Moscow Helmholtz Research Institute of Eye Diseases, Russia

ULTRASOUND BIOMICROSCOPY IN DIAGNOSIS OF ANTERIOR SEGMENT PATHOLOGY

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ULTRASOUND BIOMICROSCOPY (UBM)

UBM is a noninvasive method that uses high frequency ultrasound (25 - 60 MHz) for qualitative and quantitative evaluation of structures of anterior segment of the eye.

Advantages of UBM

- ✓ Visualization of all structures of anterior segment of the eye to the depth of 16 mm with 35 microns resolution in real time mode
- ✓ Performing both qualitative and quantitative examination of structures of anterior segment of the eye
- ✓ Performing UBM examination independently from the condition of optical media of the eye

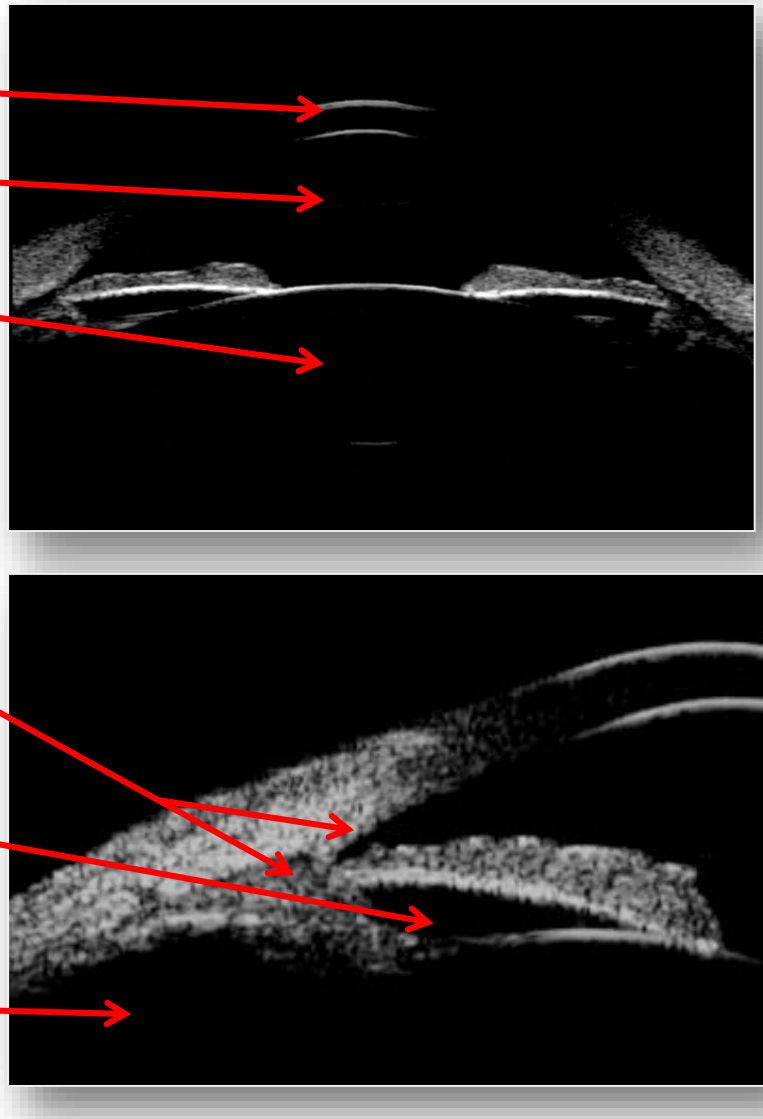
UBM imaging

- Cornea
- Anterior chamber
- Lens and zonule

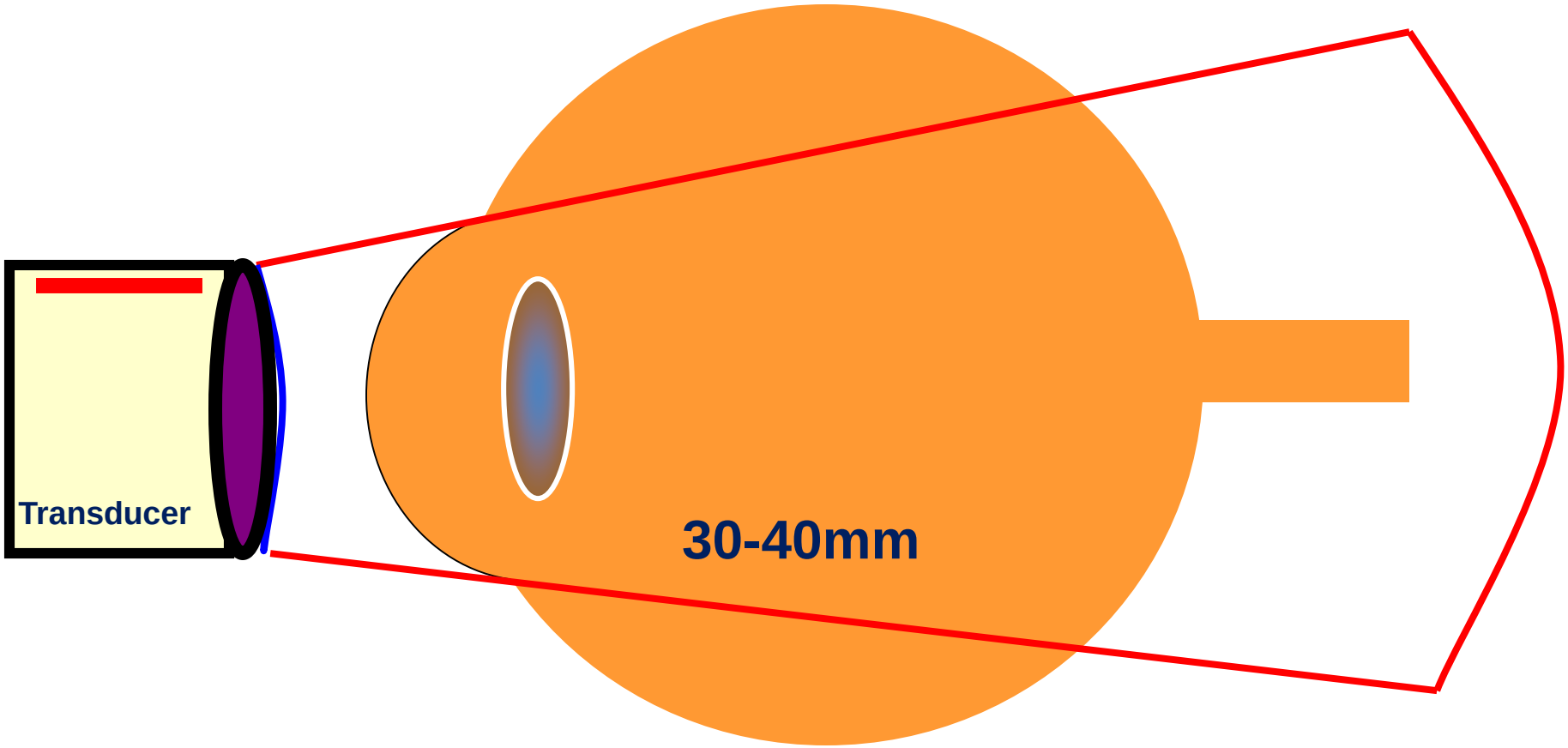
- Iridociliary complex: iris, ciliary body, the anterior chamber angle (ACA)

