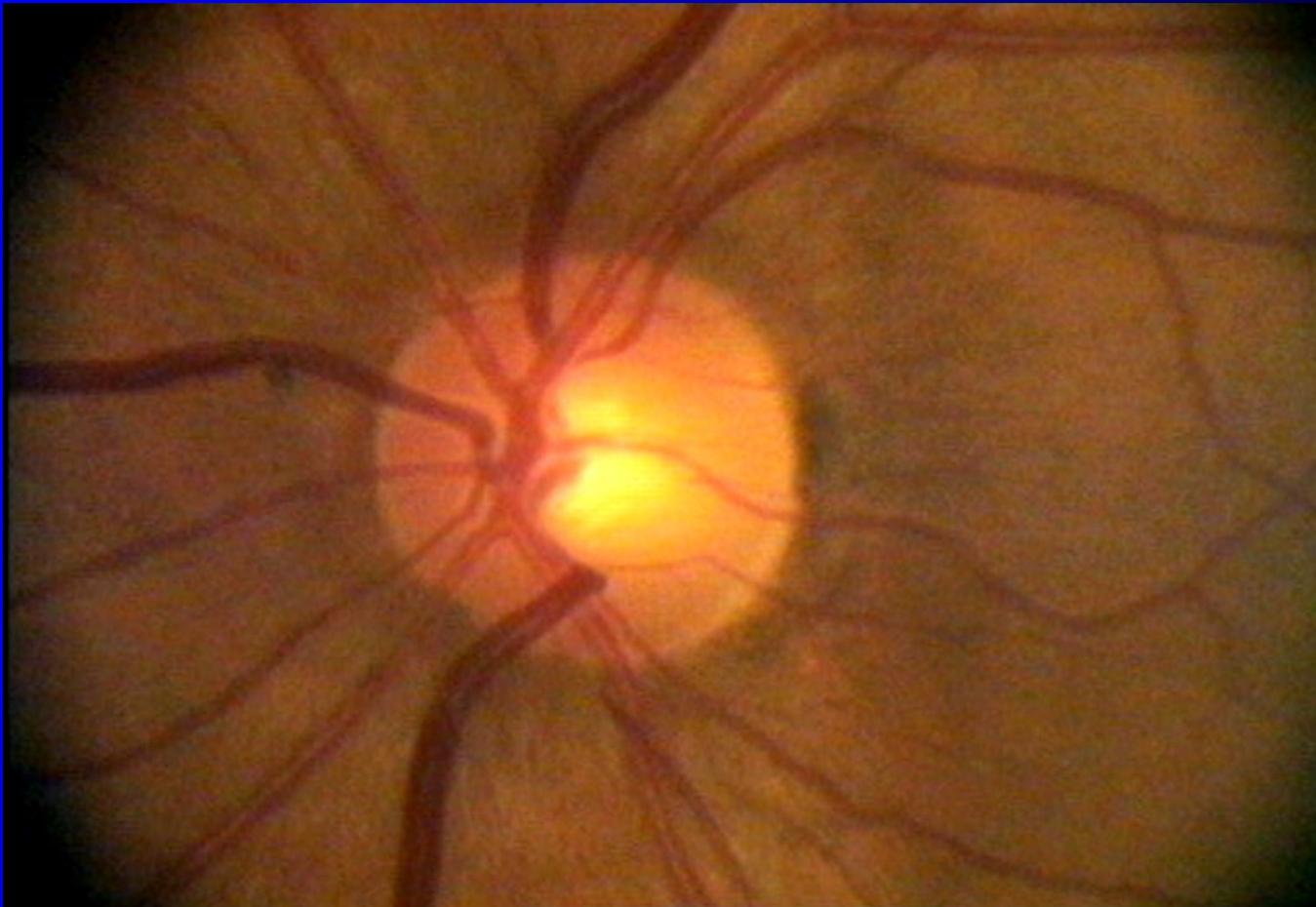
THE OPTIC DISC

The optic nerve contains over 1 million axons of the retinal ganglion cells, the cell bodies of which are in the superficial retinal layers

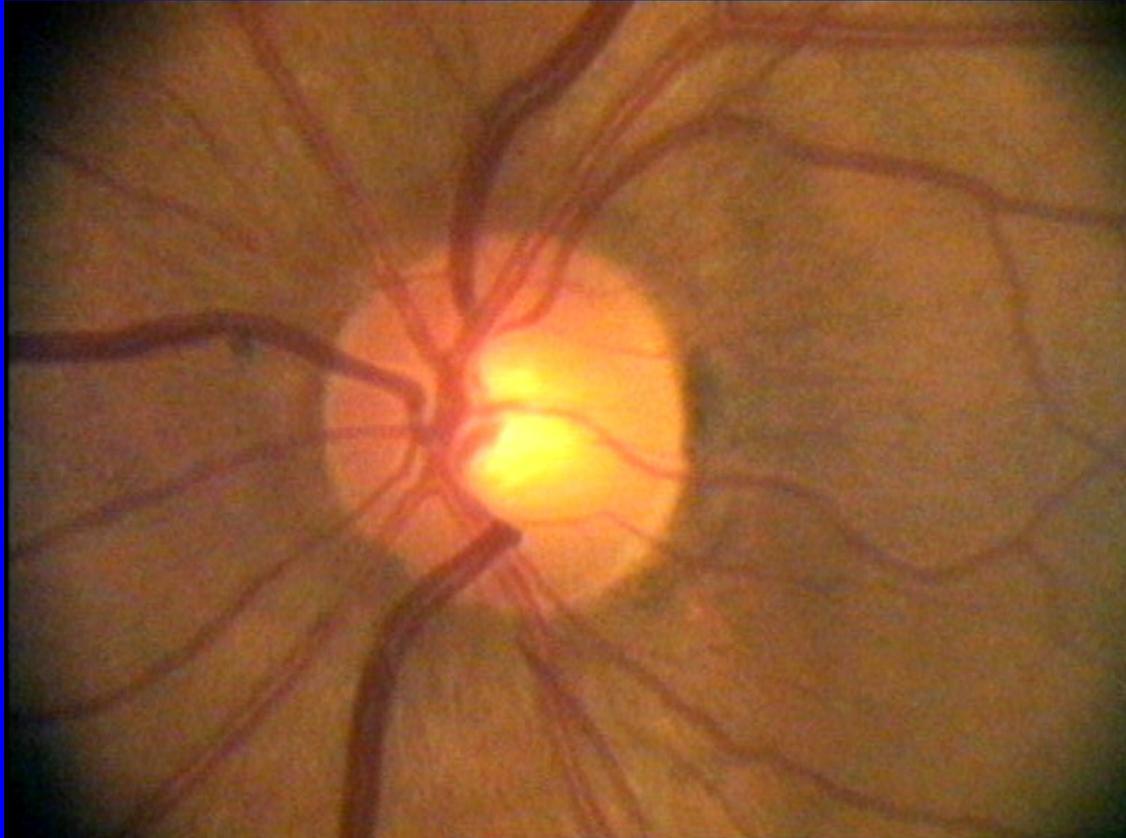


THE OPTIC DISC

The shape of the optic disc is usually a vertical oval, in the center of the disc is a depressed region, the cup, which is typically a horizontal oval

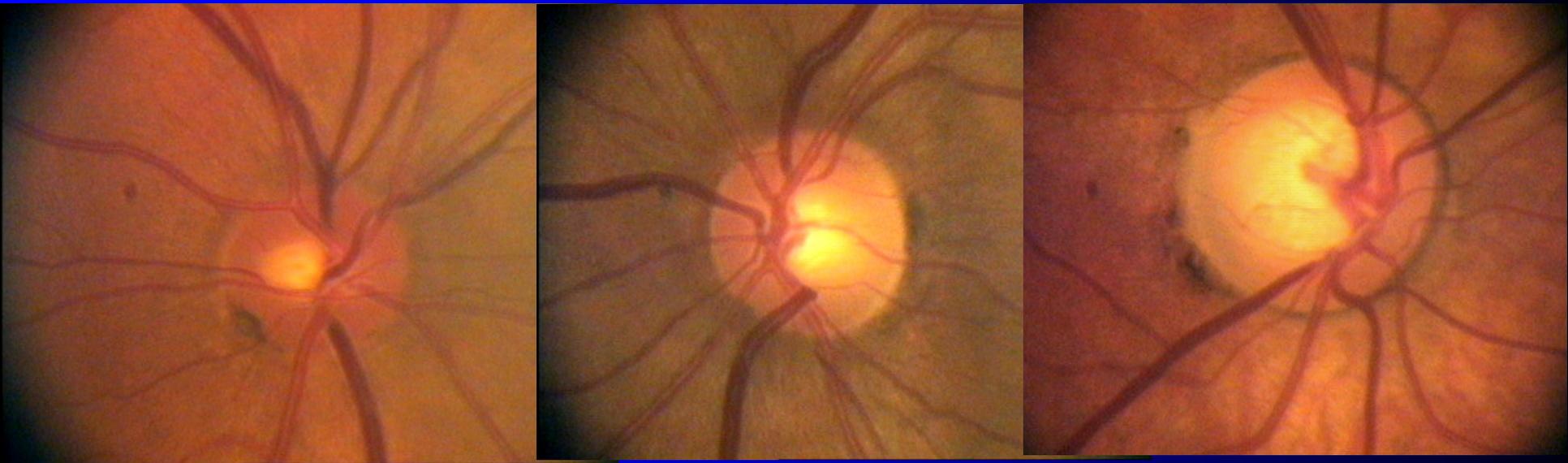


The central region is usually pale owing to the absence of axons with exposure of the underlying lamina cribrosa. The tissue between the cup and the disc margins is referred to as the neuroretinal rim and represents the location of the bulk of the axons of the ganglion cells. This tissue has usually an orange-red hue because of the associated capillaries



THE OPTIC DISC

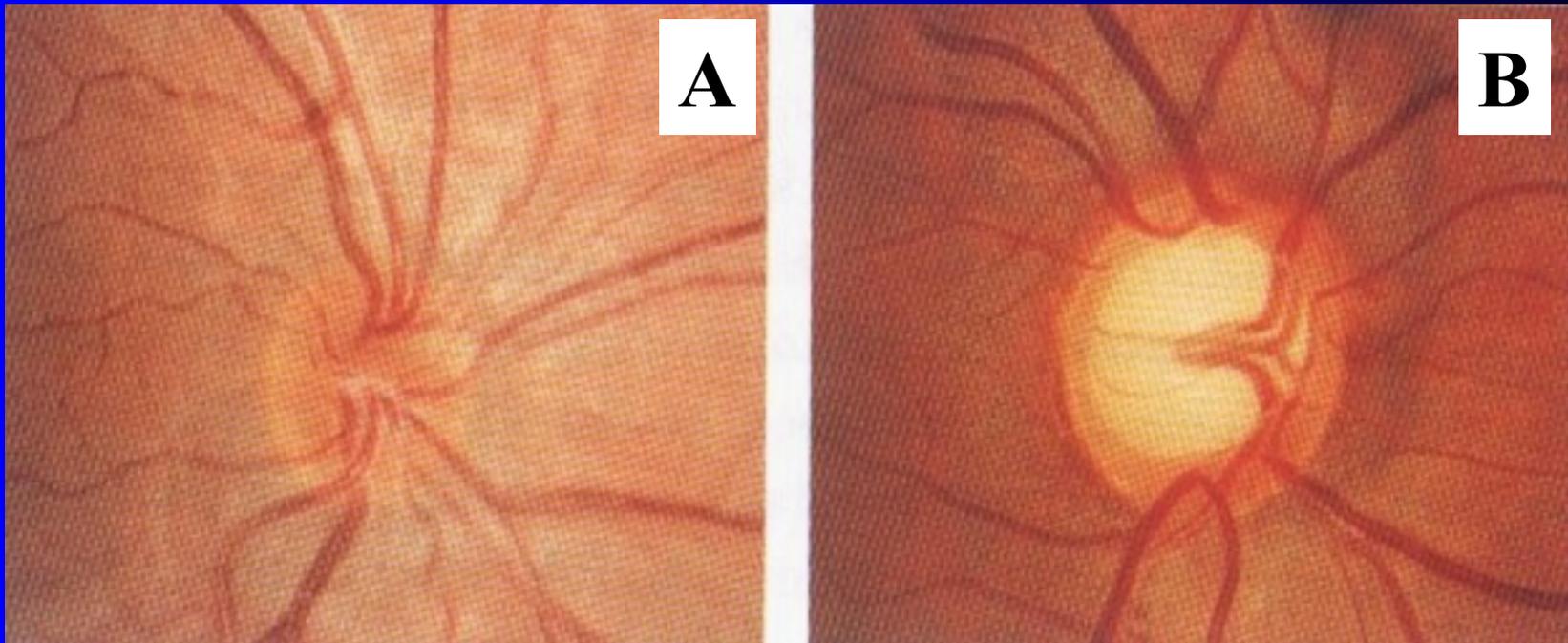
Determination of optic disc size is extremely important in evaluating glaucomatous optic neuropathy. The optic disc size is correlated with the optic cup and neuroretinal rim: the larger the optic disc, the larger cup disc and neuroretinal rim.



VARIATIONS IN OPTIC DISC SIZE

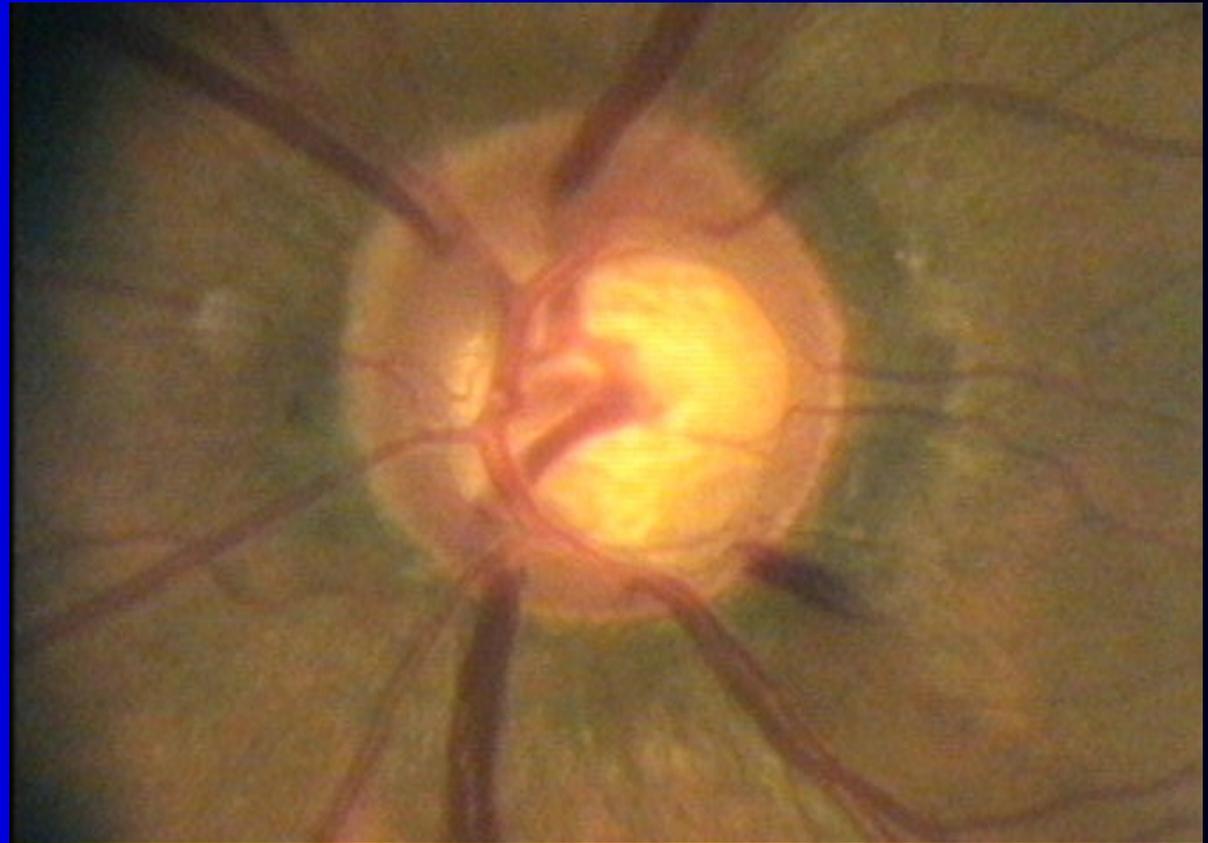
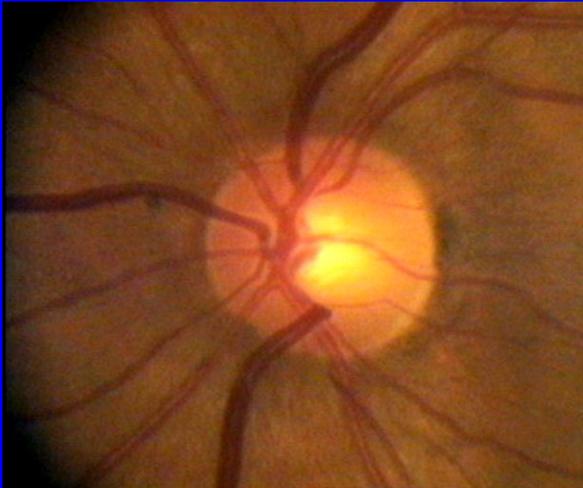
A - a small optic disc with no cup by high hypermetropic eye

B - a large optic disc with a physiologically large cup by high myopic eye



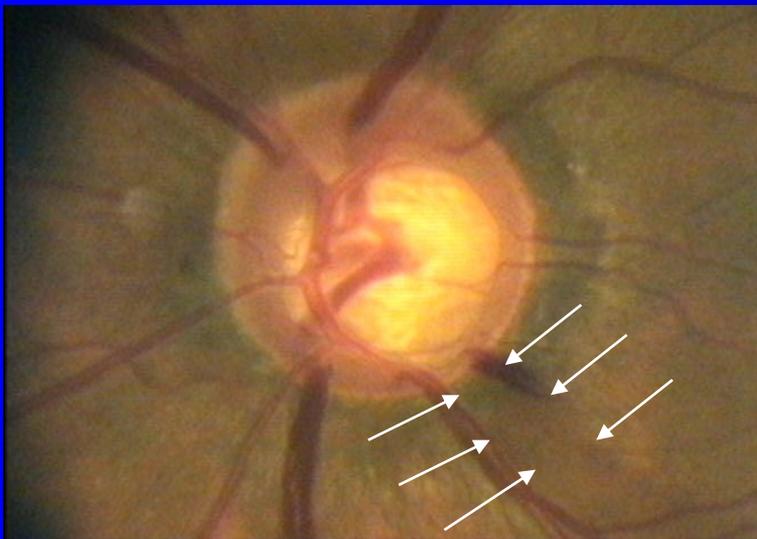
GLAUCOMATOUS OPTIC DISC

Degeneration of retinal ganglion cell axons in glaucoma leads to an increase in cup size with loss of neuroretinal rim tissue. Focal loss of the neuroretinal rim often begins as a small, localised defect in the contour of the inner edge of the cup, leading to narrowing of the rim.