- Posterior chamber

- The peripheries of vitreous and retina

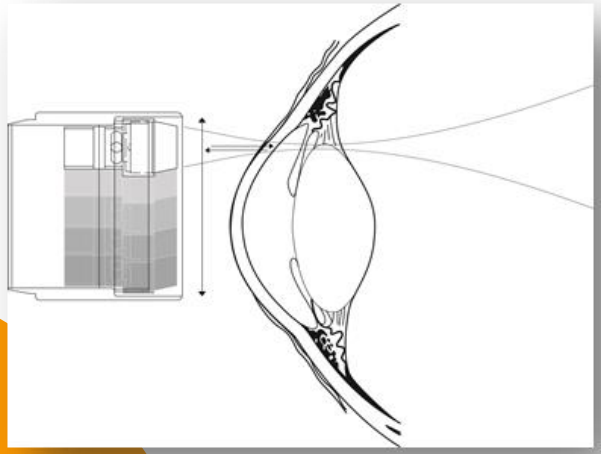


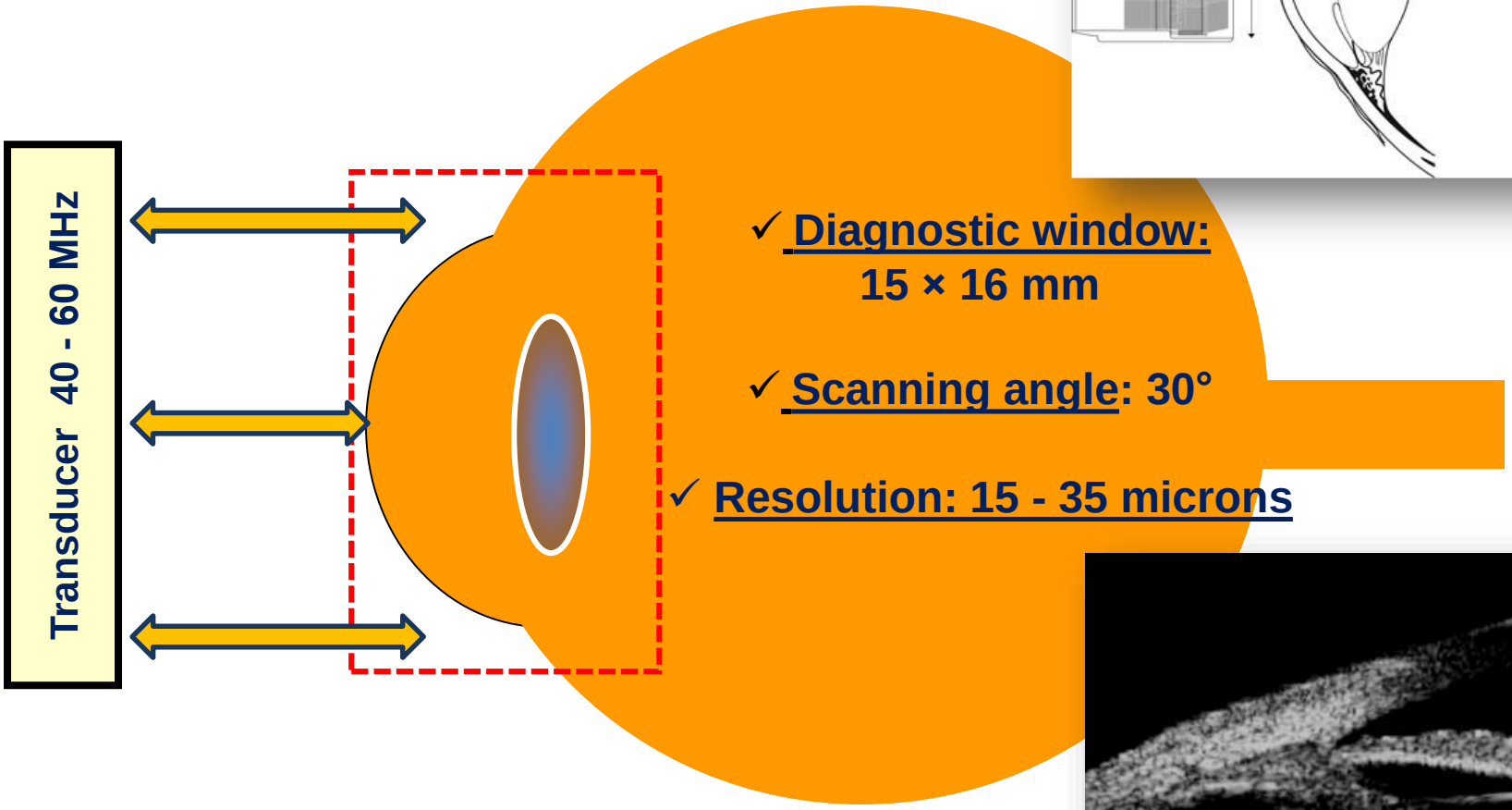
Conventional B-scan “window”



Lateral resolution = 600 microns
Axial resolution = 187 microns

Technique of UBM





- ✓ **Diagnostic window: 15 × 16 mm**
- ✓ **Scanning angle: 30°**
- ✓ **Resolution: 15 - 35 microns**

UBM Technique

- Patient in supine position with topical anesthesia

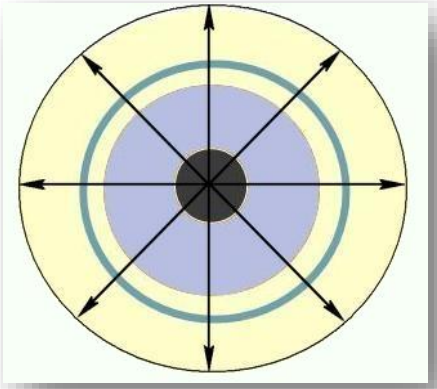
- Eye cup between eyelids filled with normal saline

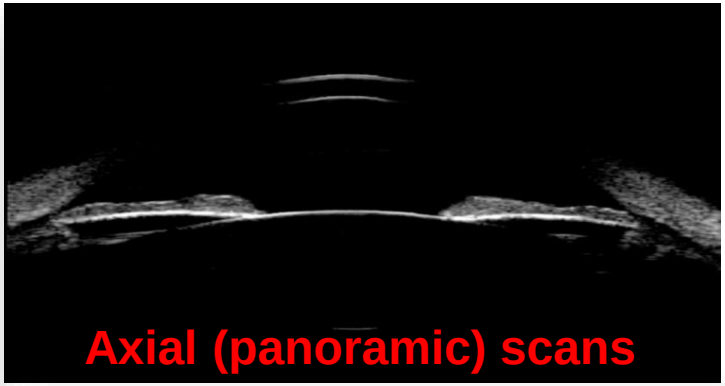
- Probe placed into eye cup

- Real-time image is displayed on a video monitor

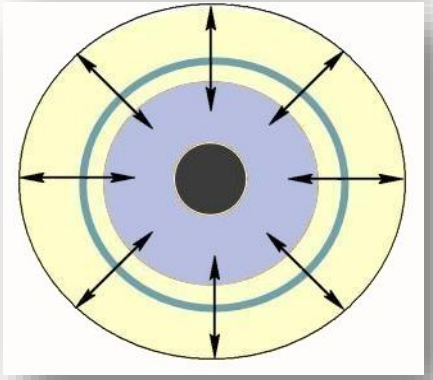
UBM of anterior segment Imaging

Basic positioning of scans

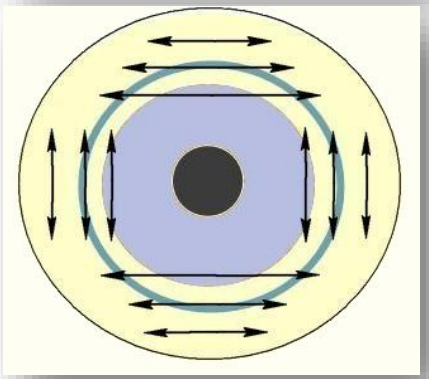




Axial (panoramic) scans

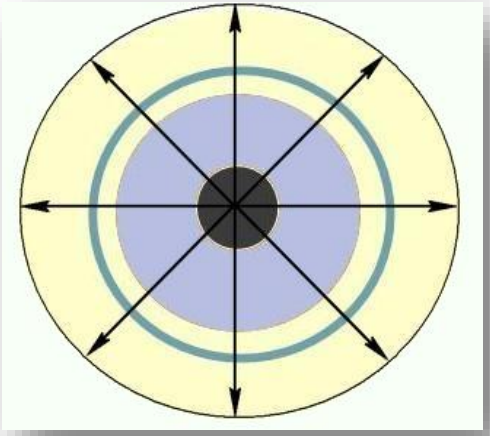


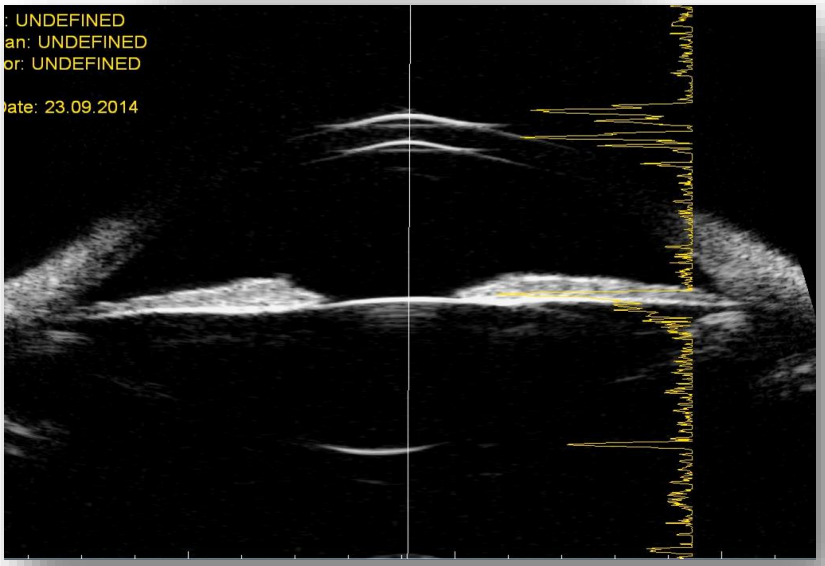
Longitudinal scans



Transverse scans

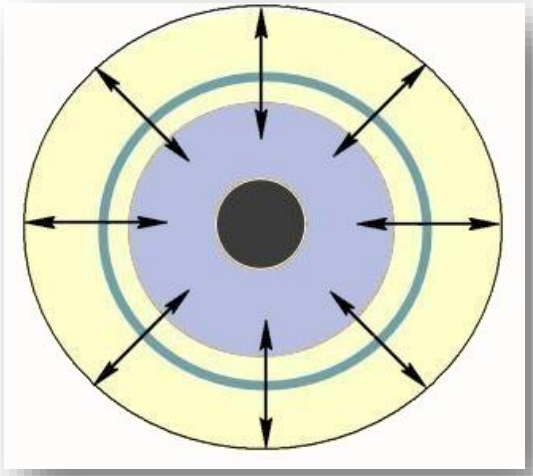
The panoramic UBM imaging of anterior segment (axial scan)

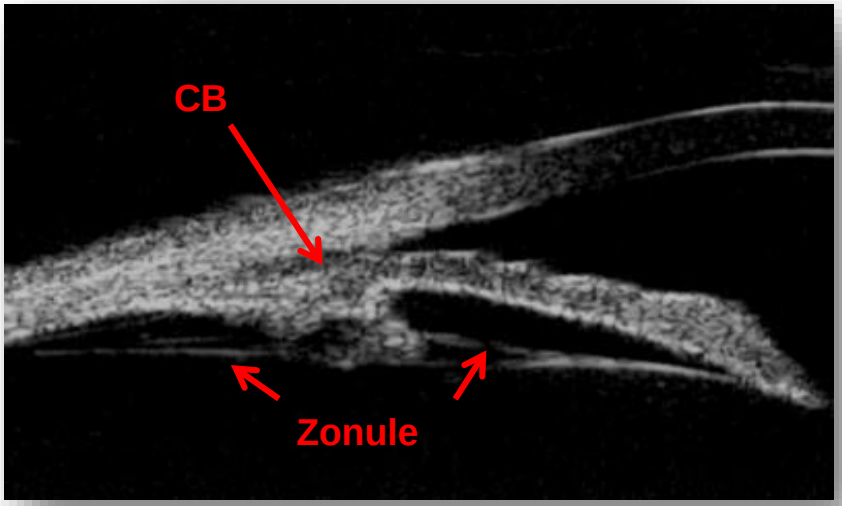




- ✓ **Direct gaze**
- ✓ **The probe perpendicular to the cornea directly over the pupil**
- ✓ **<u>UBM assessment</u>**
  - ***Cornea (thickness, transparency)***
  - ***Anterior chamber (depth, aqueous humor)***
  - ***Iris (position, structure)***
  - ***Lens (transparency, position)***
  - ***Intraocular lens position***

Longitudinal (meridional) sections

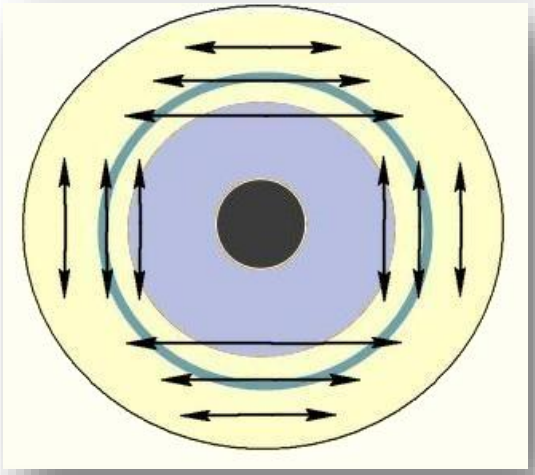


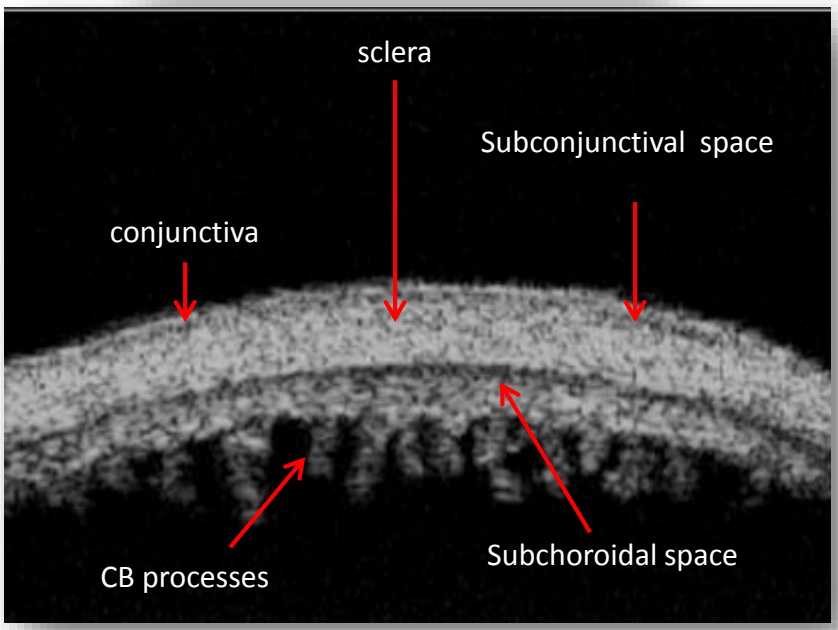


- ✓ **The probe perpendicular to the limbus with the marker towards the pupil according to meridian clock**

- ✓ **<u>UBM assessment</u>**
  - ***Anterior chamber angle (ACA)***
  - ***Iris (thickness, convexity, insertion)***
  - ***Ciliary body (thickness, structure)***
  - ***Lens (zonule, capsule)***
  - ***Intraocular lens haptic***
  - ***Peripheries of vitreous and retina***

Transverse (cross meridian) sections



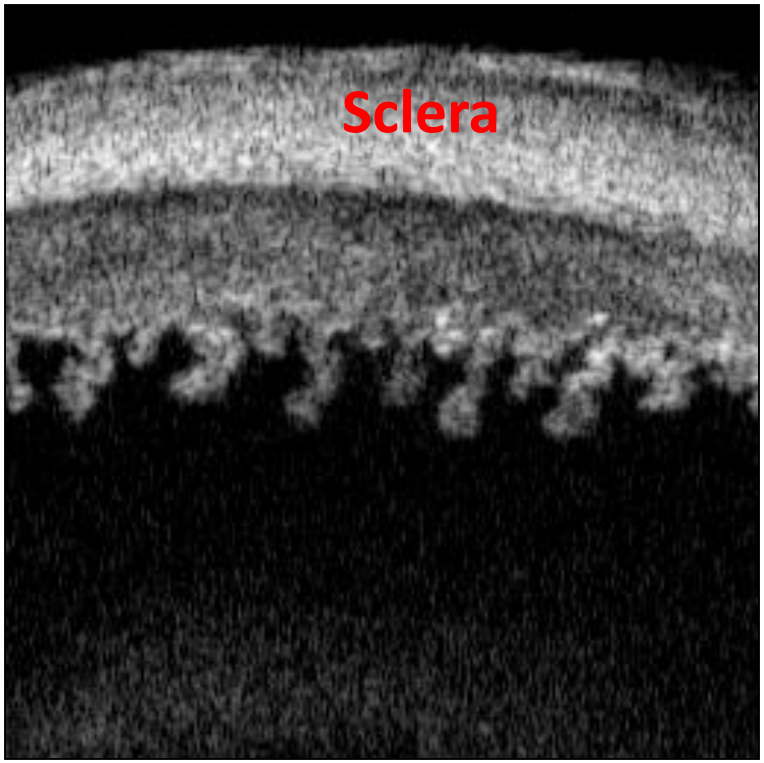


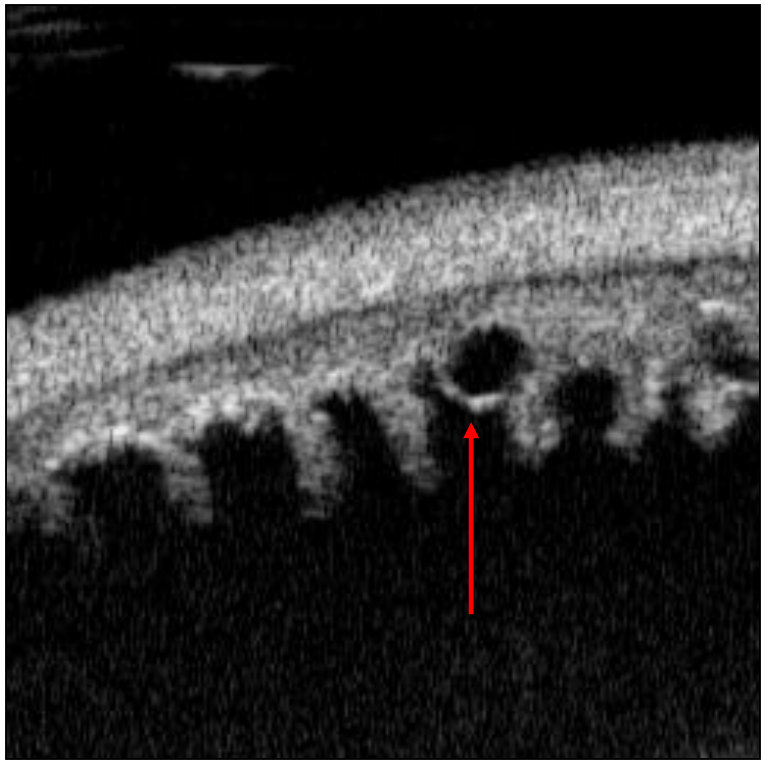
- ✓ **The probe parallel to the limbus over the central iris at the clock hour of interest**