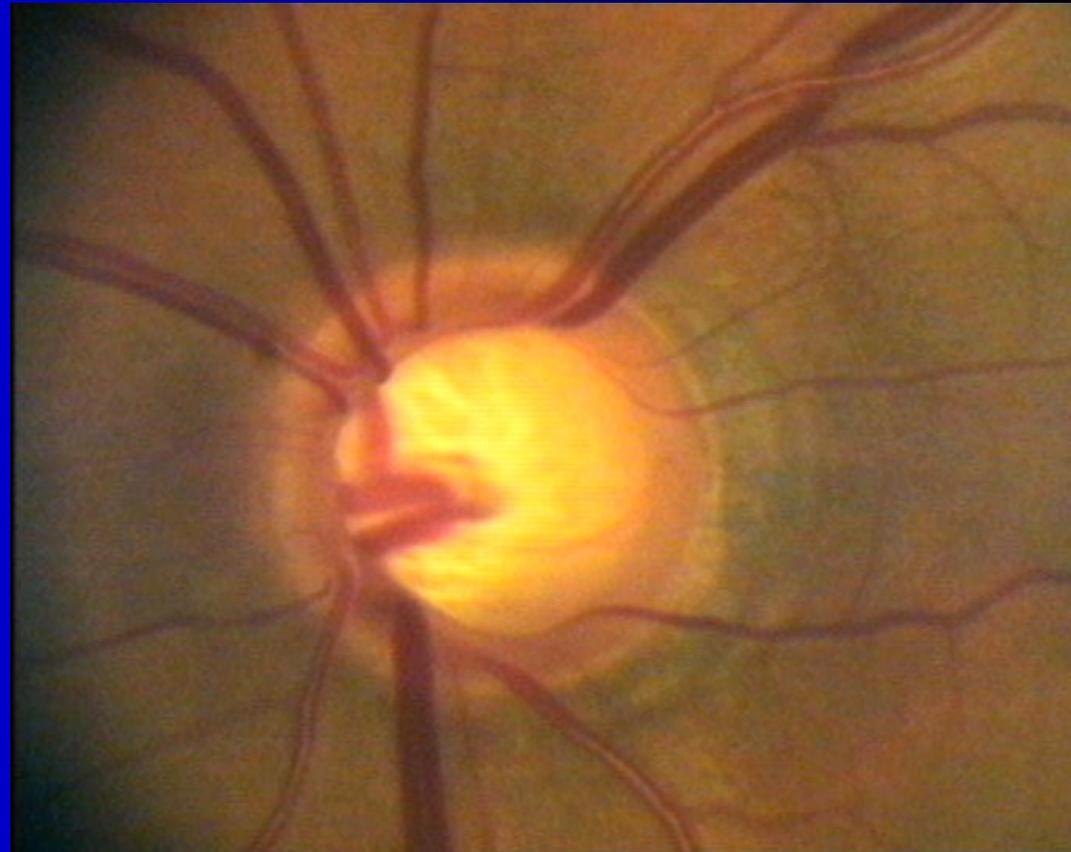


GLAUCOMATOUS OPTIC DISC

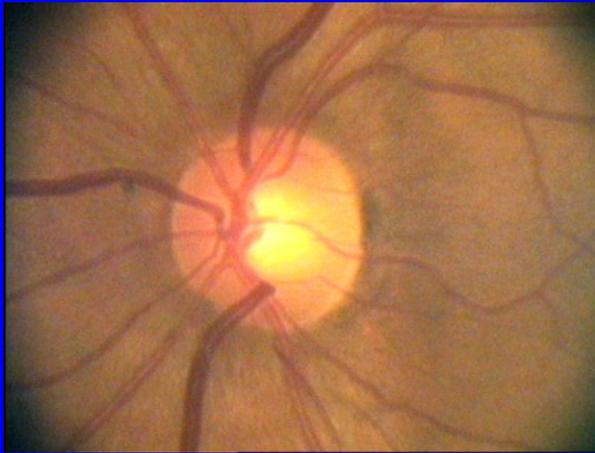
This defect may enlarge and develop a sharp margin. Vessels crossing this sharpened rim bend abruptly, this is referred to as bayoneting and is a useful marker of rim loss.



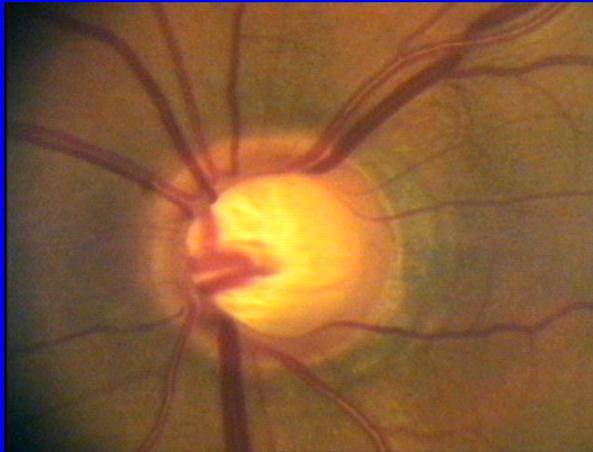
There is also an associated nerve fiber layer defect present as wedge-shaped area of attenuation of the nerve fiber layer



A

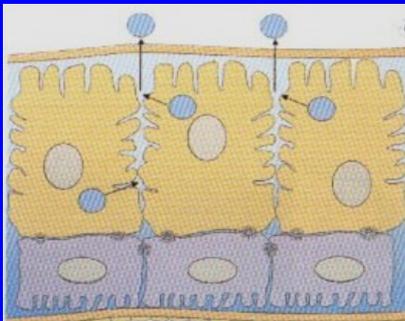
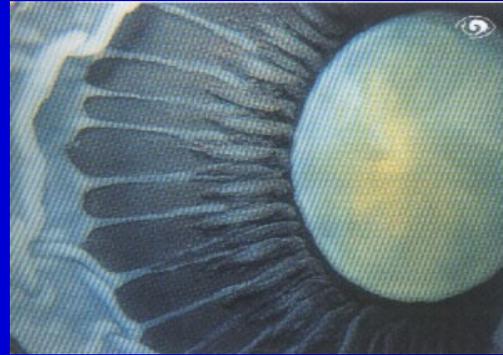
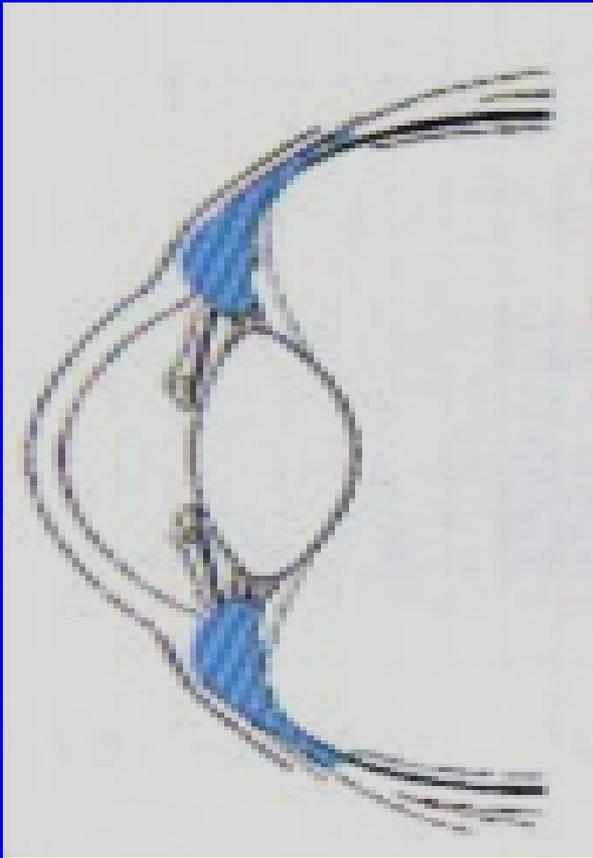


B

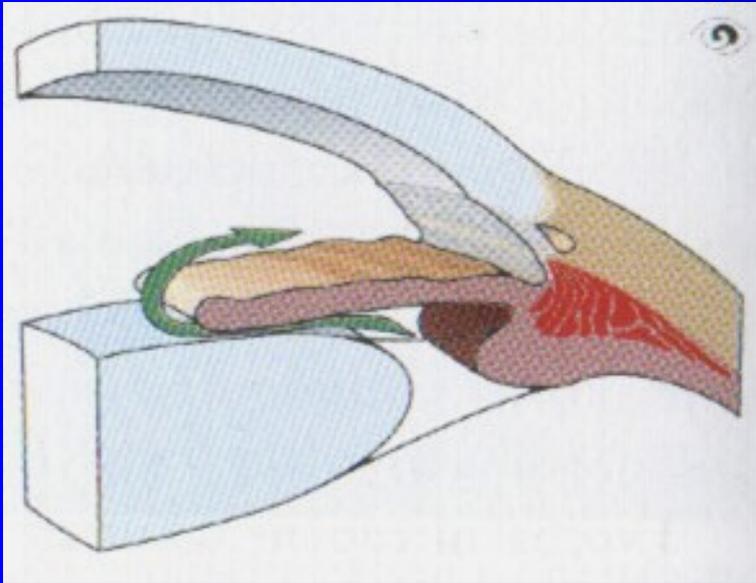


H&E stained histologic section of optic nerves.
A –normal optic nerve; **B**- optic nerve from advanced glaucoma

- **Intraocular pressure remains one of the most important risk factors for the disease**
- **Additionally, lowering of the intraocular pressure is the only rigorously proven treatment for glaucoma**
- **Although we have some understanding of the physiology of the IOP, we do not yet fully understand how the eye regulates intraocular pressure at the cellular and molecular level**

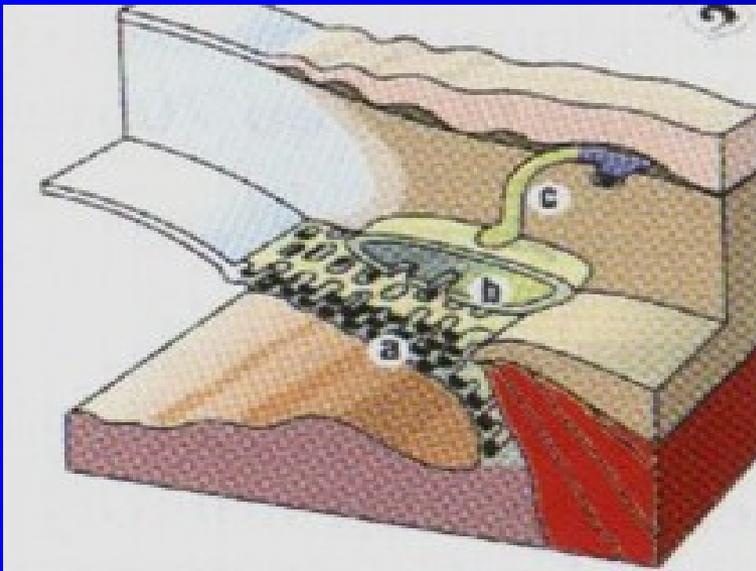


Aqueous is formed in the ciliary processes (pars plicata region of the retina). The epithelial cells of the inner nonpigmented layer are felt to be the site of aqueous production. Aqueous is produced by a combination of active secretion, ultrafiltration and diffusion.

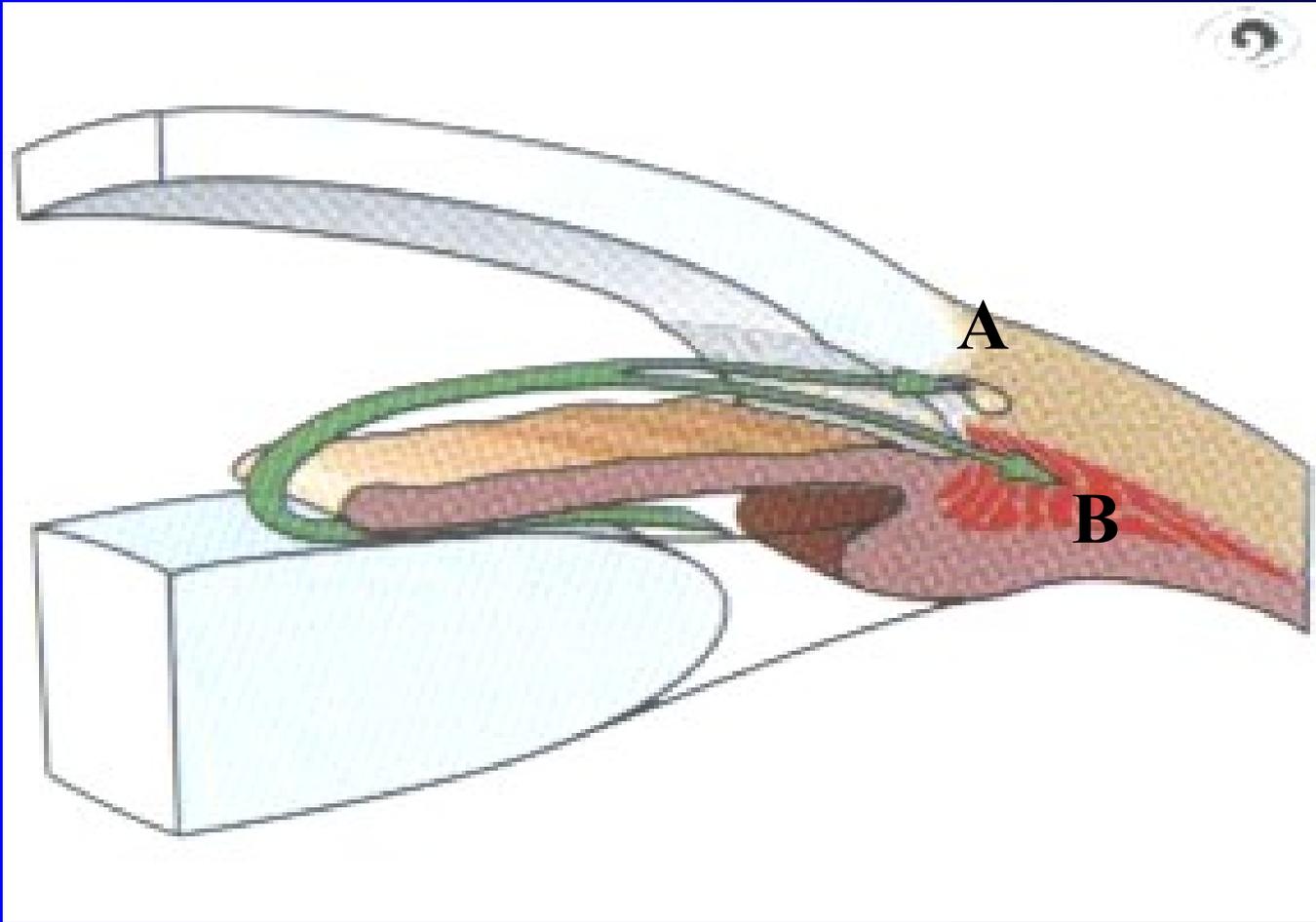


Aqueous the flows through the pupil and ino the anterior chamber nourshing the lens, cornea and iris

ROUT OF AQUEOUS FLOW



Aqueous drains through the anterior chamber angle, which conteins trabecular meshworkand ciliary body



- A) between 80-90% of aqueous outflow is through the trabecular meshwork: the co-called conventional pathway
- B) With the remaining 10-20% through the ciliary body face: the co-called uveoscleral or alternative pathway

- **Intraocular pressure is physiologically determined by rate of aqueous production in the ciliary body, resistance to outflow through the conventional outflow tract (trabecular meshwork and Schlemm's canal), resistance to outflow through the unconventional outflow (uveoscleral), and episcleral venous pressure**
- **Elevation of episcleral venous pressure or changes in the trabecular meshwork can result in an elevated intraocular pressure**

GLAUCOMA RISK FACTORS

- **Intraocular pressure**
- **Age (mostly by older patients)**
- **Family history (genetic)**
- **Rasa (black persons have higher IOP)**
- **Sex (female more often)**
- **Refractive errores**
- **Diabetes, hypertension**

CLINICAL EXAMINATION

- **History**
- **Visual acuity**
- **Biomikroskopy** slit lamp observation
- **Tonometry** IOP measurement
- **Gonioscopy** observation of the anterior chamber angle
- **Perimetry** visual field testing
- **Pachymetry** measurement of thickness of the cornea
- **Optic disc observation** (direct, indirect,documentation)
- **Measurement of the tickness of the nerve fiber layer**

BIOMIKROSCOPY



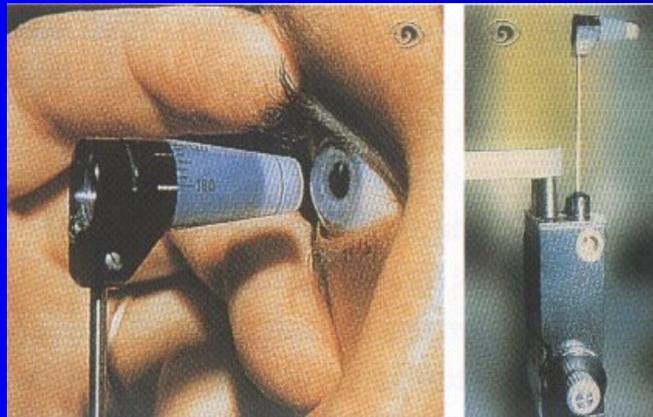
TONOMETRY

measurement of the IOP

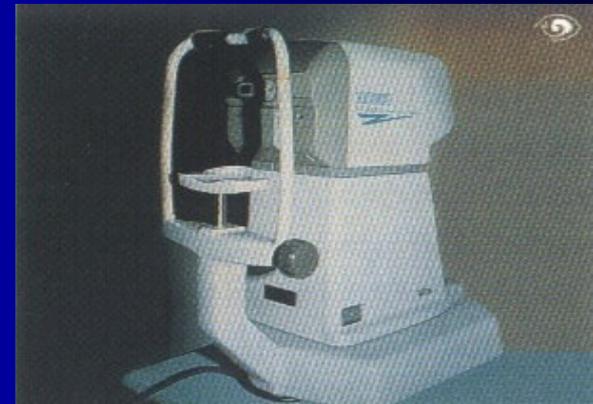
- palpation



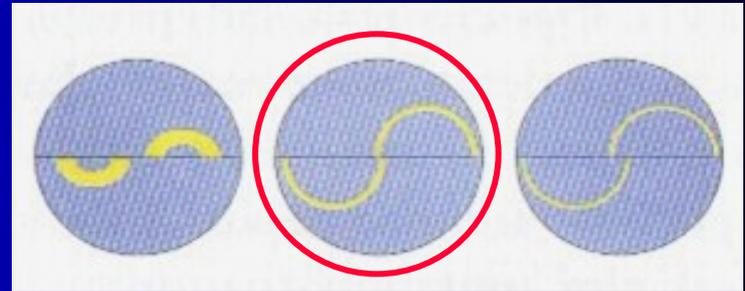
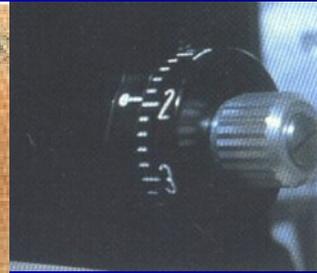
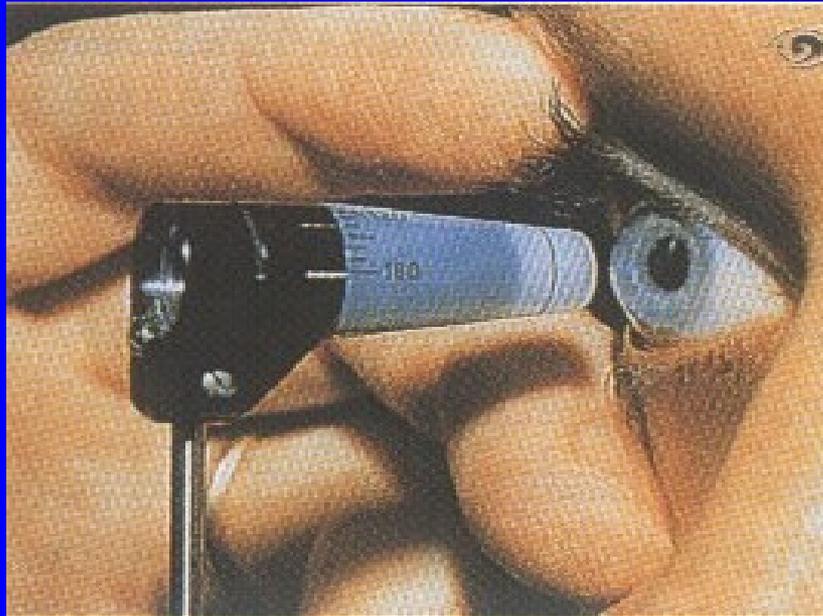
- applanation



- noncontact



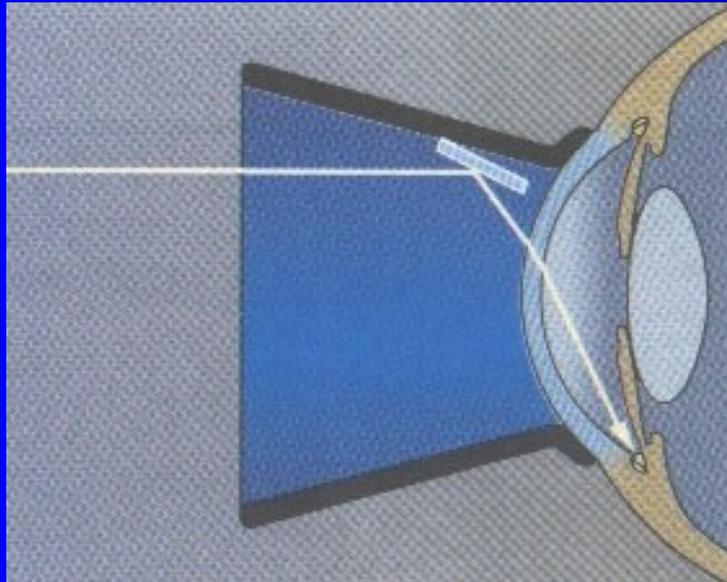
Goldmann applanation, the „gold standard“ of measurement of IOP: an area of the cornea is deforming with small amount of force that is used to calculate the IOP



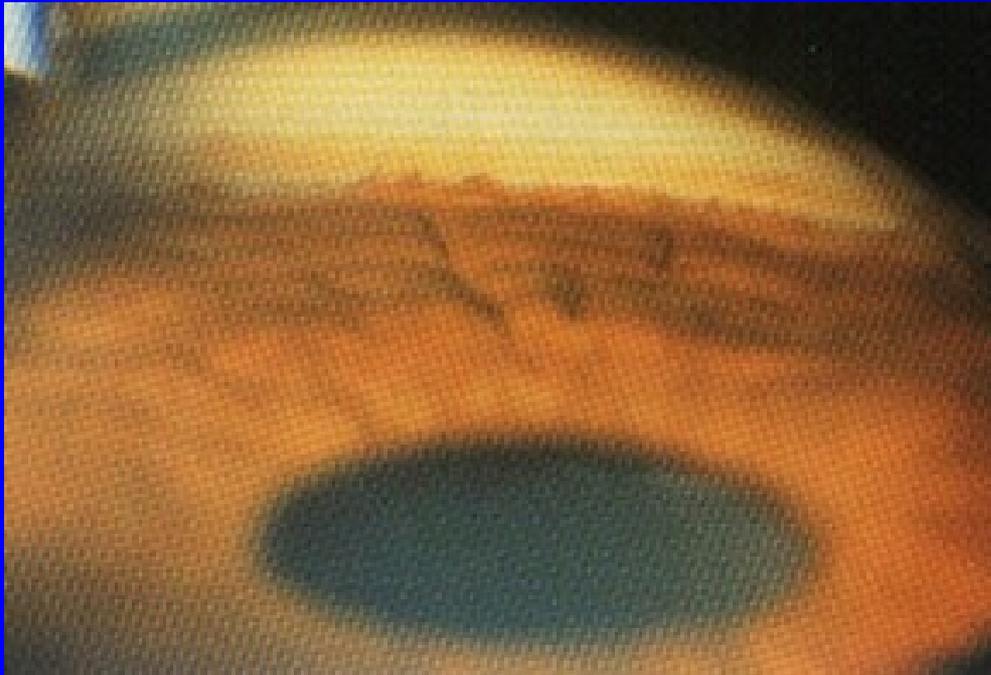
The patient is seated at the slit lamp, the cornea is viewed through a prismatic doubling device, the applanation head is gently placed against a fluorescein-stained, anesthetized cornea. The examiner sees a split image of the tear meniscus around the tonometer head. These fluorescein rings just overlap when the pressure at the head equals the intraocular pressure.