- ✓ **<u>UBM assessment :</u>**
  - ***Iris (thickness, convexity, structure)***
  - ***Ciliary body (thickness, structure, processes, pars plana)***
  - ***Peripheries of vitreous and retina (ora)***

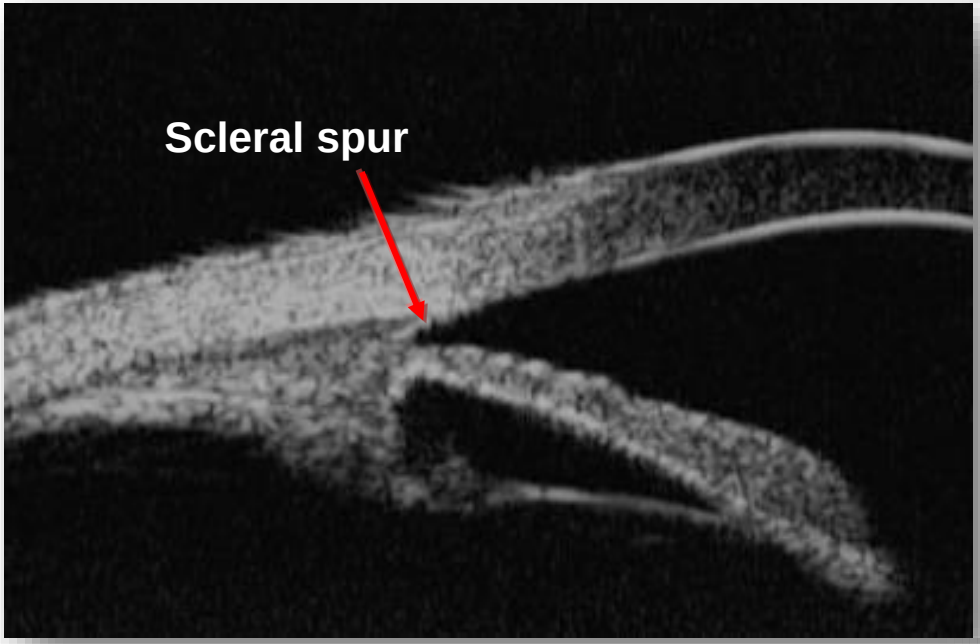
Transverse Section

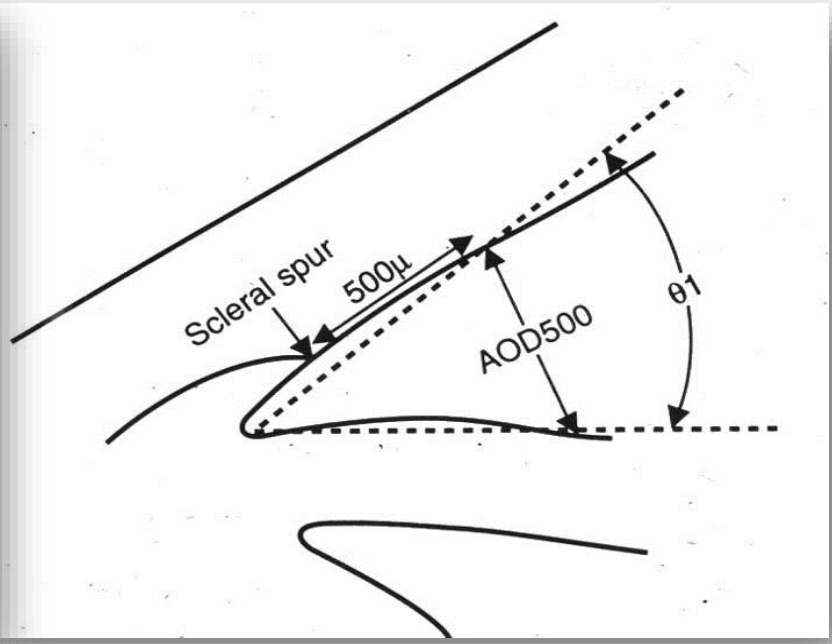
ciliary processes





Angle opening measurements





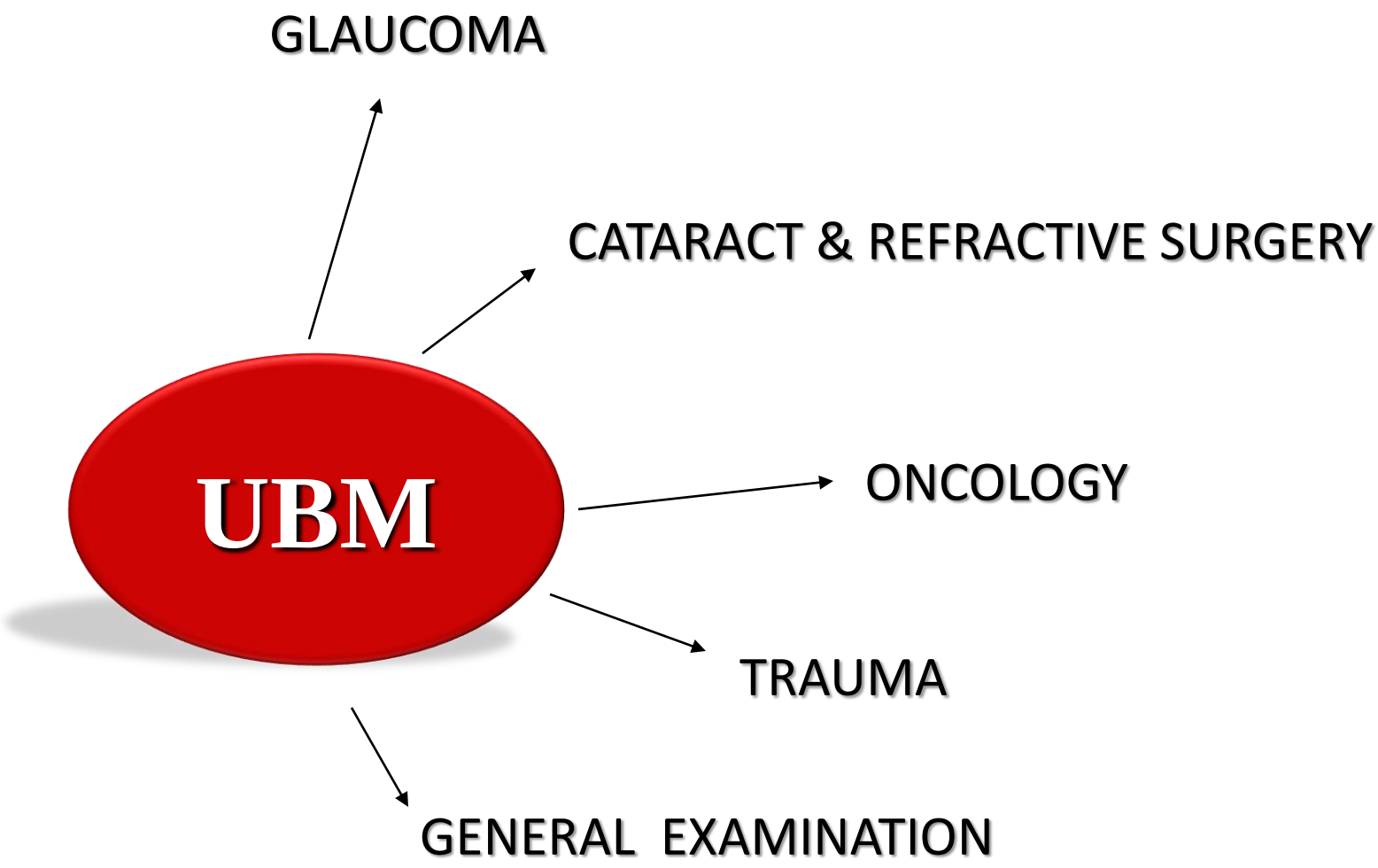
Scleral spur is located where the trabecular meshwork meets the interface line between the sclera and CB

AOD 500 = Angle opening distance at 500 µm from scleral spur

! AOD 500 Emmetropia -0,30 mm, Myopia–0,34 mm, Hypermetropia–0,17 mm

Echographic parameters of anterior segment structures in healthy subjects

	Reflectivity	Structure	Size
Cornea	Low	Regular	0,55 – 0,59 mm
AC	Anechoic	-	3,0 – 3,6 mm
Iris	Medium	Irregular	0,2 – 0,4 mm
CB	Medium	Regular	0,7 – 0,73 mm
Lens	Low	Regular	3,5 – 4,7 mm
Zonule	Medium	Regular	1,0 – 1,3 mm
ACA	-	-	20° - 40°
Sclera	High	Regular	0,6 – 0,8 mm


GLAUCOMA
CATARACT & REFRACTIVE SURGERY
UBM
ONCOLOGY
TRAUMA
GENERAL EXAMINATION

UBM and Glaucoma

Anatomo - topographic relationships among the structures of ACA

Mechanisms in development of glaucoma

Approaches in the treatment of glaucoma

Following up the patients after treatment

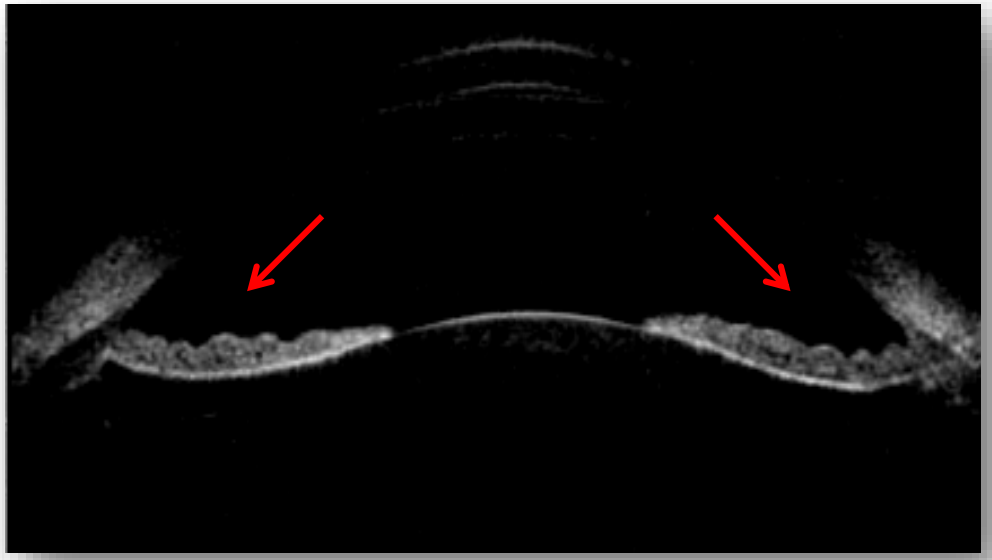
Morphological changes of ciliary body

Topography of newly created outflow tracts during glaucoma surgery

Location of the drainage devices

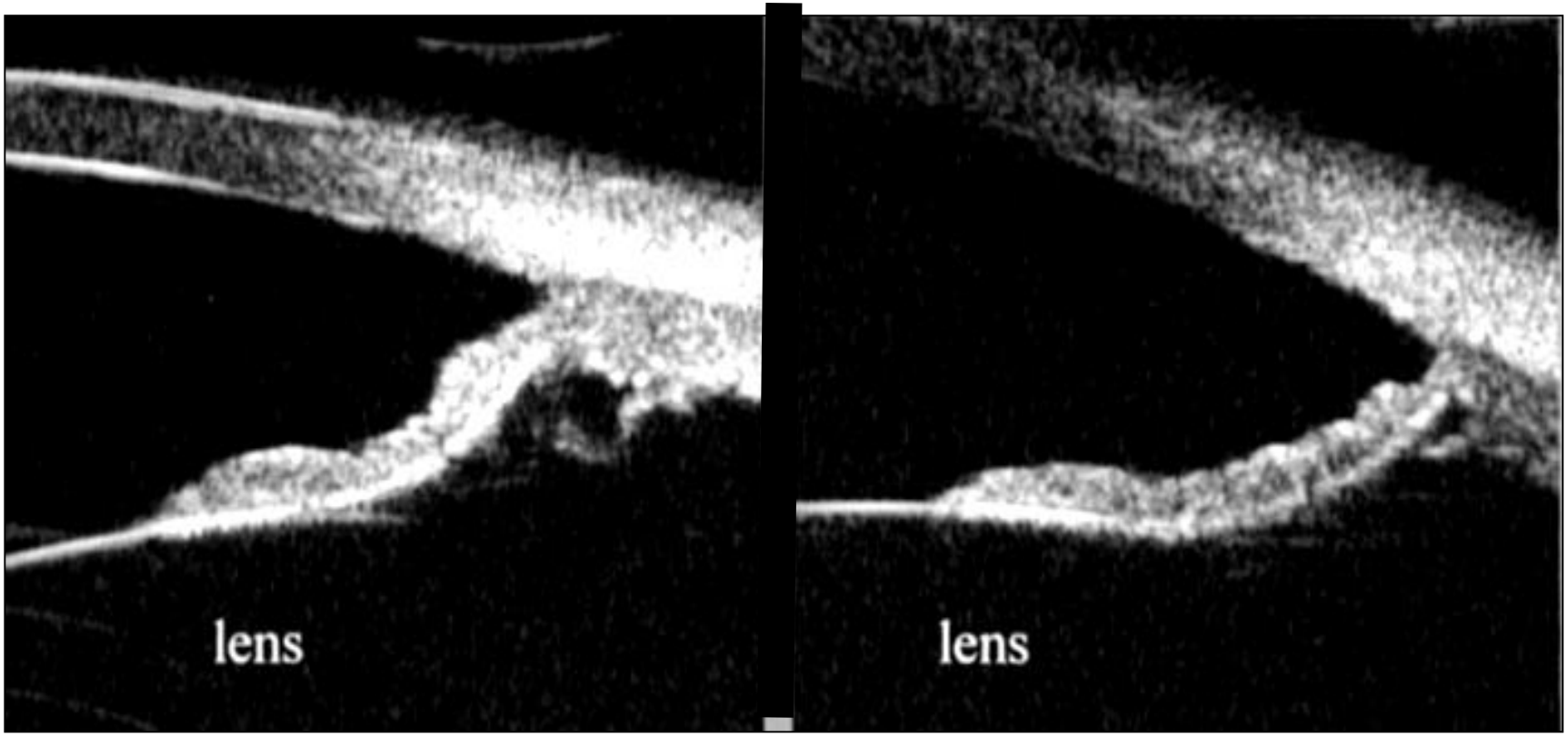
Pigmentary glaucoma (pigment dispersion syndrome)

Mechanism : dissemination of pigment granules from the posterior iris



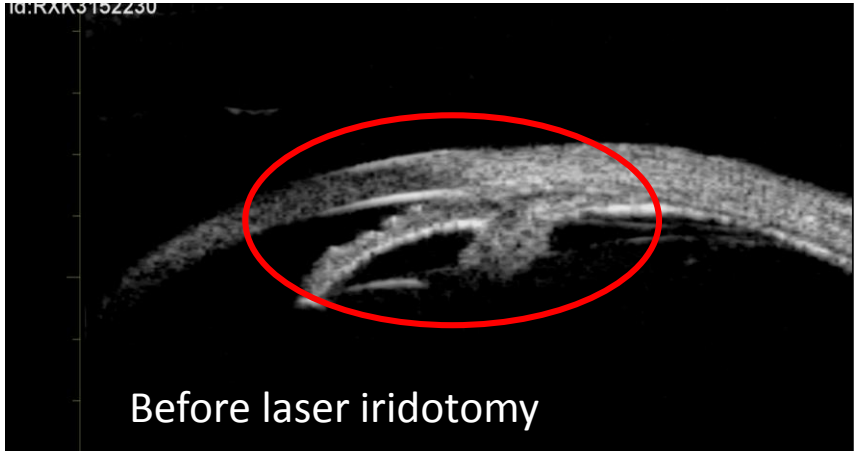
- ✓ Widely open angle
- ✓ Iris configuration (concave)
- ✓ Reverse pupillary block
- ✓ Amount of iridozonular contact

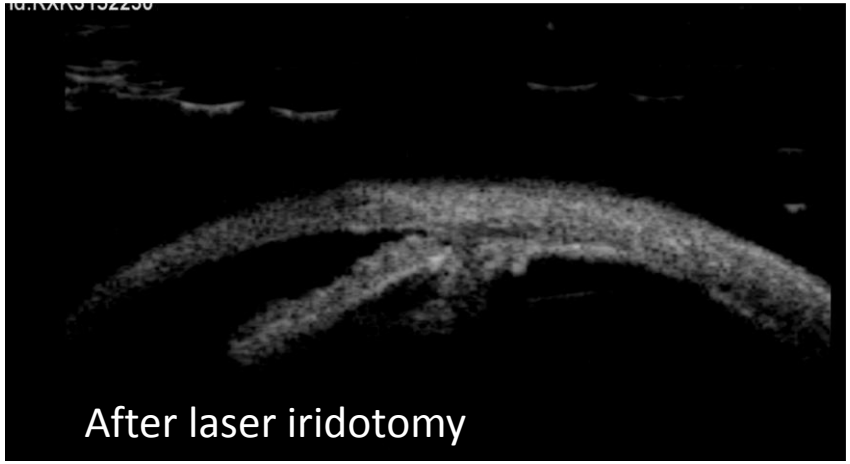
Pigment dispersion syndrome



Papillary block glaucoma

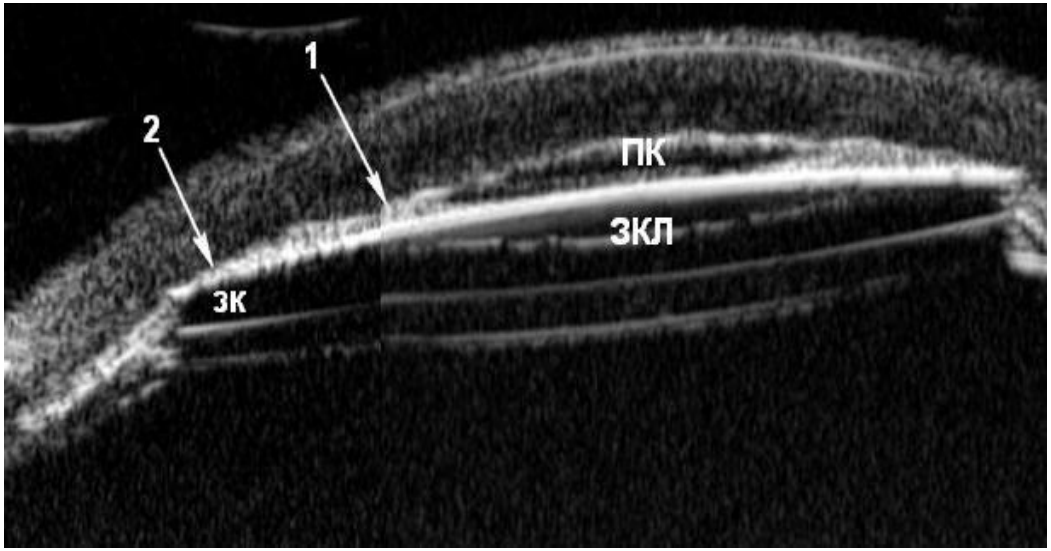
Mechanism : **at the iridolenticular contact, resistance to aqueous flow from the PC to the AC creates an unbalanced relative pressure gradient between two chambers**