Gonioscopy

visualisation of the configuration of the anterior chamber angle:
The angle is visualized with the lens that has one or more mirrors,
allowing the evaluation of the structures opposite to the mirror
employed. The examination is performed using the slit lamp.
To obtain a good view of the angle, the incidence of the light beam
must be perpendicular to the mirror of the lens.



Gonioscopy



Perimetry: visual field testing

- **Psychophysical testing – the subjective testing of peripheral vision of the eye (glaucoma affects the peripheral vision before affecting central acuity)**
- **Glaucomatous visual field defects are those that are typically found with lesions localizing to the optic nerve (visual field abnormalities have localizing value for lesions along the entire visual tract: from retina to occipital lobes)**
- **Perimetric testing attempts to determine the visual threshold at a particular location in the visual field. The visual threshold is defined as the minimum level of light that can be perceived at a given location in the visual field. This concept is also termed *retinal sensitivity*.**

Perimetry

- **The visual threshold is highest in the fovea, which is defined as the center of the visual field. As the field extends peripherally, the sensitivity decreases.**
- **There are two main methods of perimetry: **static** and kinetic**
- **Static visual field testing presents visual stimuli in varying sizes and intensities at fixed locations. This testing is automated and presents white-colored stimuli on a standard background**



A

A – normal eye

B – beginning of glaucoma

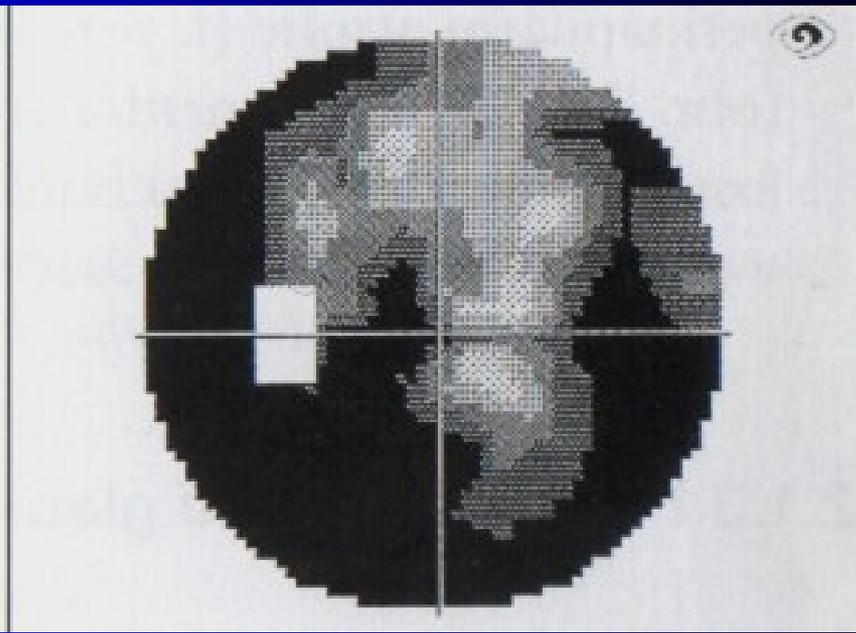
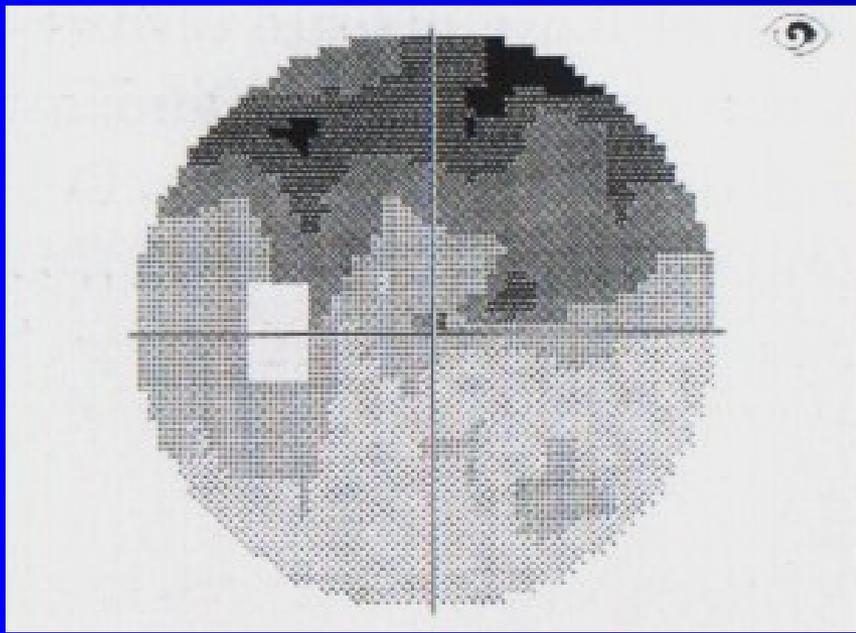
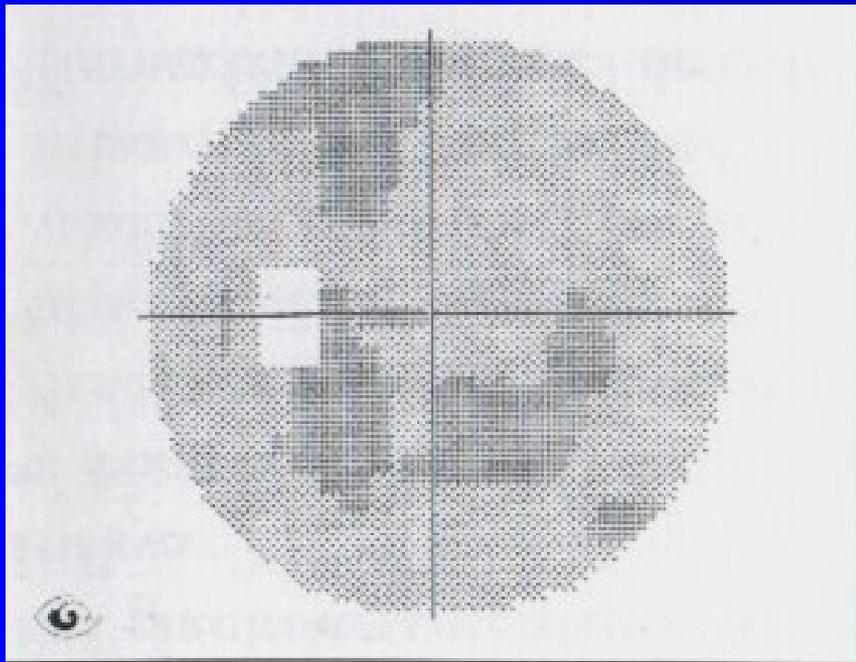
C – advanced stage of glaucoma



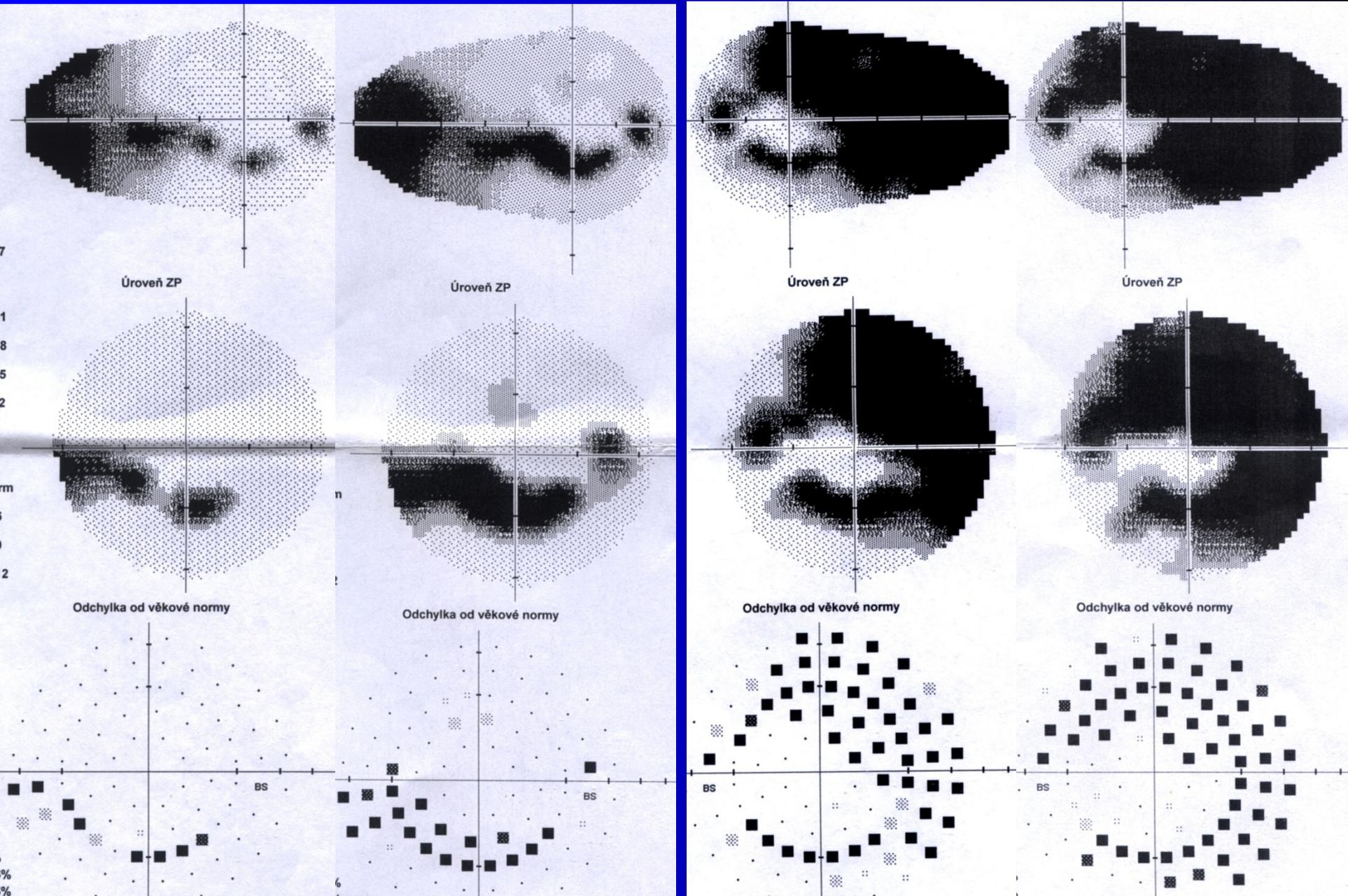
B



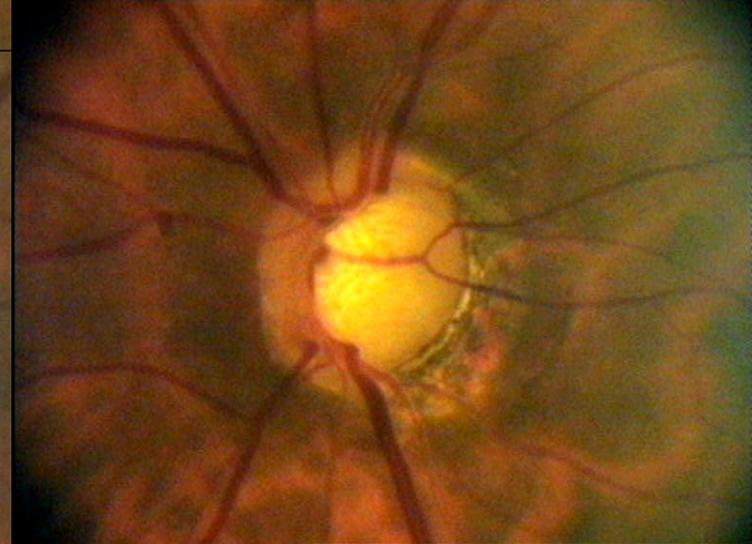
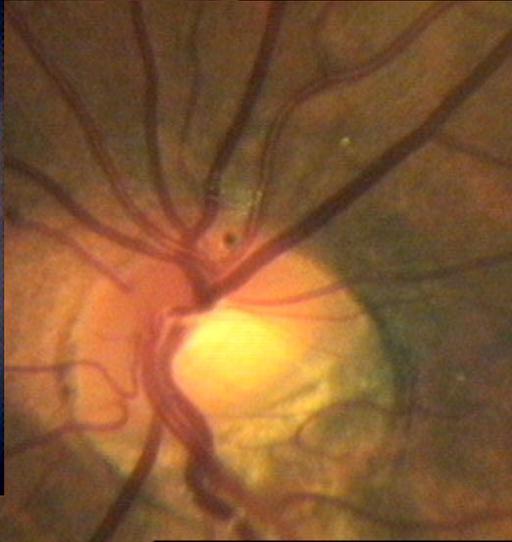
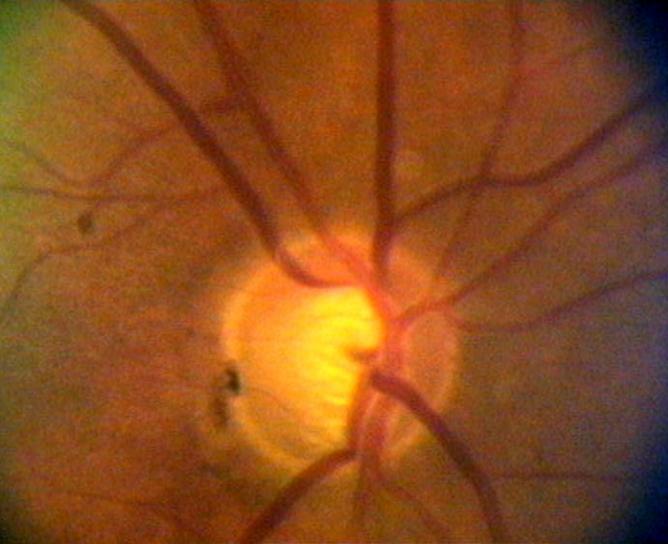
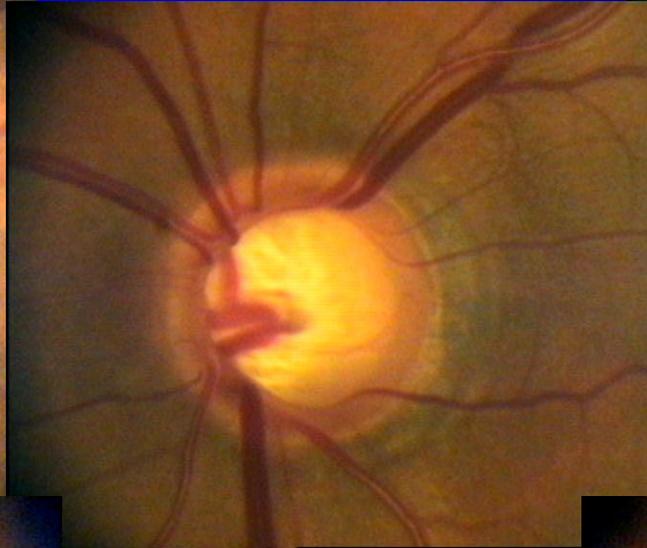
C



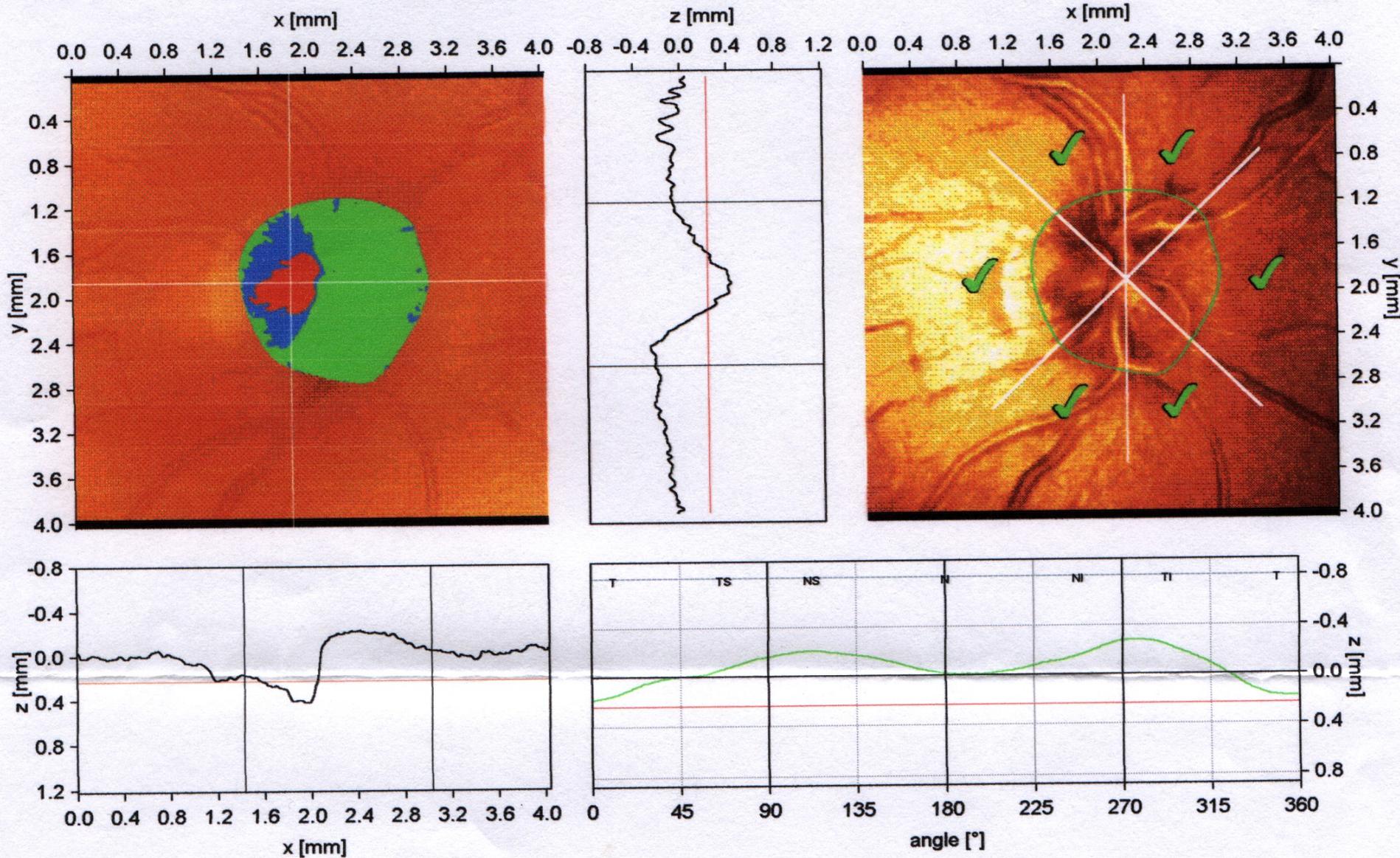
Patient, 55 years old, POAG billat.