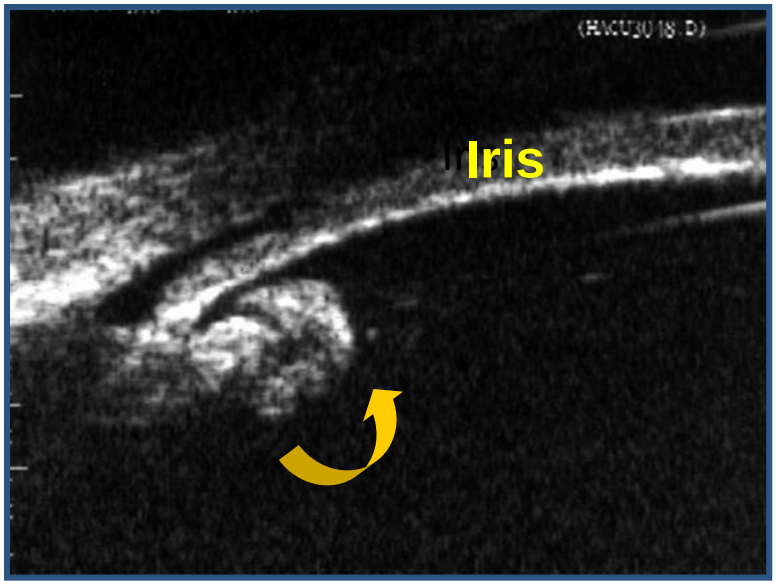




- ✓ Anterior iris bowing , narrowing of the angle.
- ✓ Iris-lens contact is relatively small – “dotted”
- ✓ LI eliminated the pressure differential between PC & AC and release the iris convexity and the iridocorneal angle wideness

Malignant glaucoma (ciliary block)





- Angle closure is caused by pressure differential between the vitreous and aqueous compartment
- Swelling or anterior rotation of the ciliary body with formal rotation of the lens-iris diaphragm and relation of the zonular apparatus may cause anterior lens displacement.

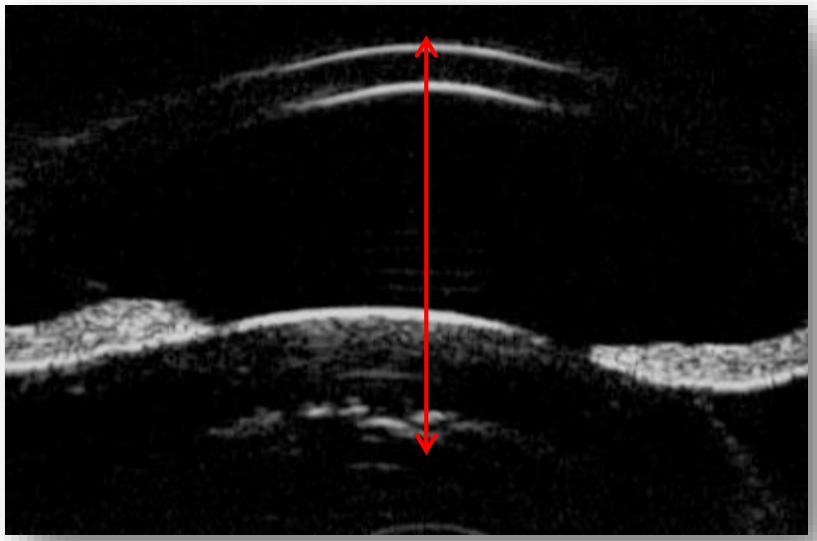
Plateau iris syndrome

Mechanism : narrowing of the ACA due to insertion of the iris anteriorly on the CB or displacement of CB anteriorly

- Iris thickness
- Iris profile is straight
- Ciliary processes are moved forward, closing the ciliary sulcus and supporting the peripheral iris
- Peripheral angle is narrow

Pseudoexofoliative glaucoma

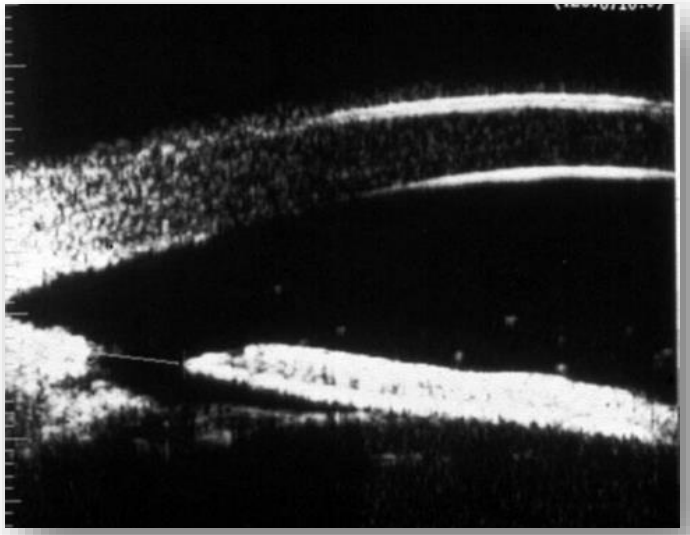
Mechanism : the occlusion of the trabecular meshwork from the material and pigment

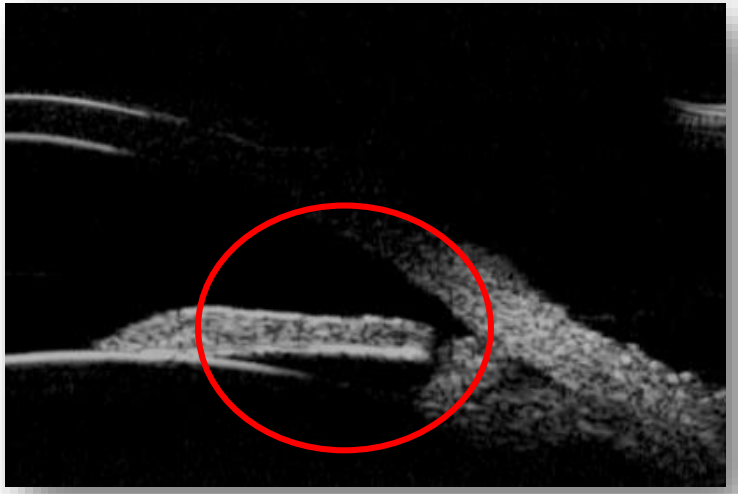


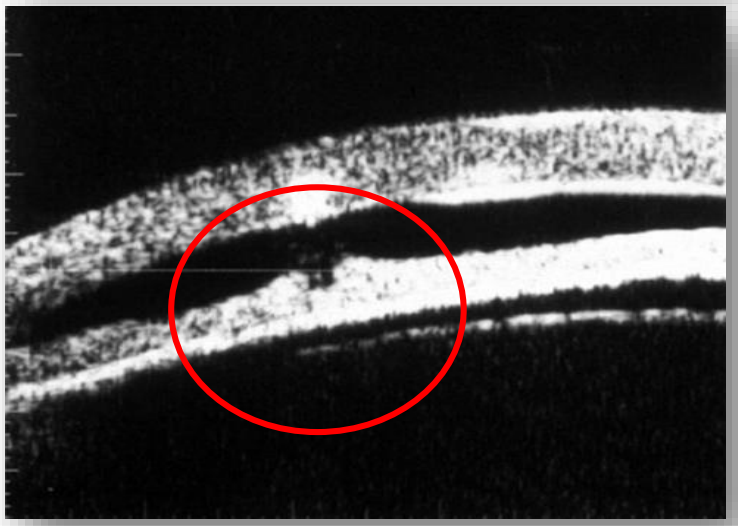
- ✓ Stages of changes
- ✓ Small high reflective areas which are limited to the pupillary margin, on the anterior surface of the lens, in the ACA
- ✓ Various lengths of zonule with partial lysis
- ✓ Lens displacement with zonule laxity