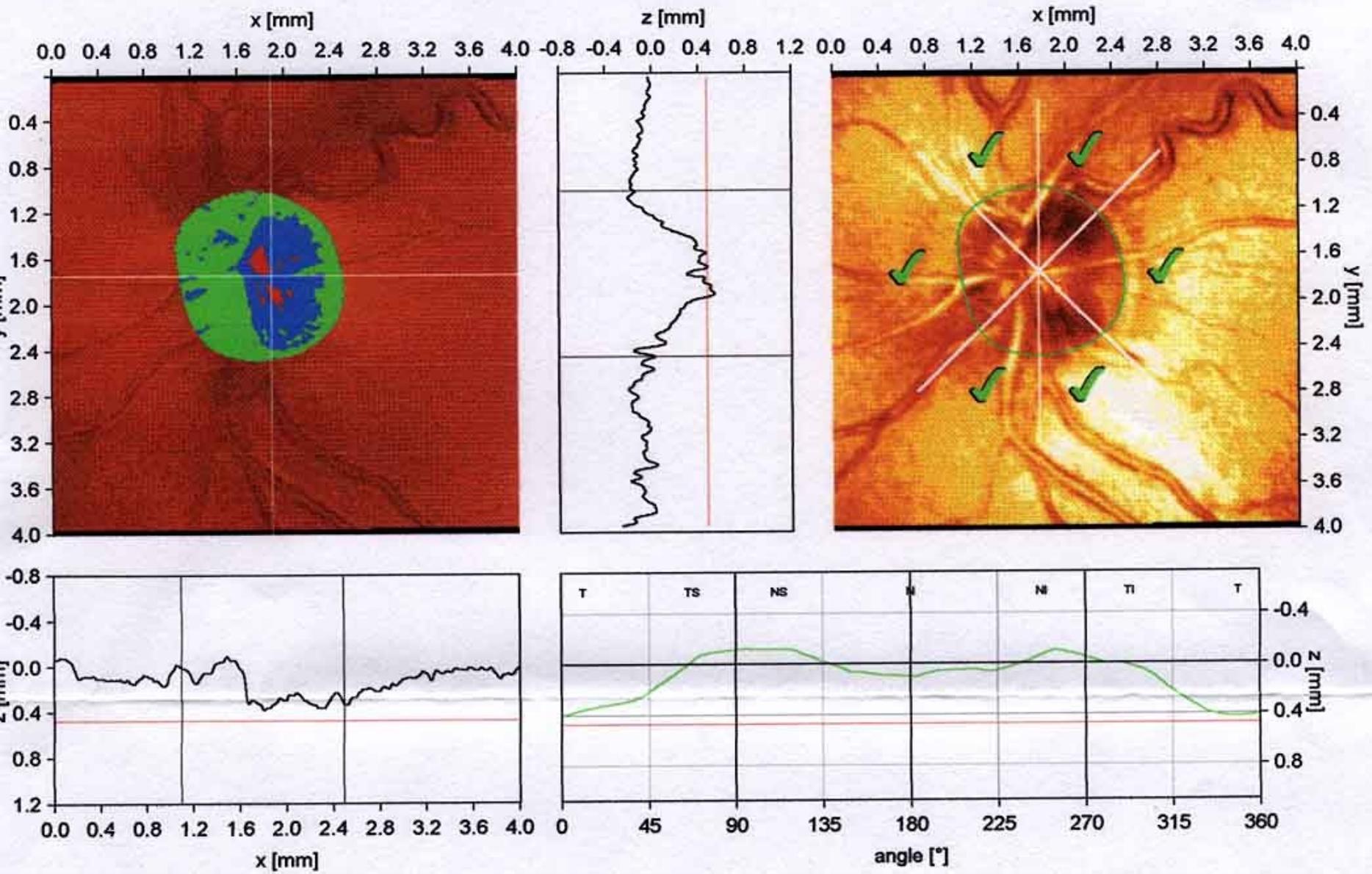
DOCUMENTATION OF THE OPTIC DISC



Laser tomography



Laser tomography



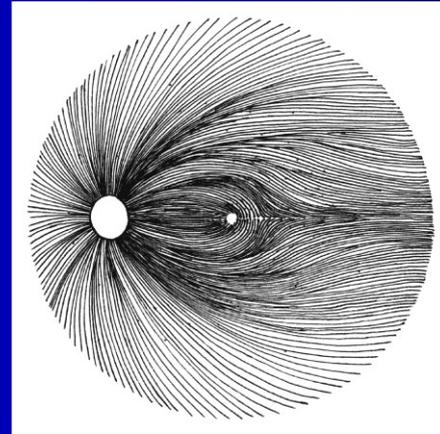
MEASUREMENT OF THE THICKNESS OF THE NERVE FIBER LAYER

- **The nerve fibers are the axons of the ganglion cells, their losses indicate the losses of the ganglion cells**
- **The visual field defects correlate with the changes in the nerve fiber layer**

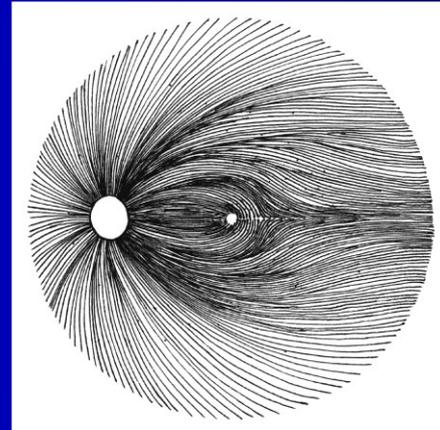
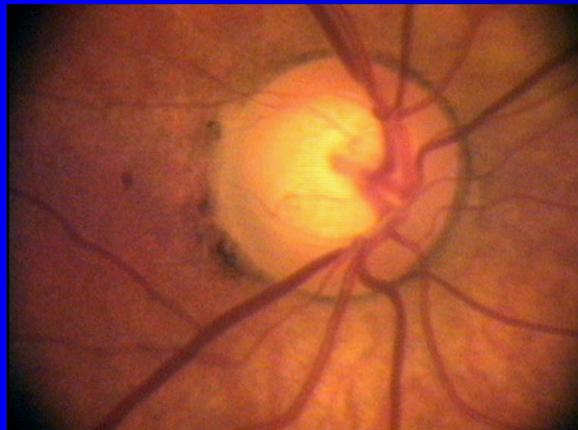
Differences of the size and the form of the optic disc

Uniformity in the nerve fiber layer

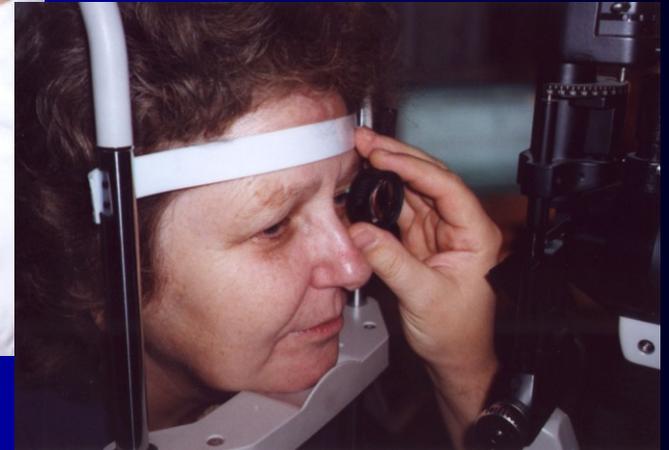
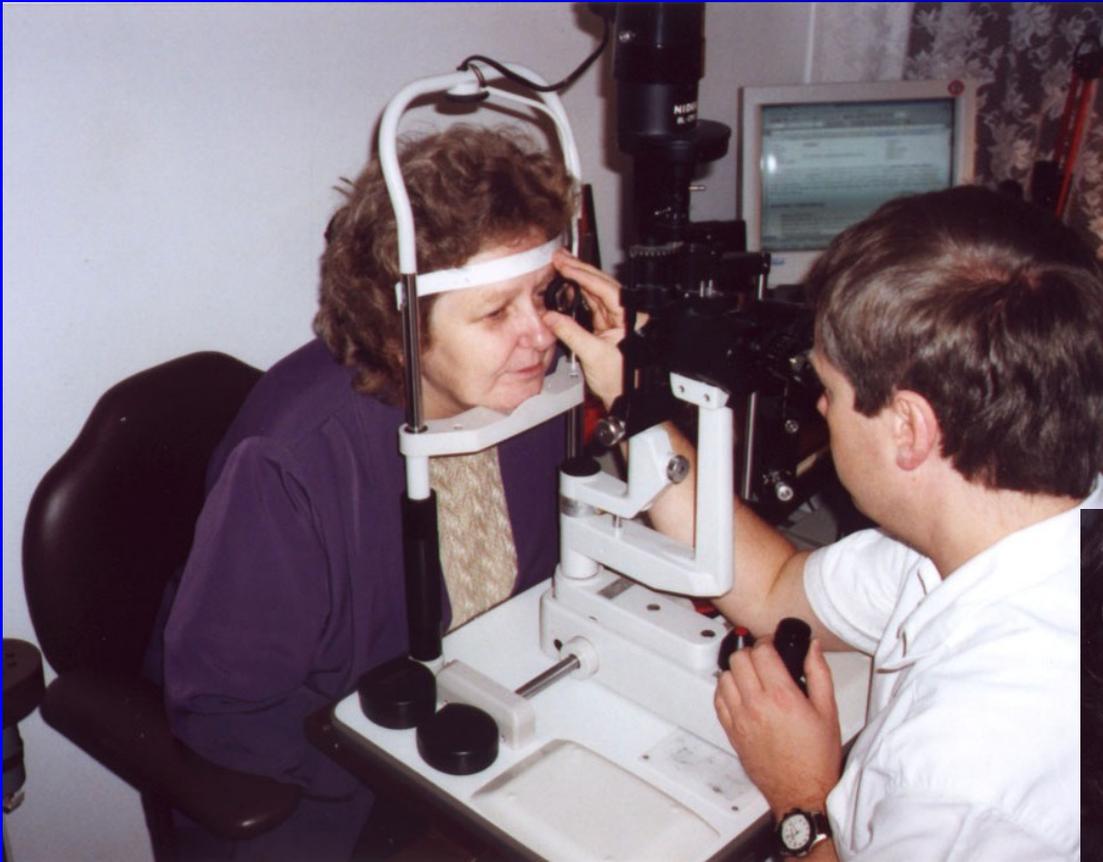
100%
difference

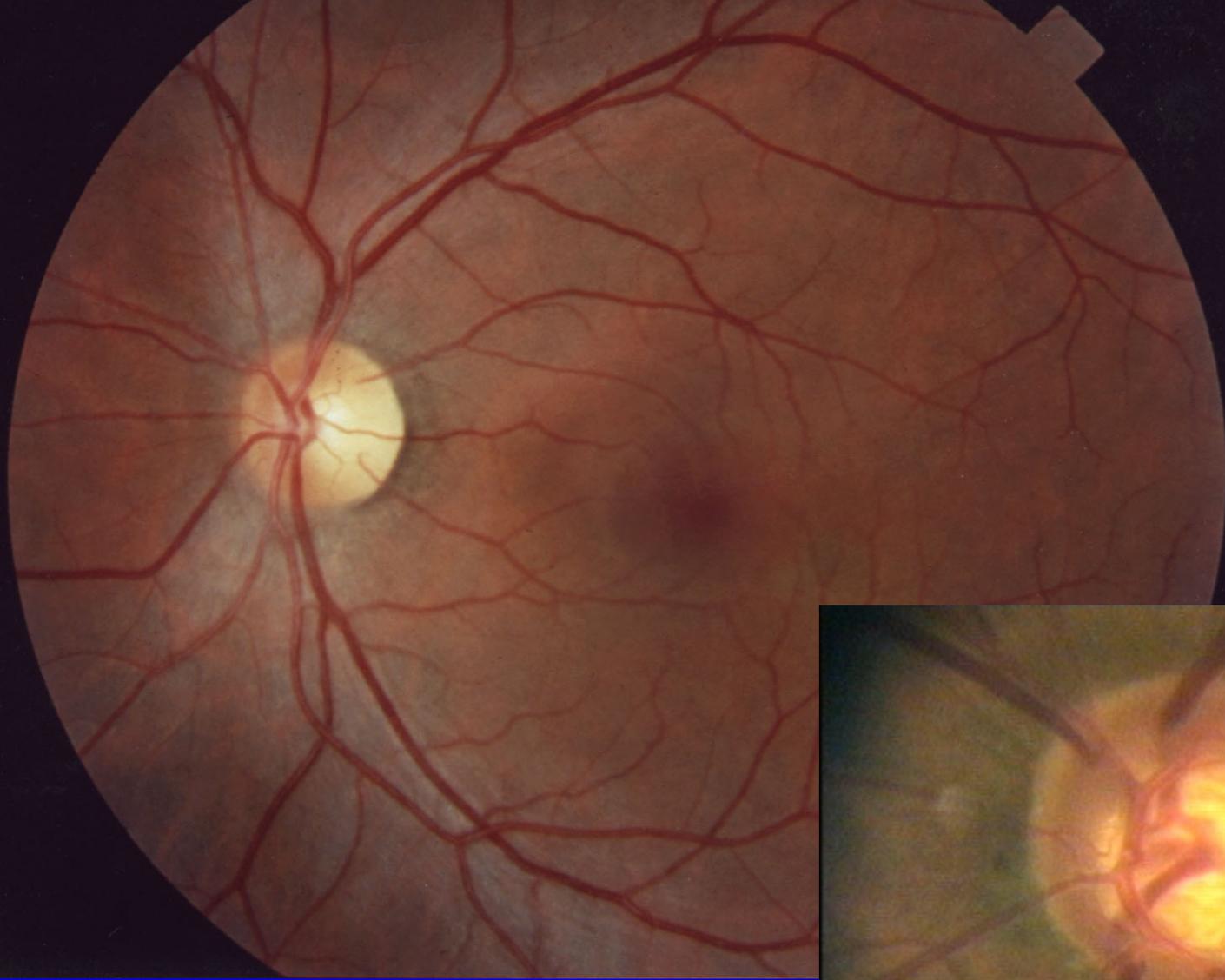


97%
uniformity

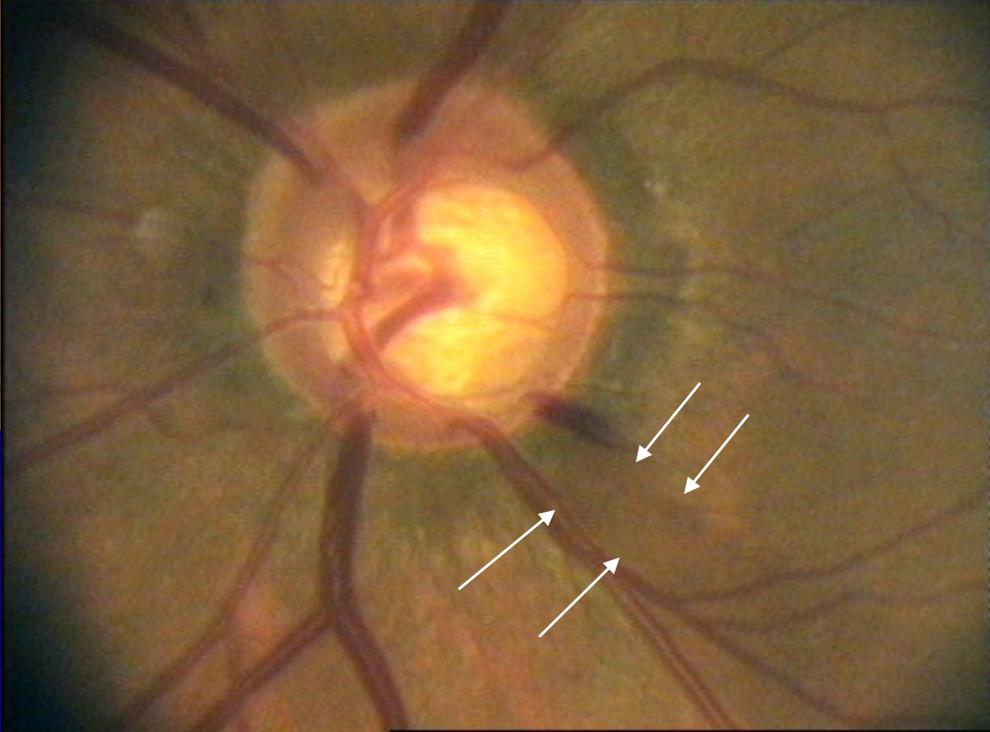


Slit lamp observation of the nerve fiber layer

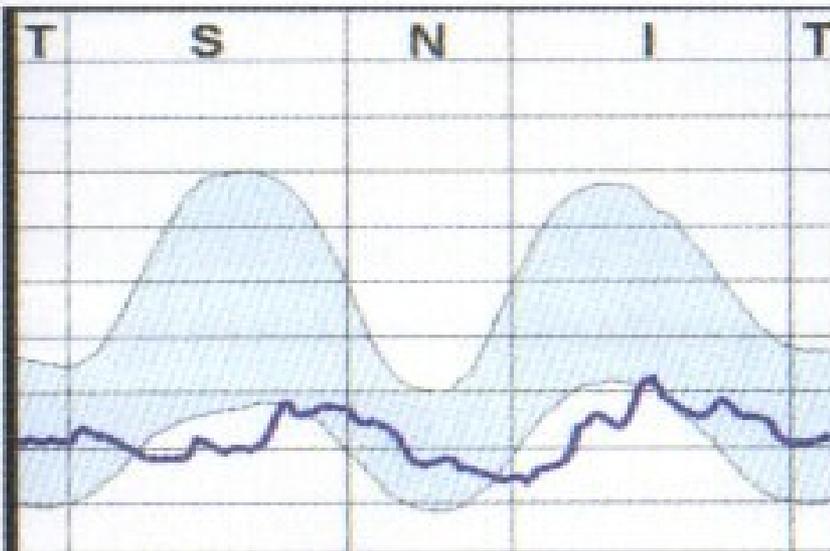
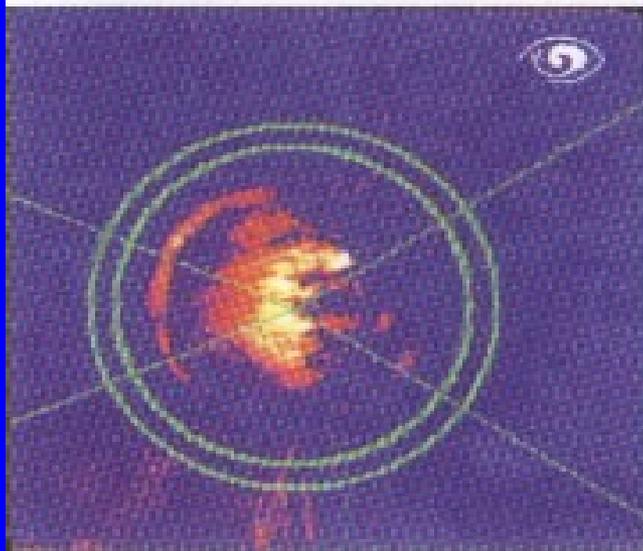
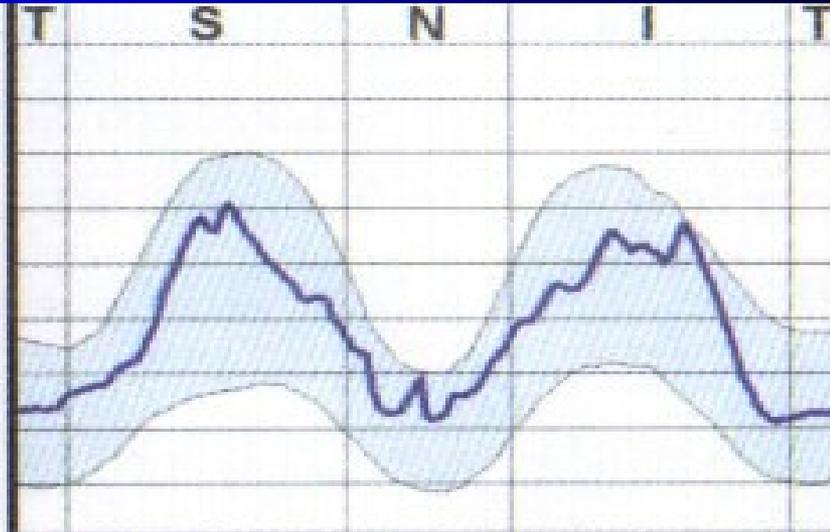
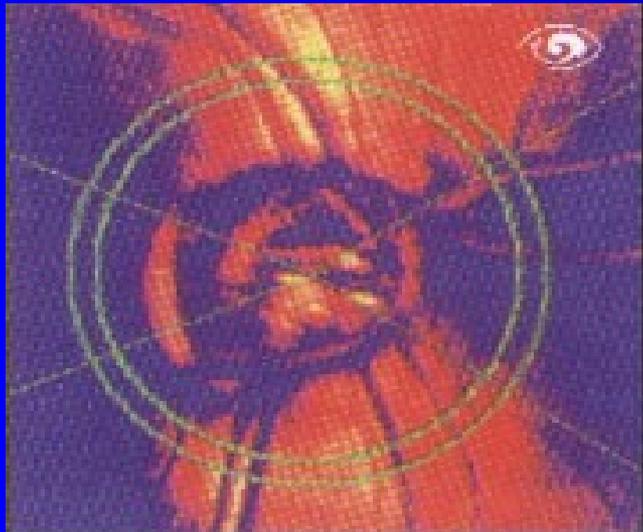




nerve fiber layer defect present as wedge-shaped area of attenuation of the nerve fiber layer