UBM in the assessment of efficacy of treatment for glaucoma

Laser iridotomy



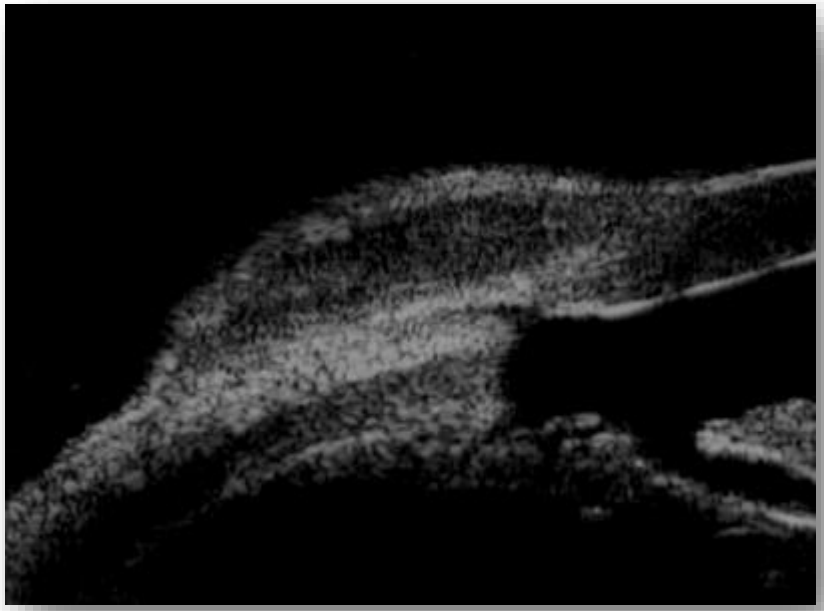




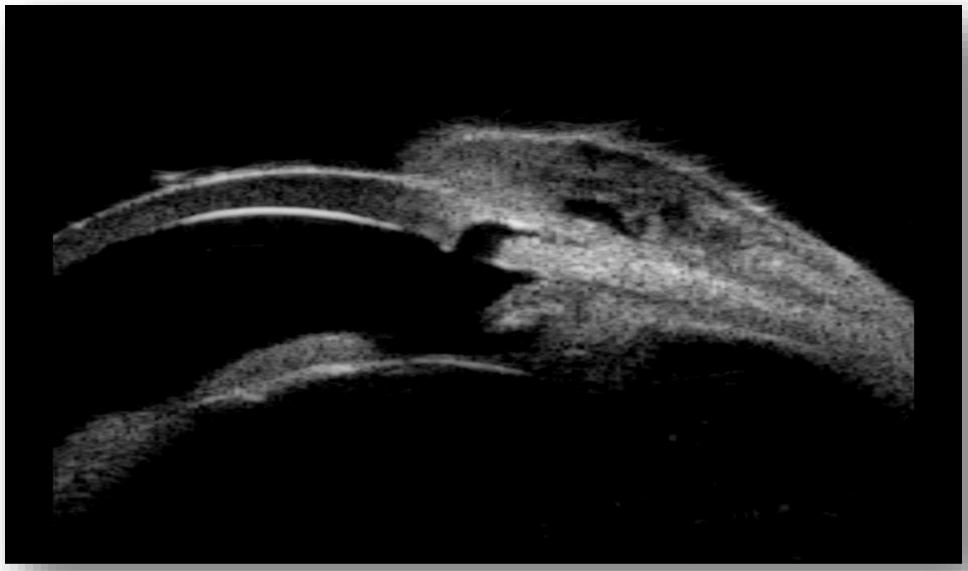
Iridotomy – defect of iris

- ✓ **Location: peripheral iris**
- ✓ **Diameter: more than 0,2 mm**

UBM in the assessment of efficacy of glaucoma surgery



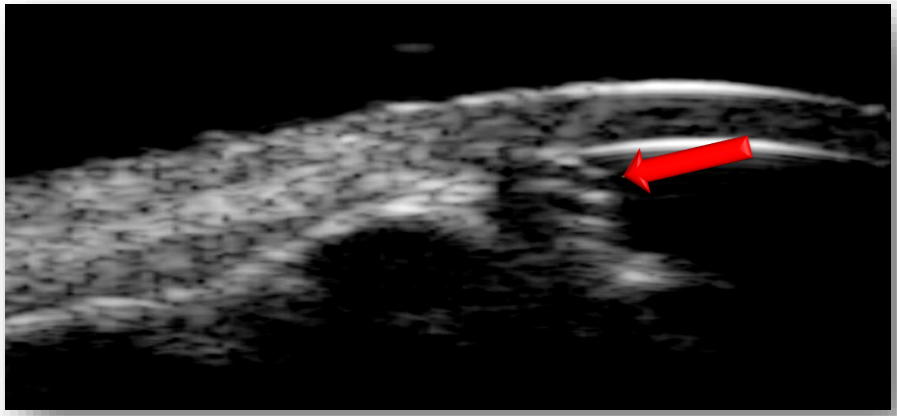
Normal filtering bleb – subconjunctival fluid collection and low to moderate intrableb reflectivity



Filtering cystic bleb – hyporeflective areas filled with multiple fluid collections of varying size and intensity

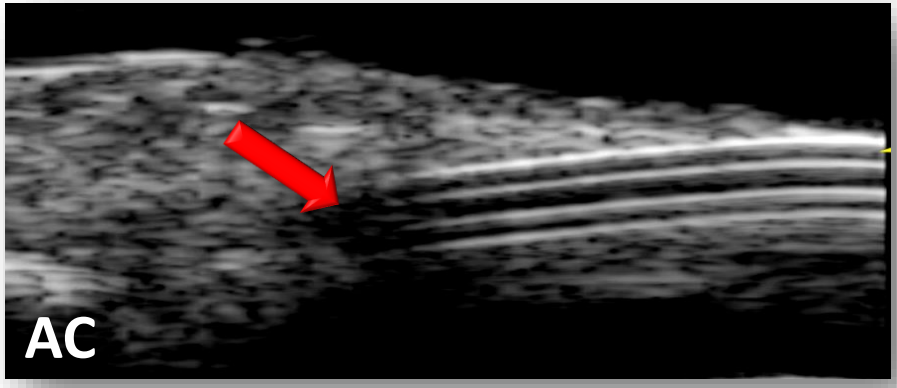
Glaucoma drainage devices

Drainage device in AC, tube lumen is free



Drainage device in PC, tube lumen is free

Drainage device in sclera and doesn't reach the AC



UBM in cataract surgery

Anatomo - topographic relationships among the structures of iridolenticular diaphragm