Laser scan of the nerve fiber layer



Types of glaucoma

- **primary**
- **secondary**

- **acute**
- **chronic**
- **intermittent**

- **congenital**
- **juvenile**
- **adult**

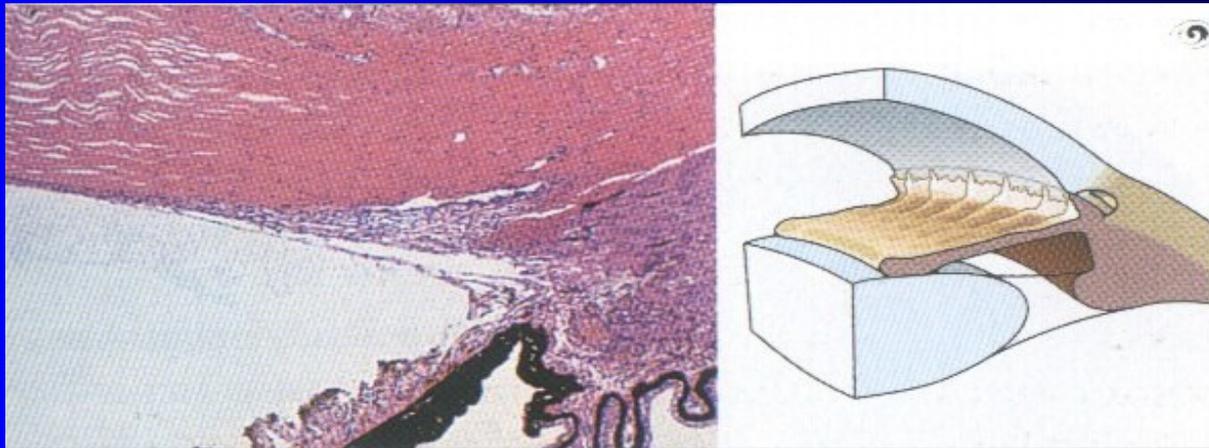
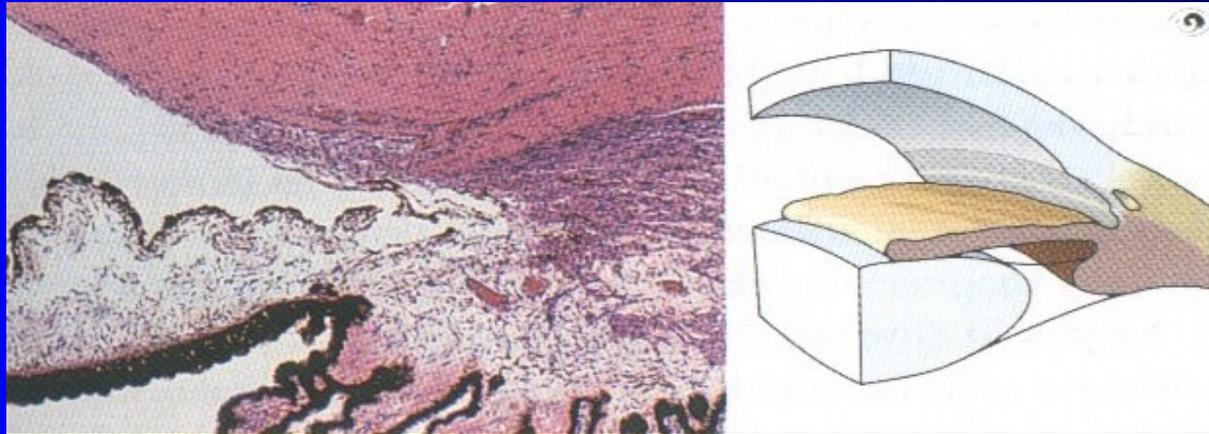
Primary Congenital Glaucoma (PCG)



- More than 80% of cases present before 1 year of age: 40% at birth, 70% between 1-6 months
- 75% of PCG cases occur bilaterally
- The disorder is more common in males and 90% of cases are sporadic, without family history
- Although an autosomal recessive model with variable penetrance has been suggested

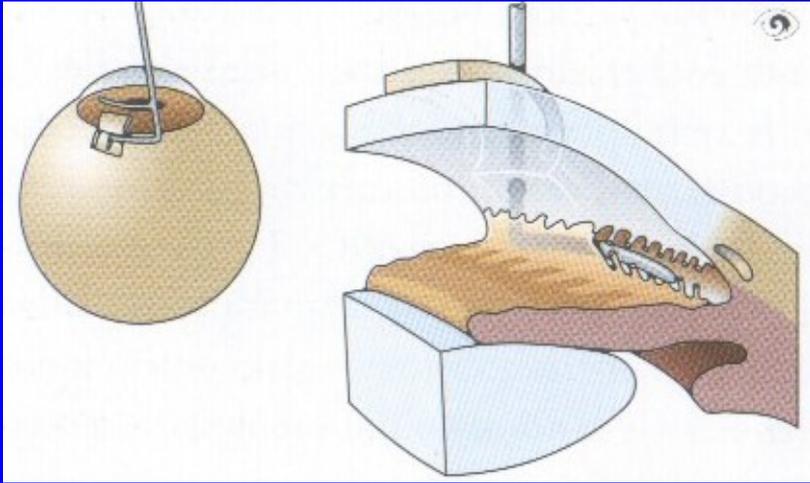
Primary Congenital Glaucoma (PCG)

Normal anterior chamber angle

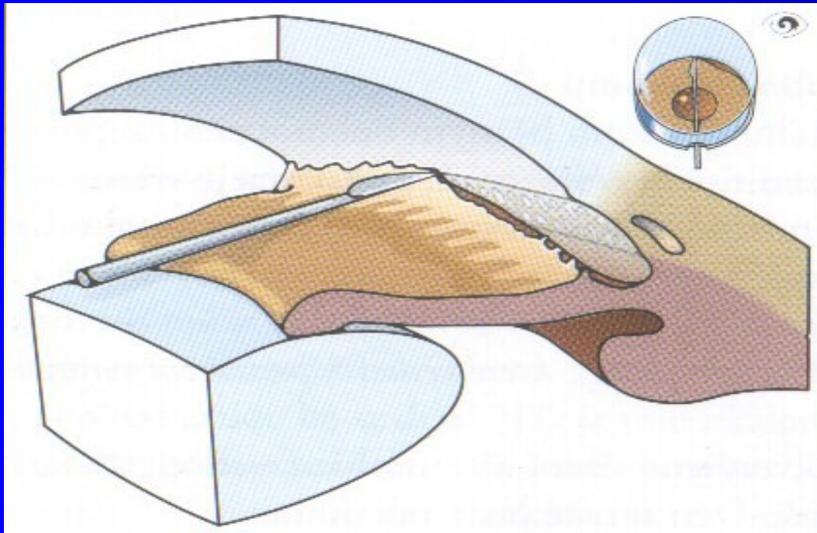


The developmental abnormality of the anterior chamber angle

The treatment of PCG is always surgical. Medical treatment can be used for a limited time. Procedures that involve trabecular incisions are the choice in this condition

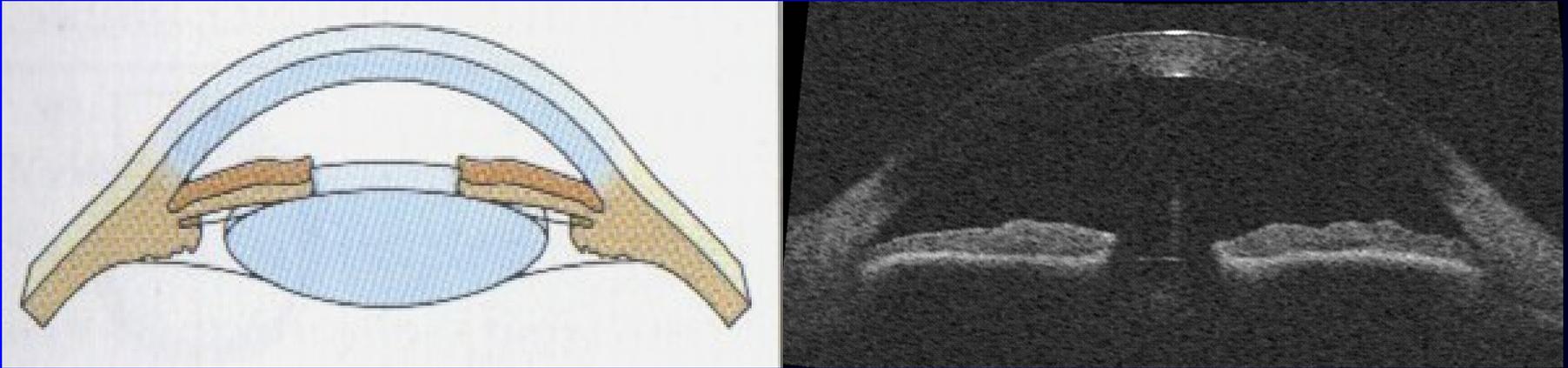


Trabeculotomy with an external approach to Schlemm's canal does not require the clear cornea



Goniotomy requires a clear cornea for visualisation of the angle

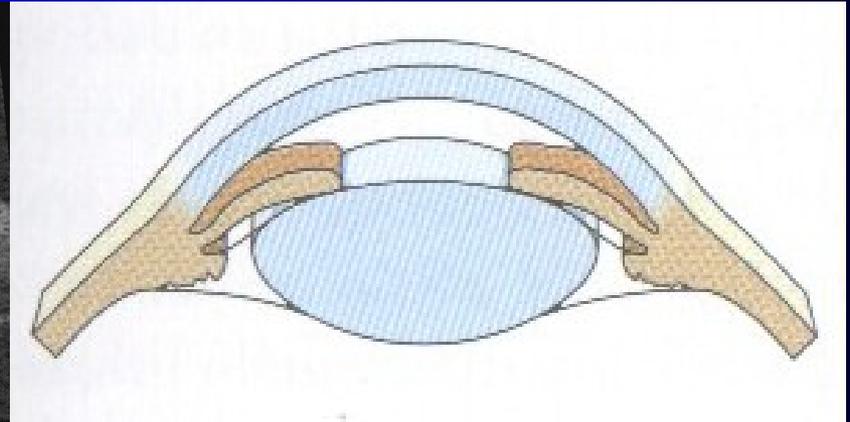
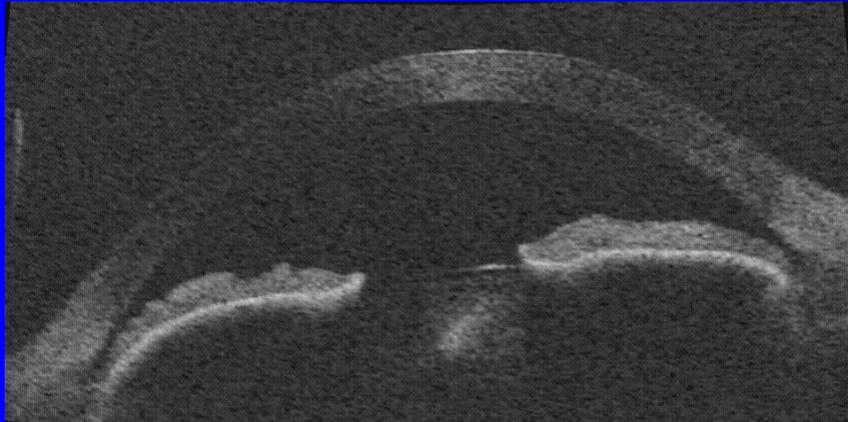
Primary open angle glaucoma (POAG)



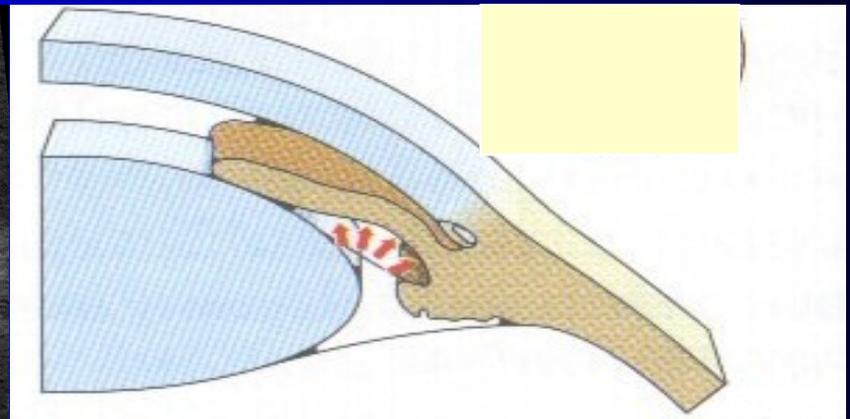
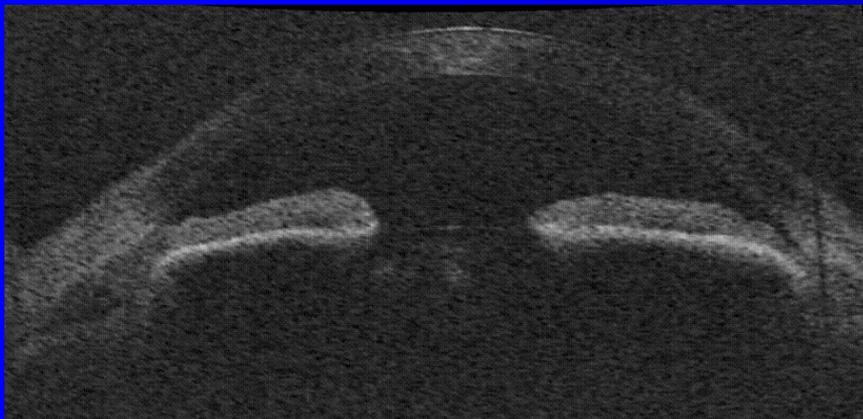
- **Leading cause of irreversible blindness (the incidence of glaucoma is estimate at around 2,5 million per year, blindness people is probably around 3 million)**
- **The majority of patients are older than 60 years of age**
- **The common pathway in the POAG is the death, sometimes by necrosis, but usually by apoptosis, of the retinal ganglion cell. This may lead to further damage, in the retina, optic nerve, and brain**
- **The patient with POAG has no problems for a long time**

PRIMARY ANGLE CLOSURE GLAUCOMA (PACG)

- arising from a preexisting iris configuration



- the apposition of the iris sphincter to the anterior lens capsule (pupillary blok) may cause an increase in pressure behind the iris and mechanical obstruction of outflow through TM



PRIMARY ANGLE CLOSURE GLAUCOMA (PACG)

- **If the pupillary blok is large and the angle is already very narrow, then complete obstruction of the TM occurs, and the IOP rise dramatically resulting **acute angle closure glaucoma****
- **By acute PACG symptoms** range from unilateral mild blurring and pain to extreme pain, nausea, vomiting. These symptoms often occure during the evening. Attacts may be associated with dim illumination, stress, or prolonged near work

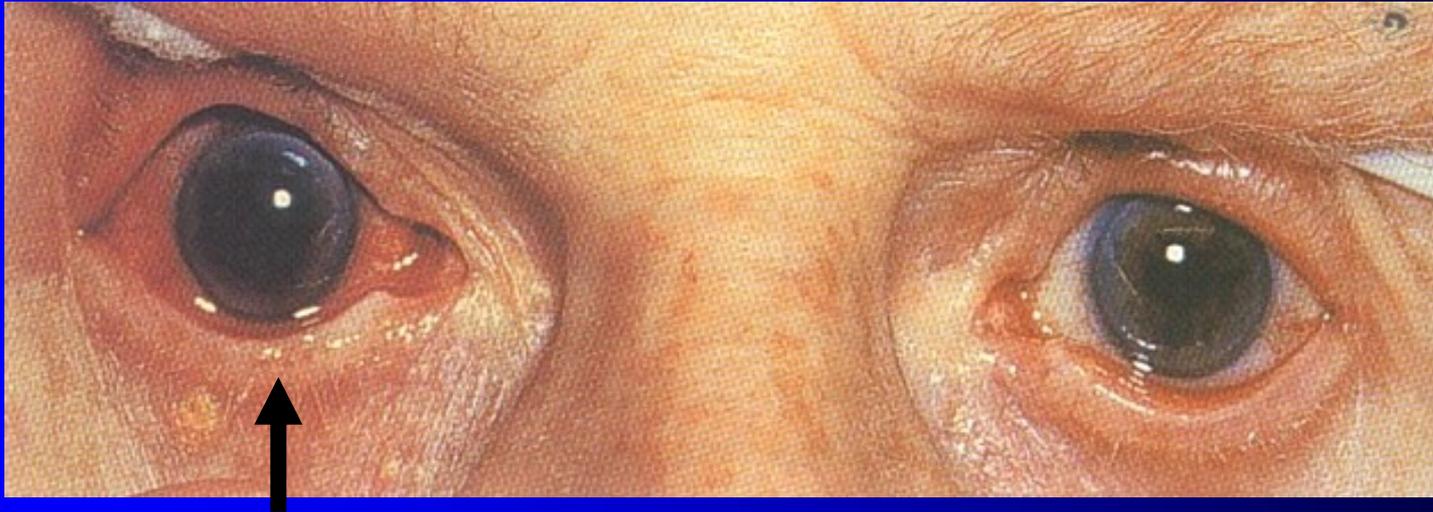
PRIMARY ANGLE CLOSURE GLAUCOMA (PACG)

- If the pupillary block is small, the angle is narrow, and the TM is blocked only in small portion, then IOP rises very slowly, often over many years. This process is termed **chronic primary angle closure glaucoma**
- **By chronic PACG** usually, there are no symptoms. Once the closure is complete, the pressure may rise acutely, and the patient may experience pain

PRIMARY ANGLE CLOSURE GLAUCOMA (PACG)

- **Subacute angle-closure** lies between acute and chronic with regard to the amount of time the IOP rises.
- Symptoms of **subacute angle closure** include intermittent attacks of pain and possibly mildly blurry vision. Symptoms often occur with dim illumination, stress, and near work. Sleep may break the attack. This may be confused with migraine headache.

ACUTE ANGLE CLOSURE GLAUCOMA



The affected eye may show intensive conjunctival hyperemia, mild-dilatated pupil, corneal edema, and shallow anterior chamber. The iris is often in a bombé pattern. The IOP may be as high as 80mmHg. Early in the attack, the optic nerve head show edema and hyperemia

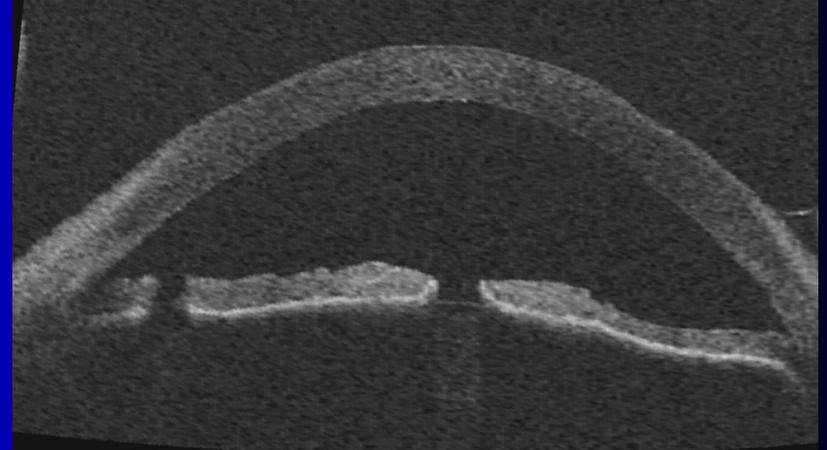
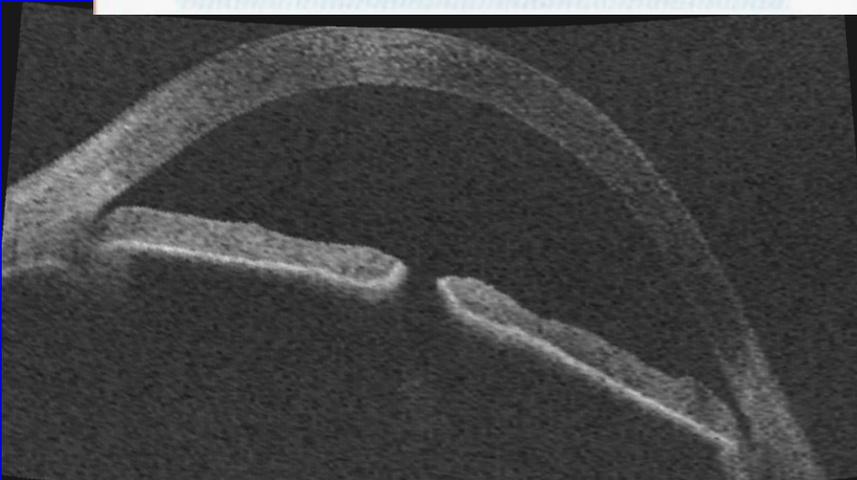
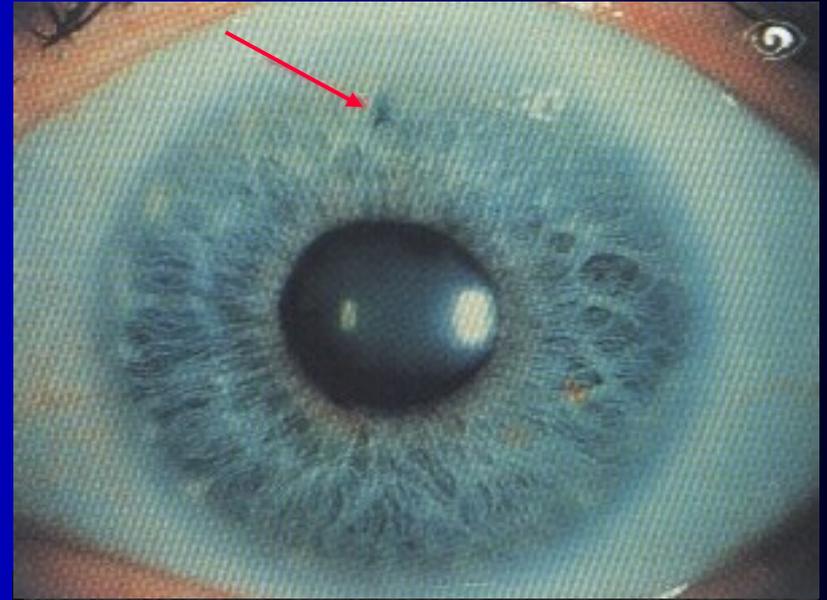
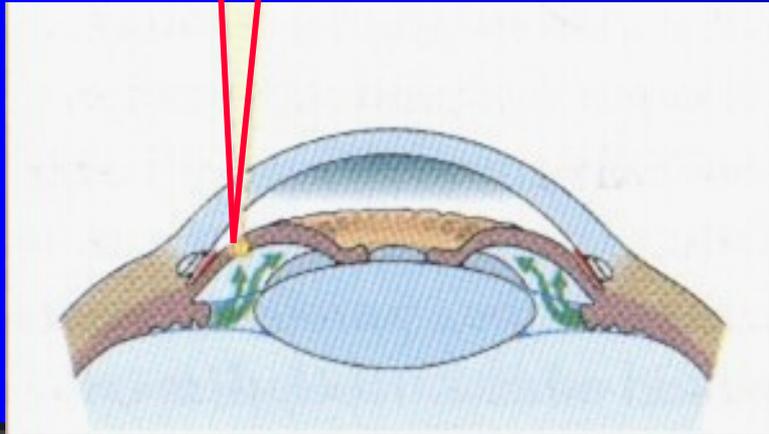


MANAGEMENT OF ACUTE PACG

- **The most common treatment method is to first lower the pressure by aqueous suppressants and osmotic agents. Miotics cause pupillary muscle constriction, which is believed to pull open the TM to increase trabecular outflow. Hyperosmolar agents dehydrate the vitreous and decrease intraocular fluid volume by osmotic drawing fluid into the intravascular space.**
- **This medication may allow the lens-diaphragm to move posteriorly and change the fluid dynamics causing the pupillary block.**
- **Once the corneal edema has cleared, a laser peripheral iridotomy can be performed.**

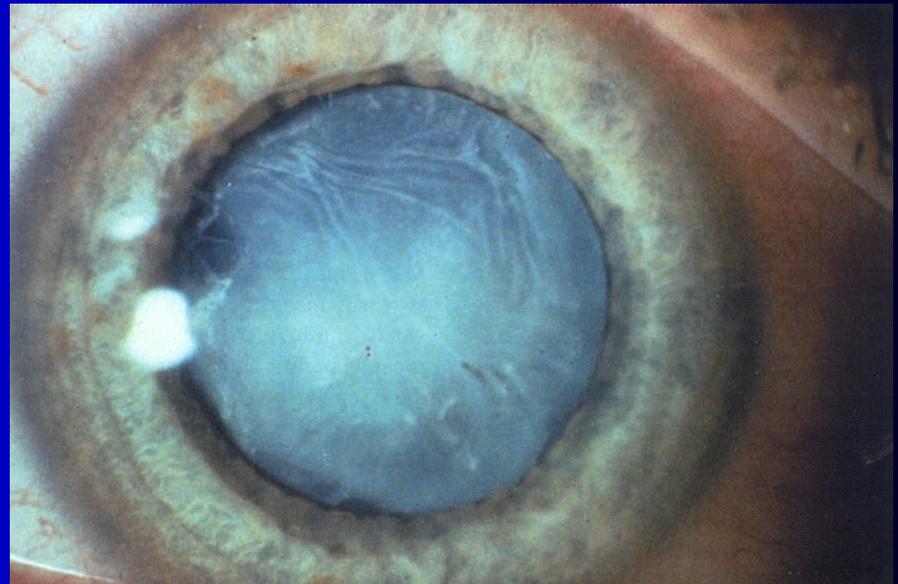
MANAGEMENT OF ACUTE PACG

Laser iridotomy



SECUDARY GLAUCOMA - open angle

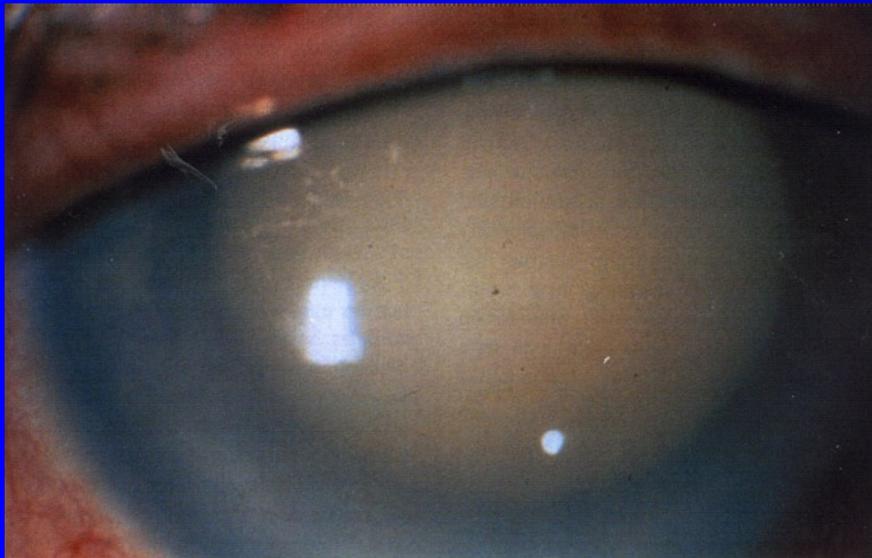
- **lens – associated glaucoma:** lens particle glaucoma, lens protein glaucoma and lens-associated uveitis
 - **lens particle glaucoma:** lens material obstruct TM, disruption to lens capsule with release of lens particule (extracapsular cataract surgery, trauma, Nd-YAG laser)
 - **lens protein glaucoma:** heavy-molecular-weight lens proteins obstruct TM, mature or hyper-mature cataract



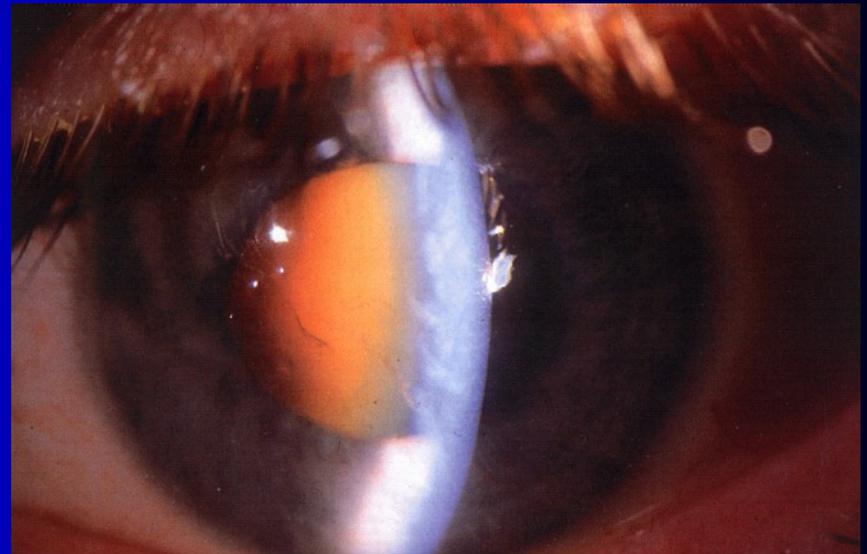
Mature cataract with folds in the anterior capsule

SECUDARY GLAUCOMA - open angle

- **lens-associated uveitis (phacoanaphylactis uveitis)**: loss of immune tolerance to lens proteins, disruption to lens capsule, exposure of large lens fragments. Rare granulomatous inflammation that develops in situation in which the immune system is exposed to lens proteins (after complicated cataract extraction, traumatic rupture of the lens capsule, extraction of the mature or hypermature cataract)



Intense AC inflammation



Corneal swelling, Descemet s folds

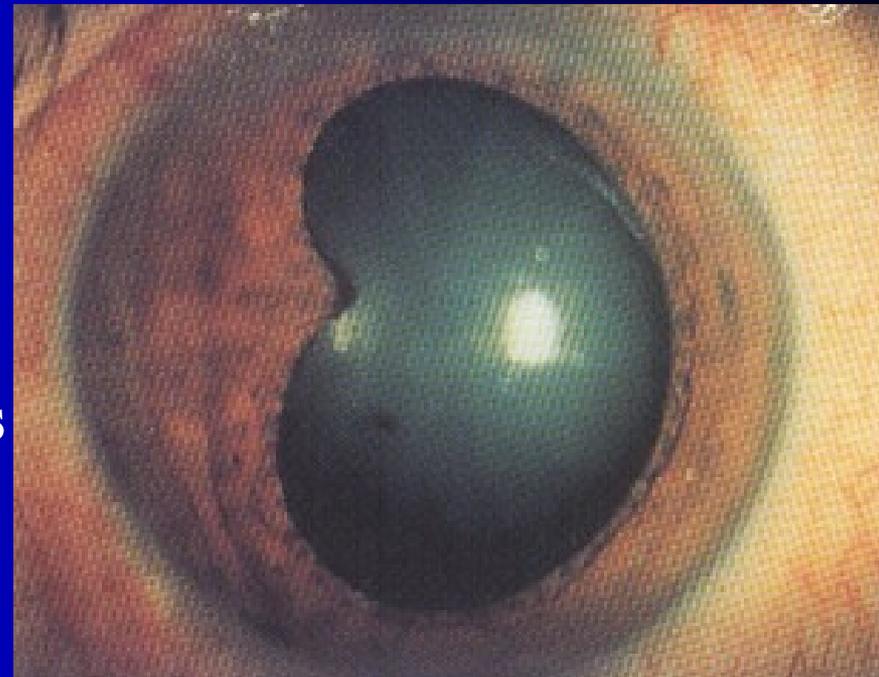
SECUDARY GLAUCOMA – open angle

- **steroid responsive glaucoma** – the incidence is related to the type, dose, and route of steroid administration (**topical, intraocular, periocular, inhaled, oral, intravenous, dermatological**) *increased glycosaminoglycans in the TM in response to steroids impede aqueous outflow and lead to elevated IOP*
- **uveitic glaucoma** - multifactorial process that can be viewed as a complication of the intraocular inflammation, *abnormal aqueous secretion, proteins, prostaglandins, inflammatory cells, trabeculitis, steroid-induced*



SECUDARY GLAUCOMA – open angle

- **uveitic glaucoma –**
 - more common by anterior uveitis and panuveitis
 - more often by granulomatous uveitis
 - the prevalence of glaucoma secondary to uveitis in adults varies from 5,2 to 19%
 - visual prognosis for children with uveitic glaucoma is worse



TRAUMATIC GLAUCOMA

- Following blunt or penetrating trauma to the globe, patients often develop difficulties with IOP control. IOP may be elevated acutely or many years following the injury. Trauma can result in injury to any of the ocular structures.



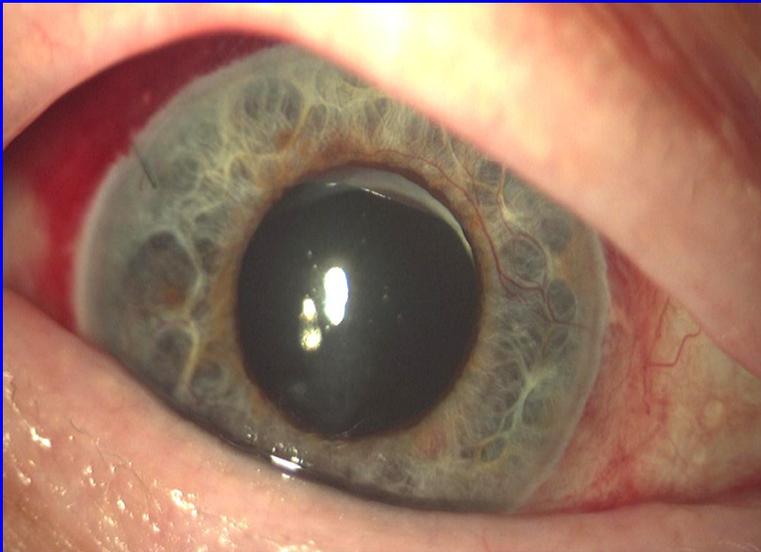
Traumatic hyphema



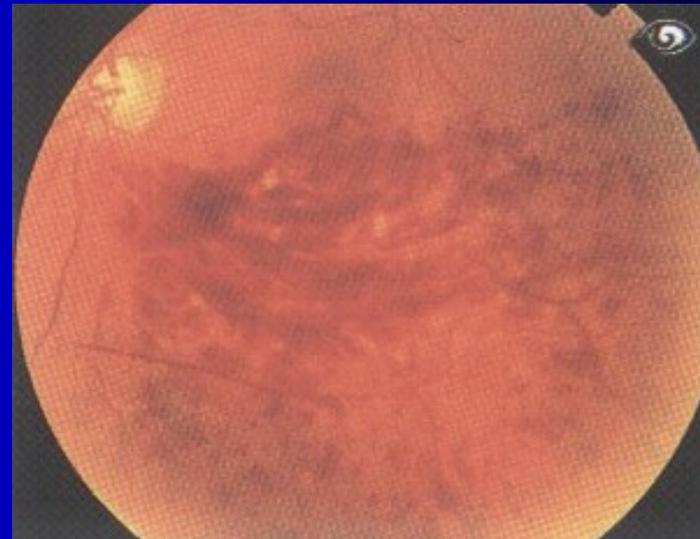
Angle recession – irregular widening of the ciliary body band

SECONDARY angle-closure GLAUCOMA

- **neovascular glaucoma** – most commonly occur after ischemic central retinal vein occlusion and proliferative diabetic retinopathy. A fibrovascular membrane grows over (tm) and closing the anterior chamber angle



Neovascularization of the iris is seen near the pupillary margin



Central retina after ischemic retinal vein occlusion

GLAUCOMA MANAGEMENT

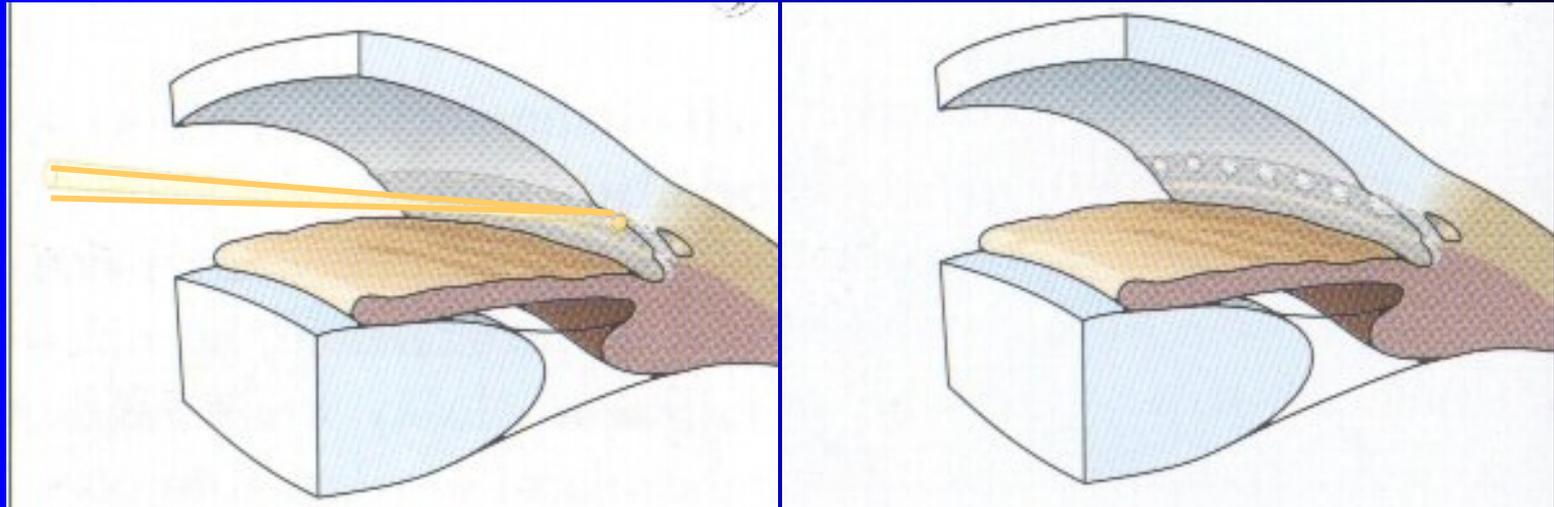
- **the goal of glaucoma treatment is to retard or halt the ganglion cell loss to prevent symptomatic visual loss**
- **medications, laser , surgery – initial treatment**
- **there are several different classes of medications. All medications work to lower IOP through varying pharmacologic mechanisms**
- **IOP is determined by the balance between secretion and drainage of aqueous humor. All medications either decrease secretion or increase outflow**

PHARMACOLOGIC AGENTS

- Alpha Agonists
- Beta-BLOCKERS
- Carbonic Anhydrase Inhibitors – Oral
- Carbonic Anhydrase Inhibitors – topical
- Hyperosmolar Agents
- Miotics
- Prostaglandins
- Sympathomimetic Agents
- **Combination Agents**

Laser trabeculoplasty

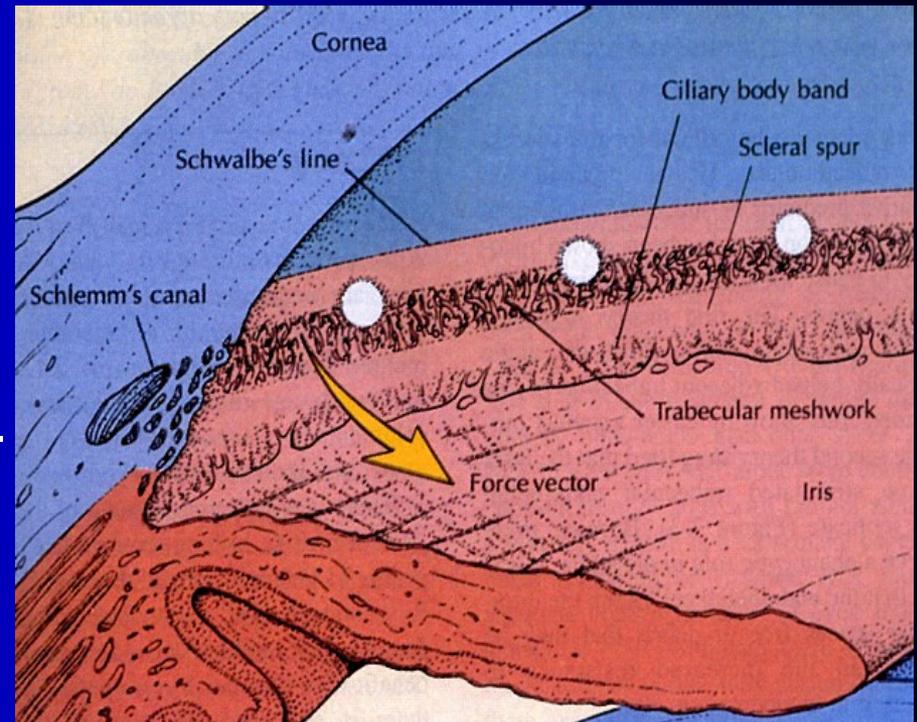
- Argon-laser trabeculoplasty ALT
- Selective laser trabekuloplasty SLT



ARGON LASER TRABECULOPLASTY

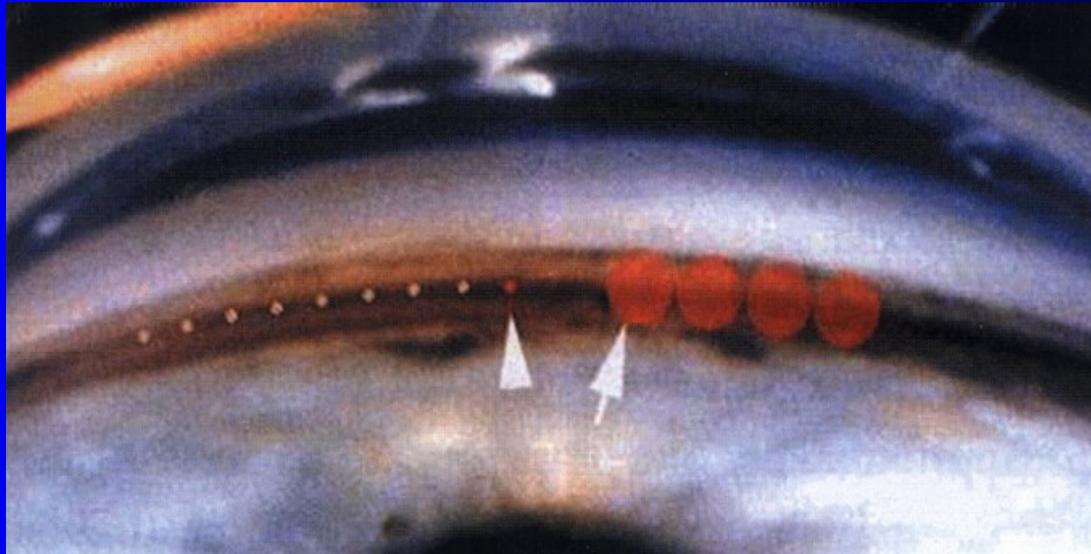
- The laser spot (size $50\mu\text{m}$) is aimed at the junction of the pigmented and nonpigmented TM. A single treatment session of the entire 360 degrees with up 100 applications, or two sessions of 180 degrees each with 50 shots, may be performed.

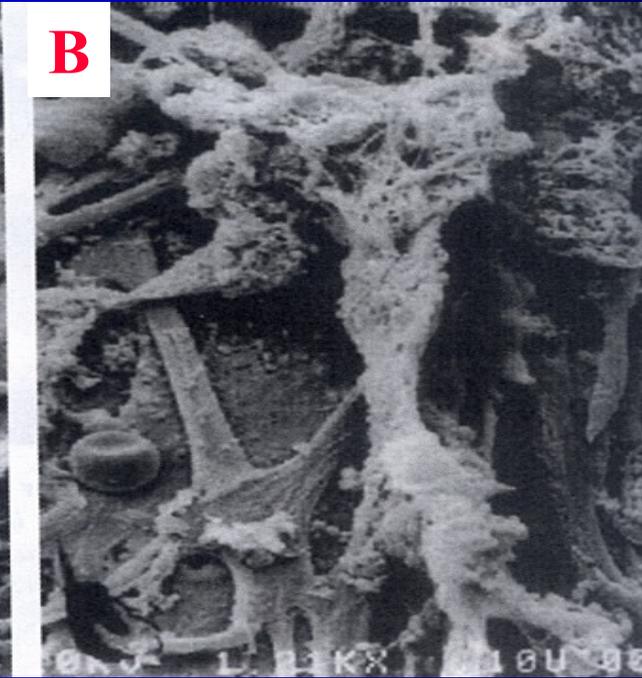
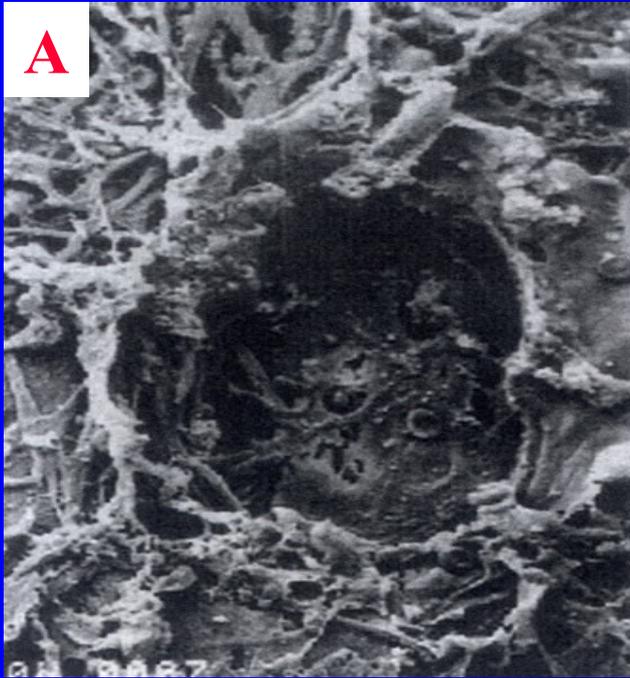
- The thermal burn with Argon laser cause melting and distortion of the trabecular beams. The contraction burns over the angle mechanically helped adjacent trabecular beams open wider , thus allowing easier aqueous outflow



SELECTIVE LASER TRABECULOPLASTY

- In contrast with the continuous wave argon laser, the selective laser does not cause any thermal injury to the trabeculum. The fixed spot size of $400\mu\text{m}$ draws the typical $50\text{-}\mu\text{m}$ spot size used by ALT. The spot size with SLT is so large that the entire angle is covered with aiming beam.



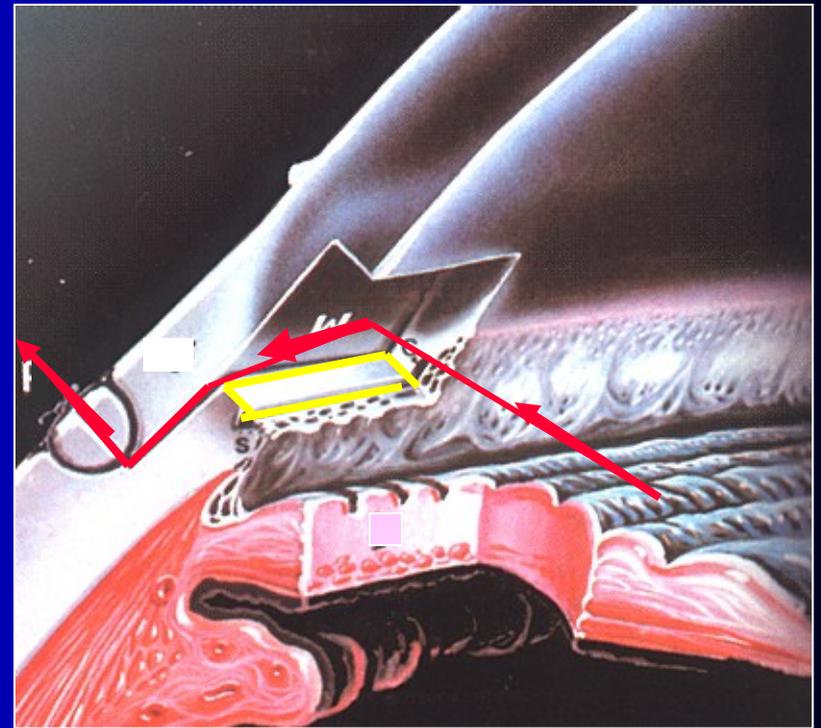
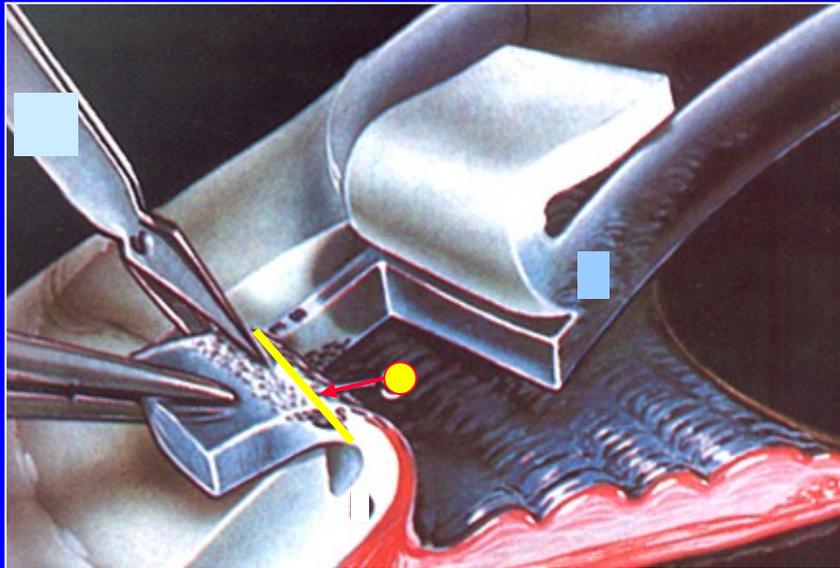


A – Argon burn resulted in coagulative melting of the trabecular beam. Lower magnification showing the crater, the curling of the collagen caused by the thermal damage

B – The selective laser did not cause any significant structural alteration. A higher magnification showing the absence of a crater, a fracture one of the sheets of collagen

GLAUCOMA SURGERY

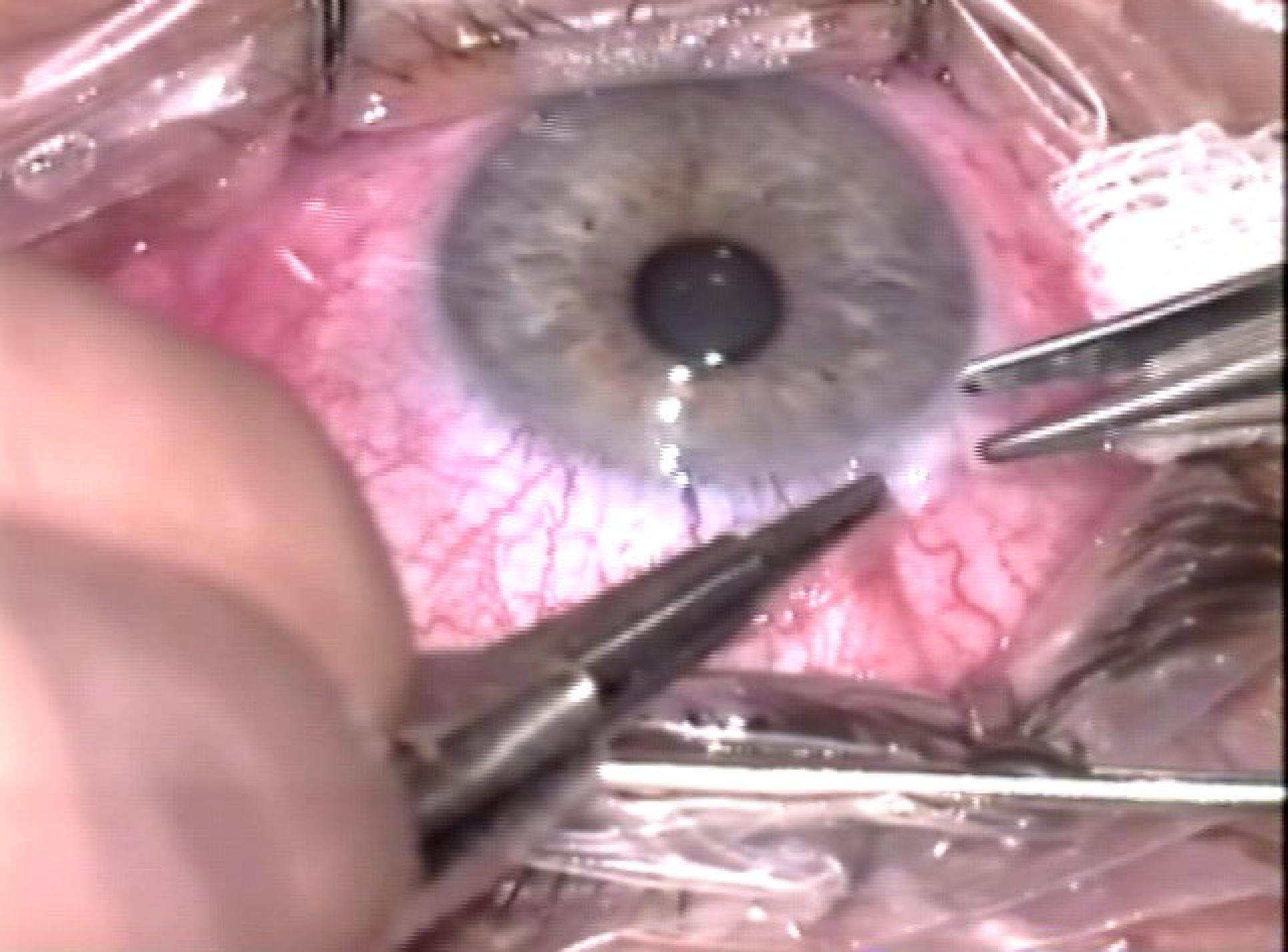
TRABECULECTOMY



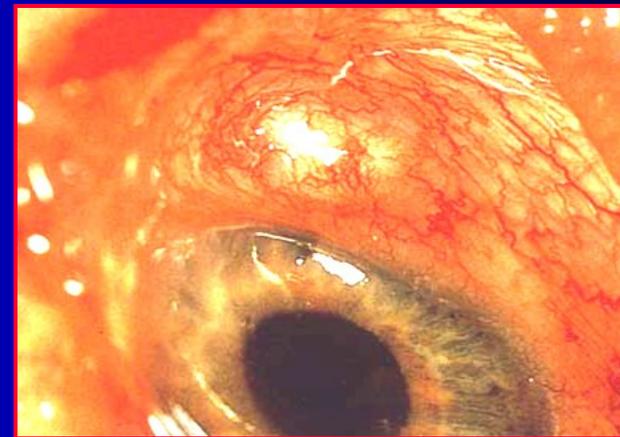
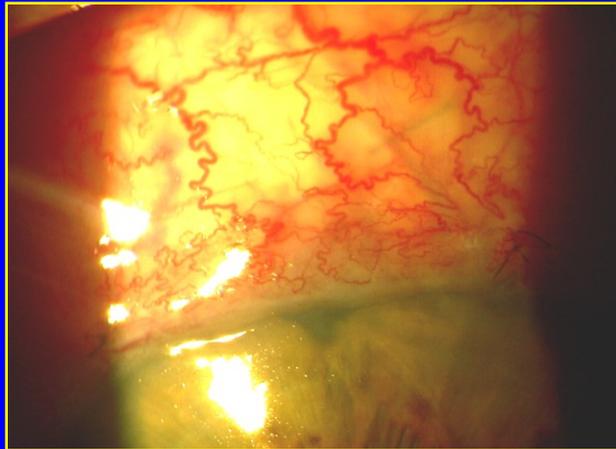
Trabeculectomy lowers the IOP by creating a fistula between the inner compartments and the subconjunctival space

ANTIMETABOLITES

- **To reduce postoperative subconjunctival fibrosis, especially important in cases at high risk for failure, antifibrotic agents (antimetabolites Mitomycin C or 5-fluorouracil) are used. The use of this agents is associated with a higher success and complication rates for primary and high-risk trabeculectomies**

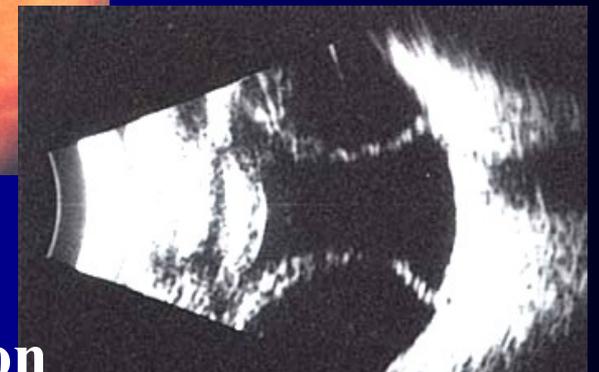
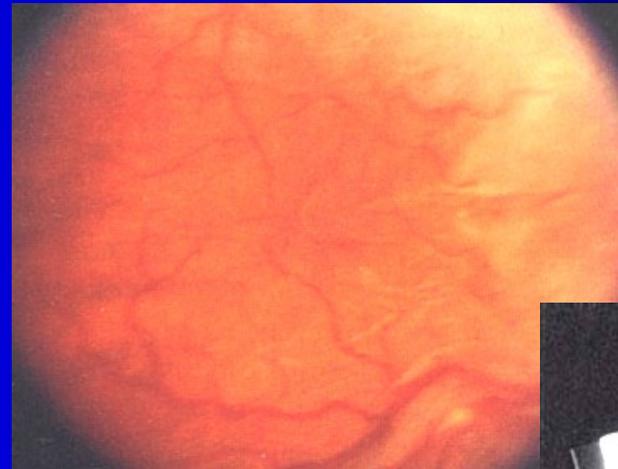
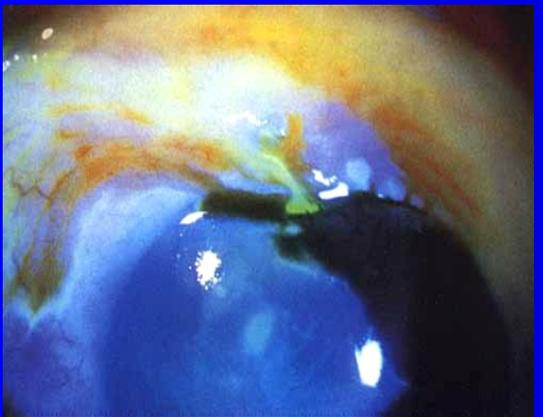
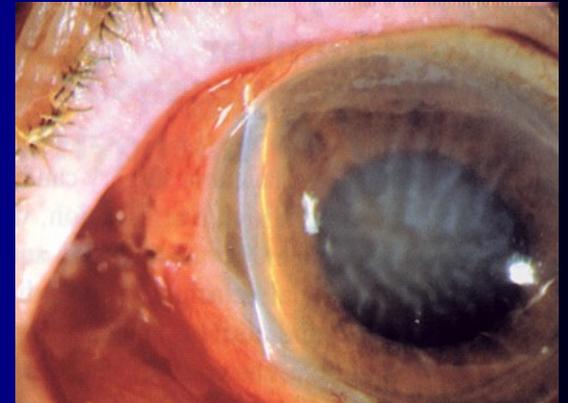
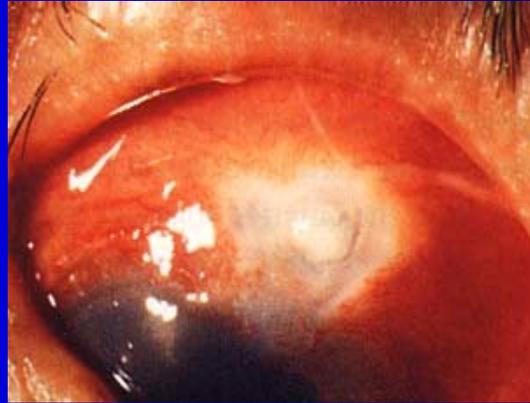
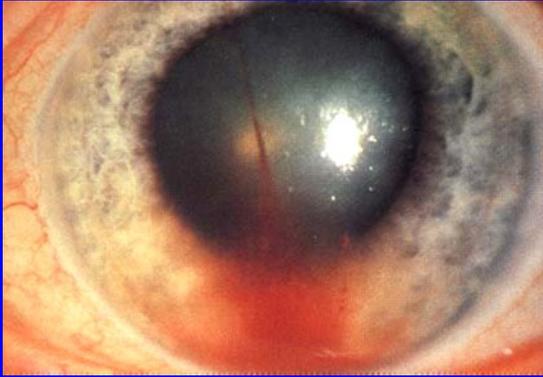


TRABECULEKTOMY – FILTERING BLEB



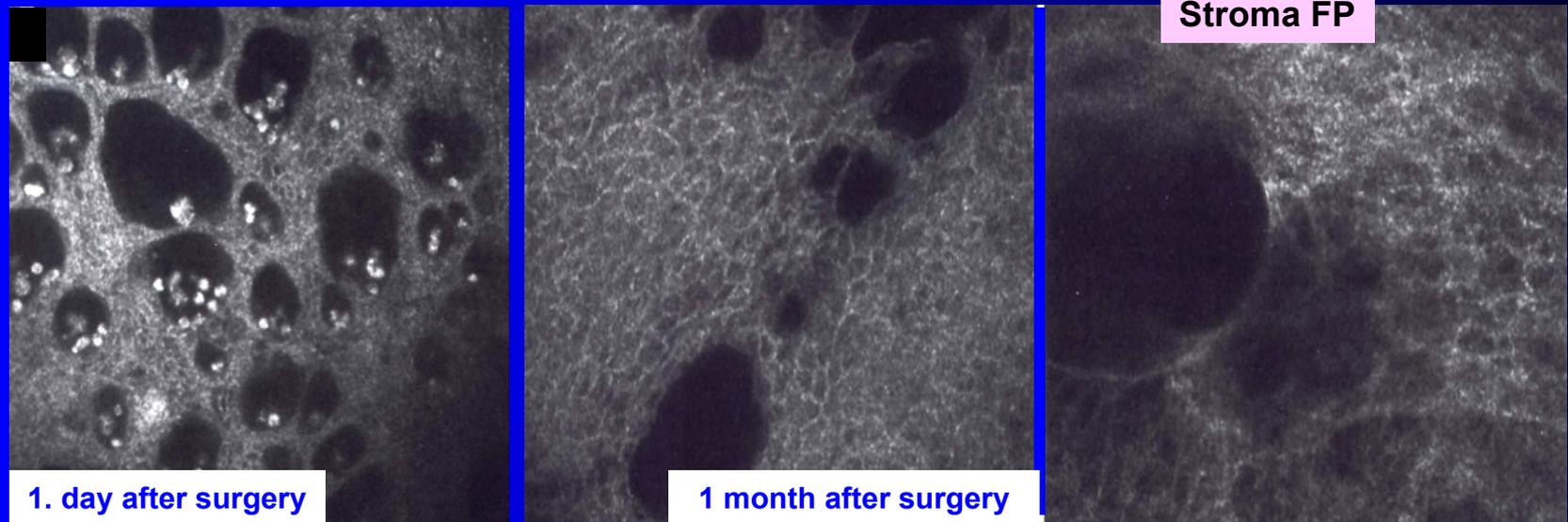
Bleb encapsulation

TRABECULEKTOMY postoperative complications



Choroidal effusion

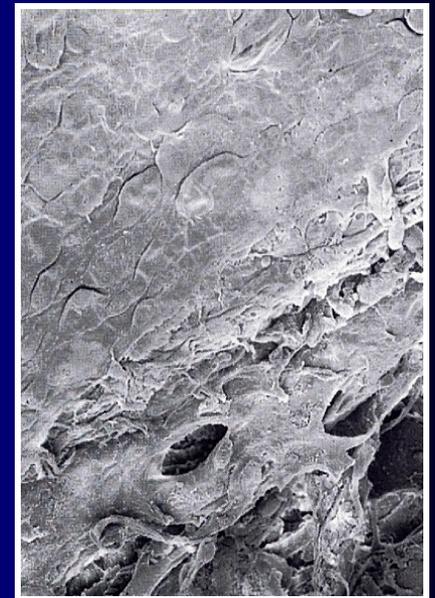
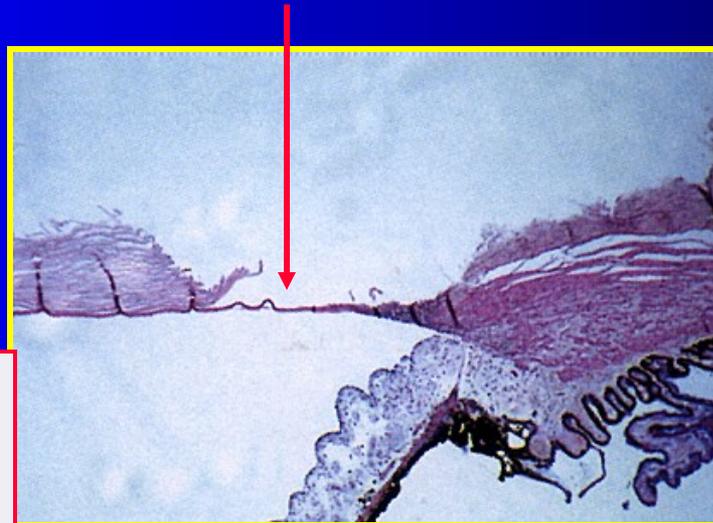
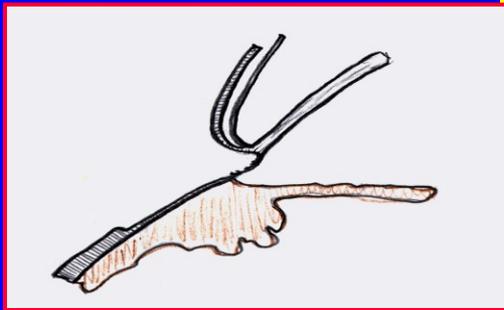
TRABECULEKTOMY – FILTERING BLEB



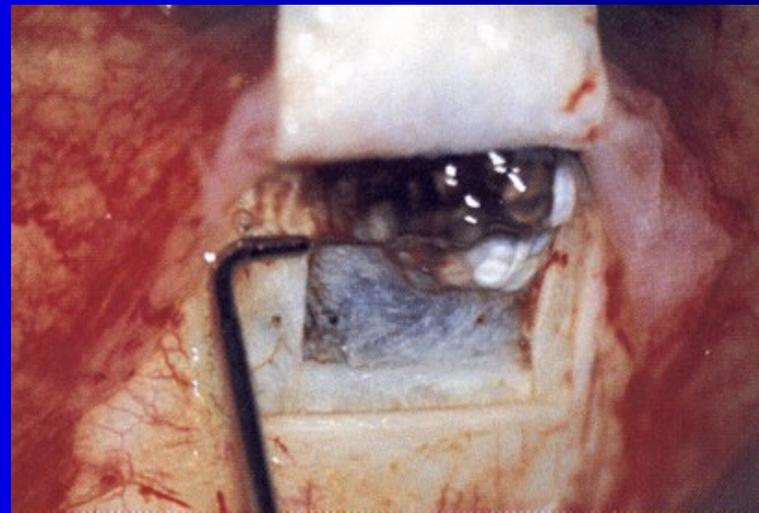
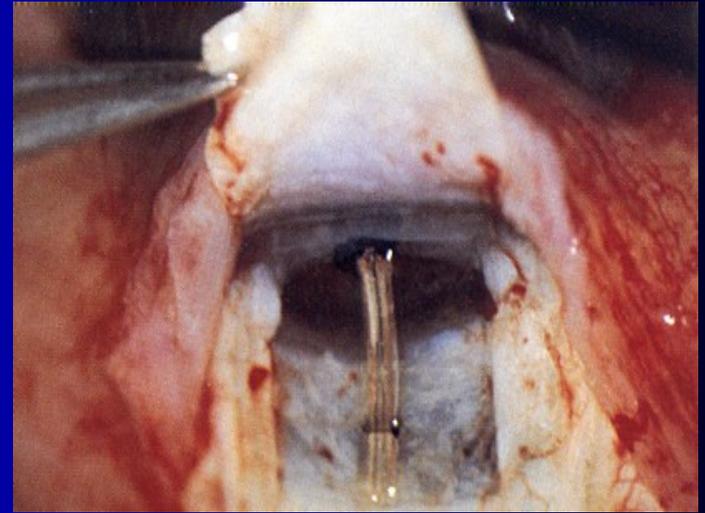
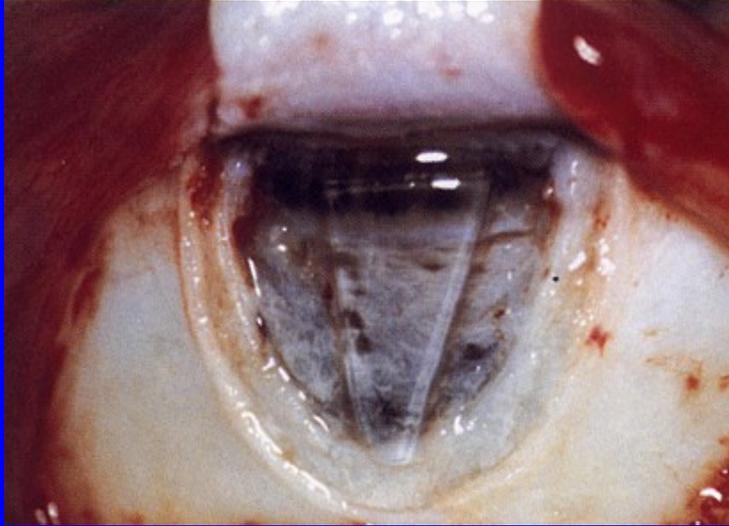
Confocal in vivo mikroskopy of the filtering bleb

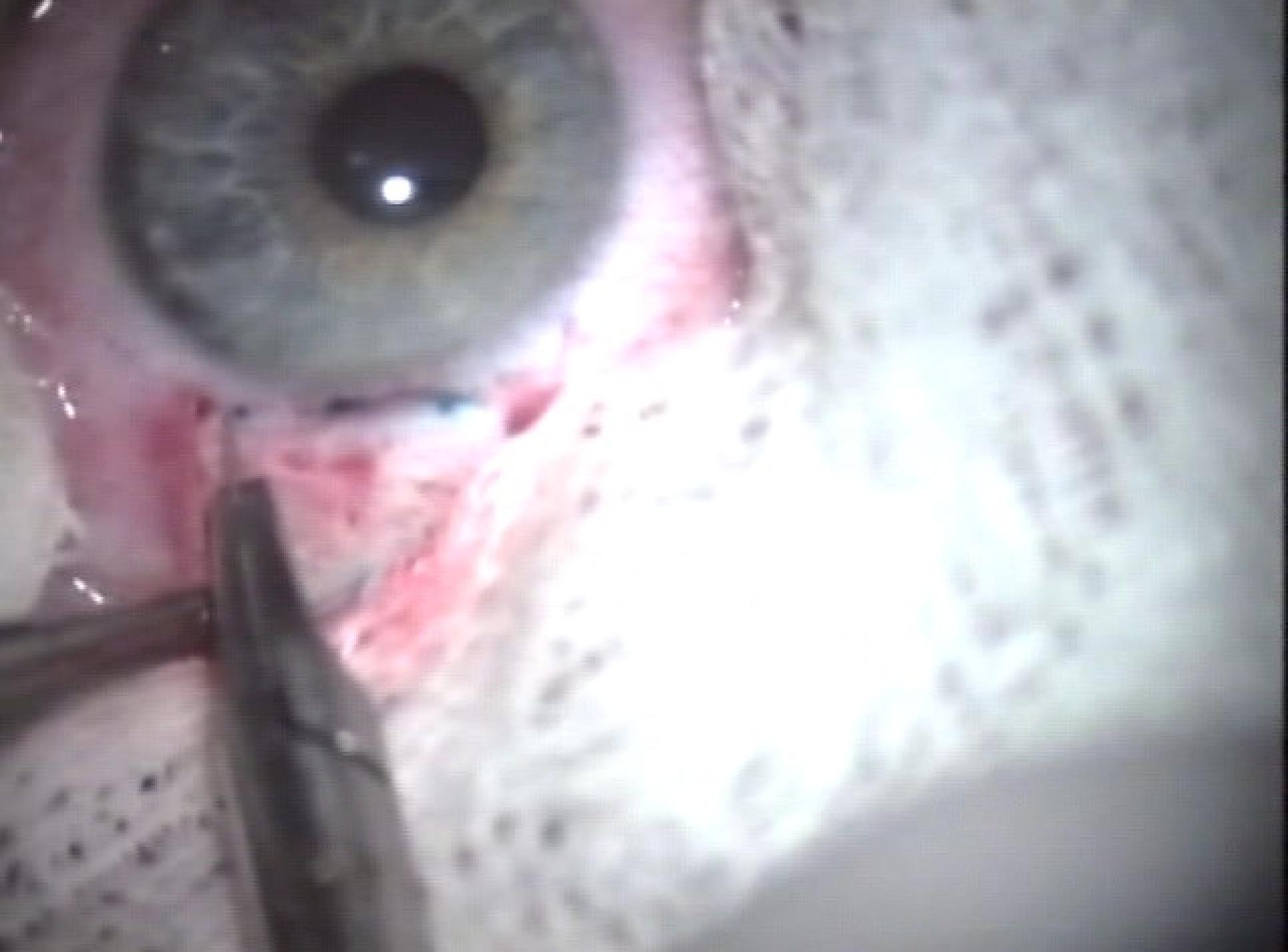
DEEP SCLERECTOMY

trabeculo – Descemet s membrane

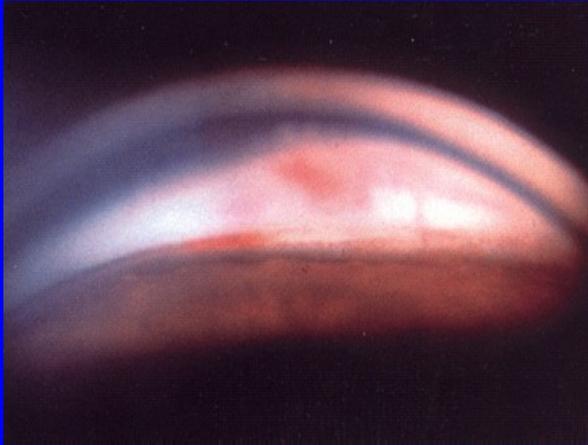


DEEP SCLERECTOMY





DEEP SCLERECTOMY



collagen implant

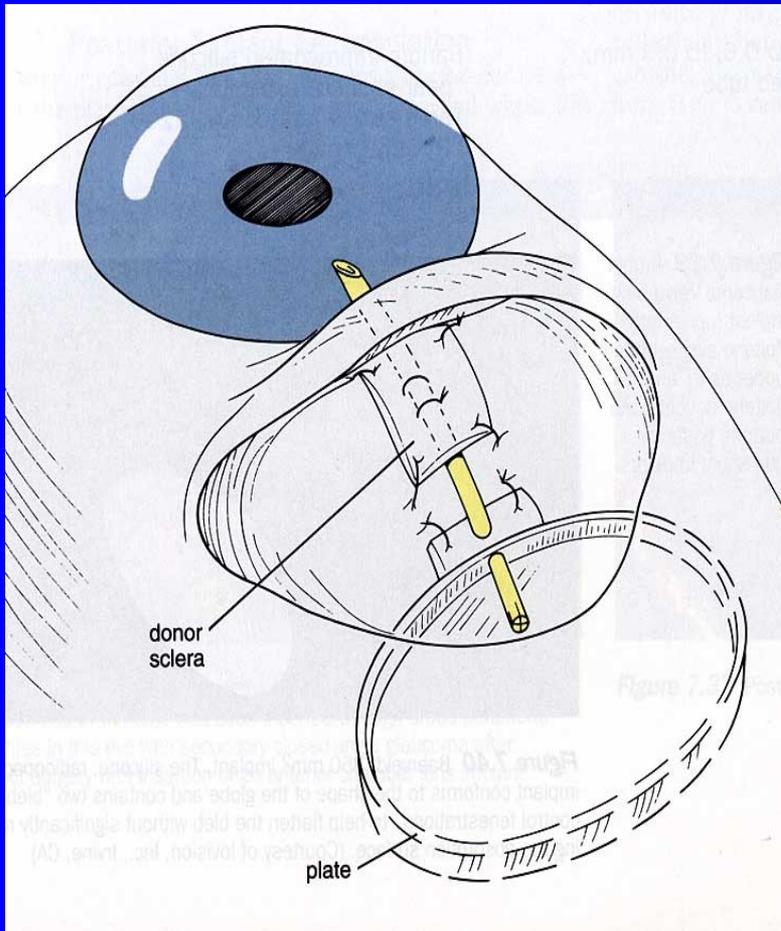
Laser goniopuncture



GLAUCOMA DRAINAGE DEVICES

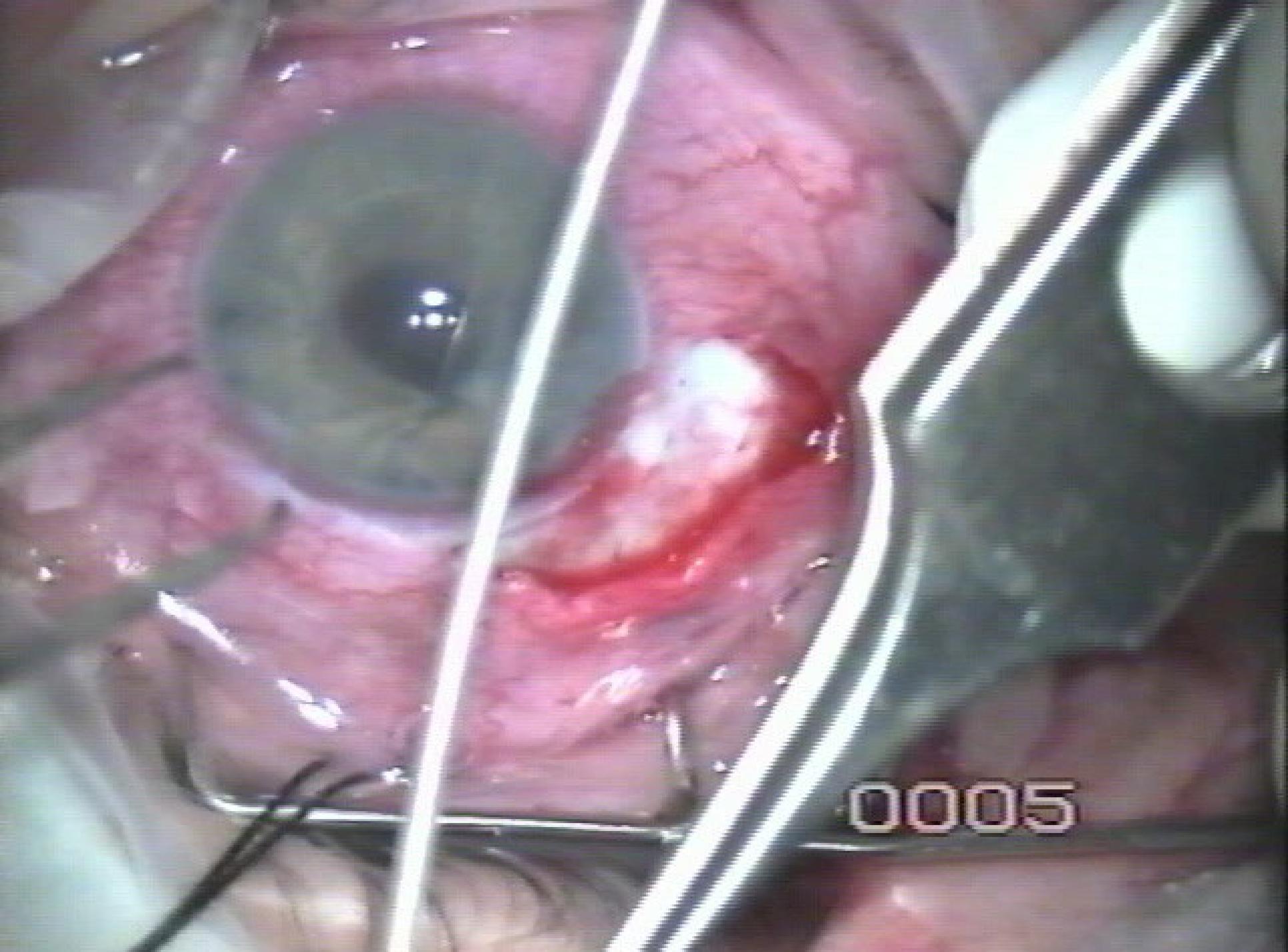
- **Glaucoma drainage devices, also called aqueous shunts or tube shunts, are used to reduce the IOP in patients with uncontrolled glaucoma in whom filtration surgery with antifibrotic agents has already failed or is unlikely to succeed**

GLAUCOMA DRAINAGE DEVICES



The shunting device consists of a posteriorly placed, episcleral plate implant connected to a silicon tube that is inserted into the eye, usually in the anterior chamber

A posterior filtering bleb is formed around the episcleral implant. Aqueous is resorbed by venous capillaries and lymphatics



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