Location of lens, the condition of lens substance and zonule

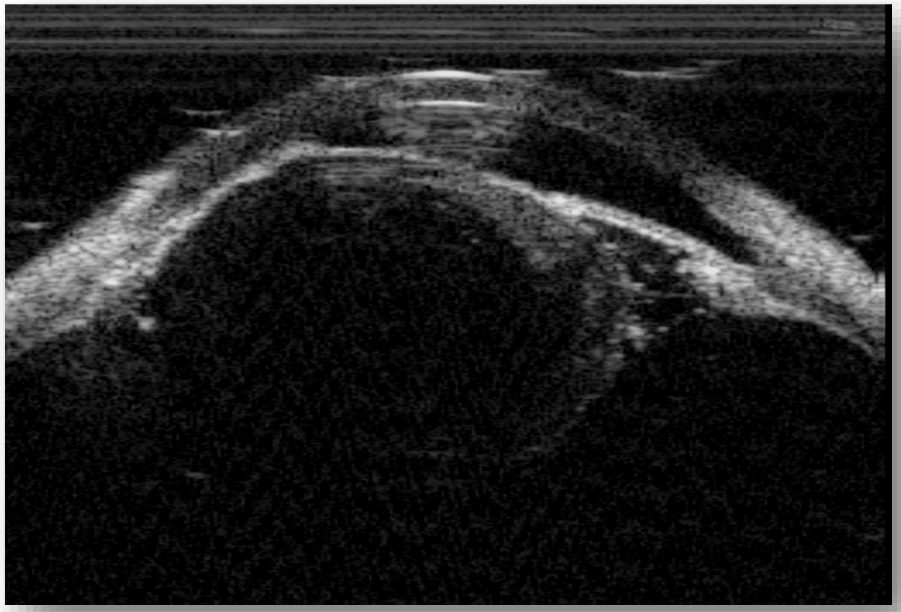
Approaches to cataract surgery

Following up the patients after cataract surgery

Position of IOL, haptics and optical elements

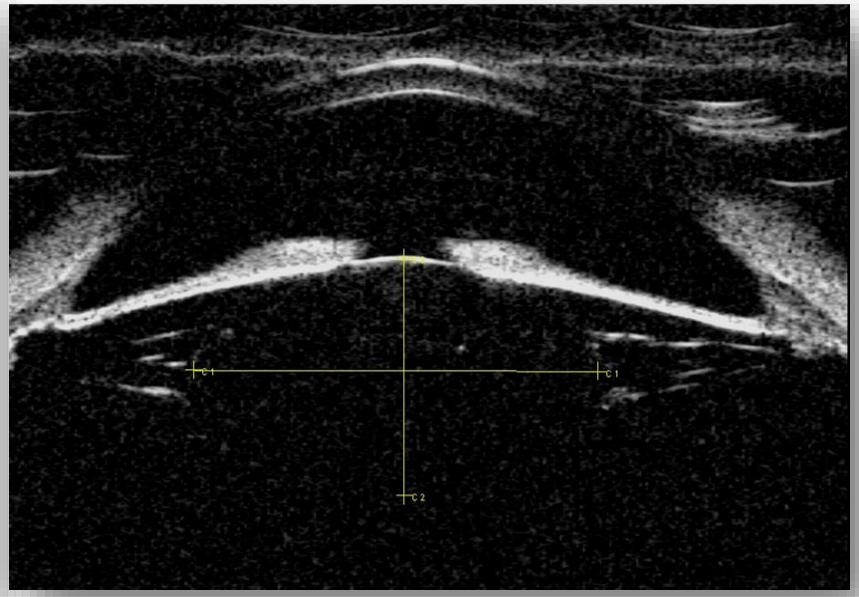
Capsular bag status

Lens anomalies



Peters anomaly

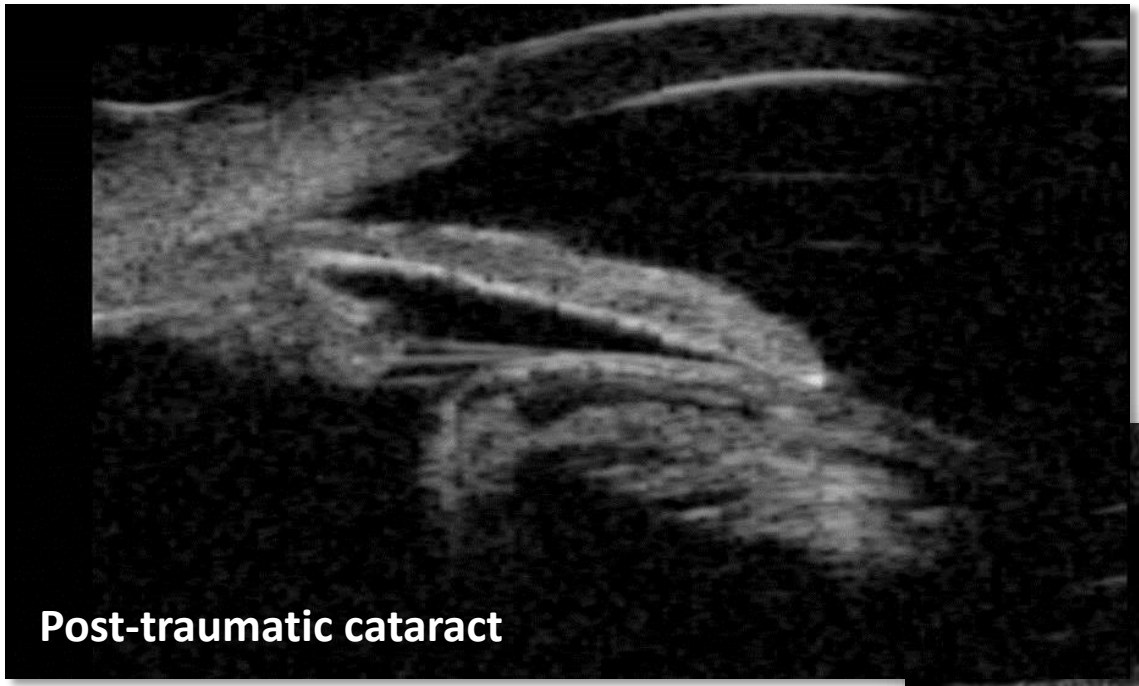
- ✓ Central corneal lenticular adhesion
- ✓ Spherophakia , cataract, ectopic lens
- ✓ Thinning of iris (dystrophy)
- ✓ Iridocorneal adhesion



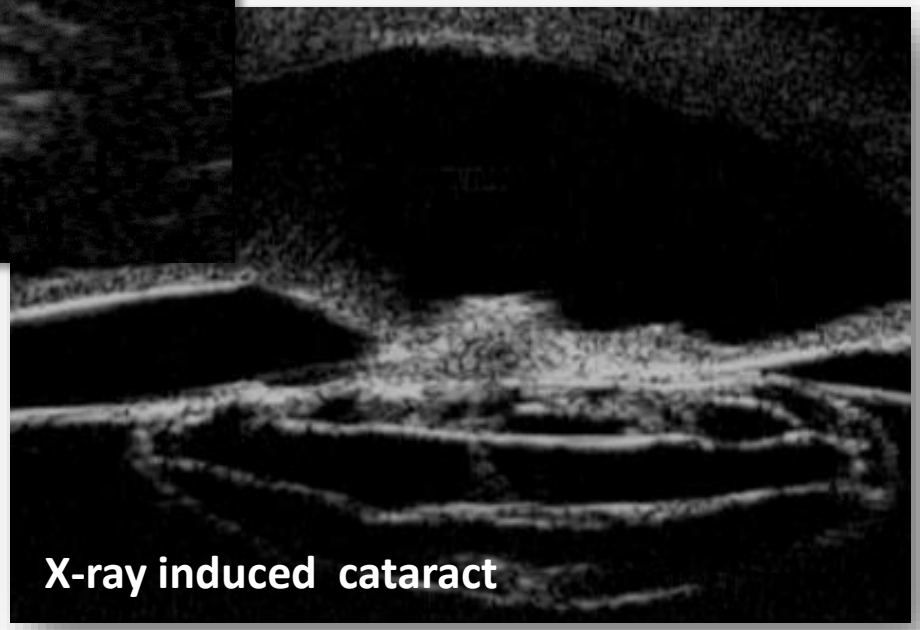
Microphakia

- ✓ Abnormally small lens
- ✓ Thinning of iris and CB (dystrophy)

Cataract



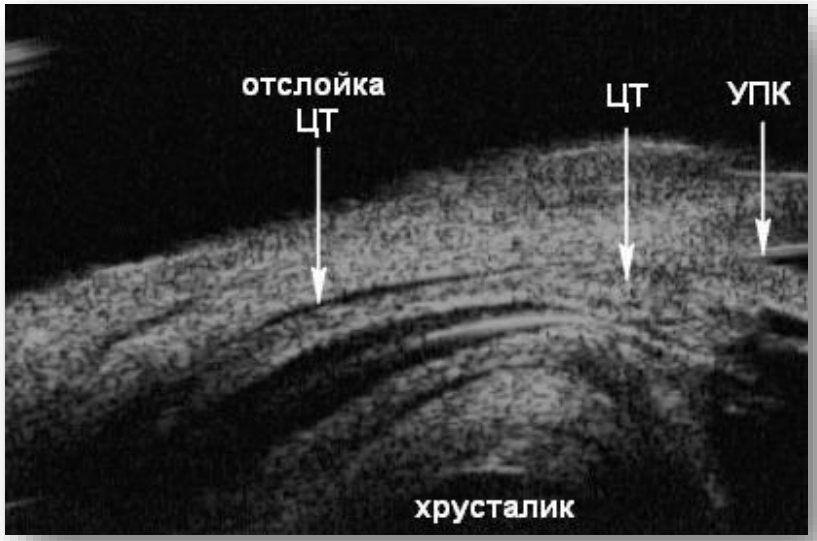
Post-traumatic cataract



X-ray induced cataract

Hyperechoic areas of lens, their shape, number and placement depend on the type of the cataract

Post-traumatic changes of lens



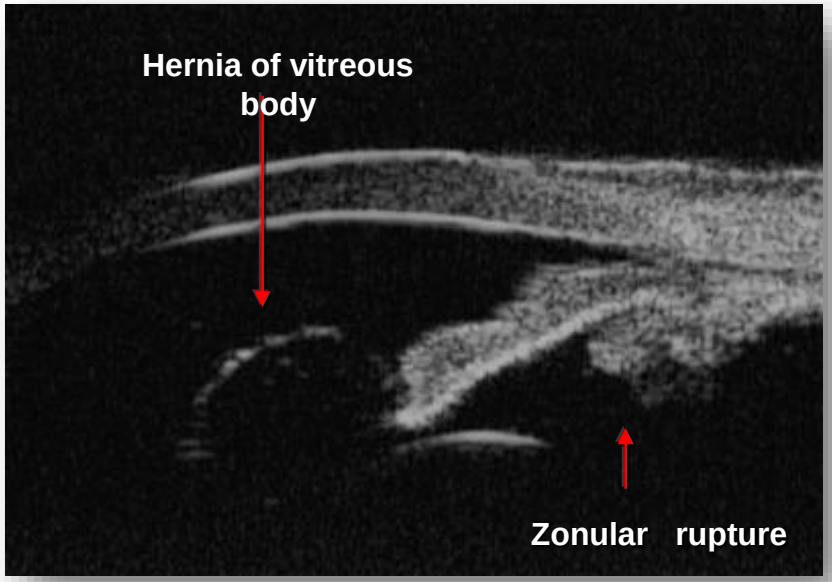
Immature cataract:

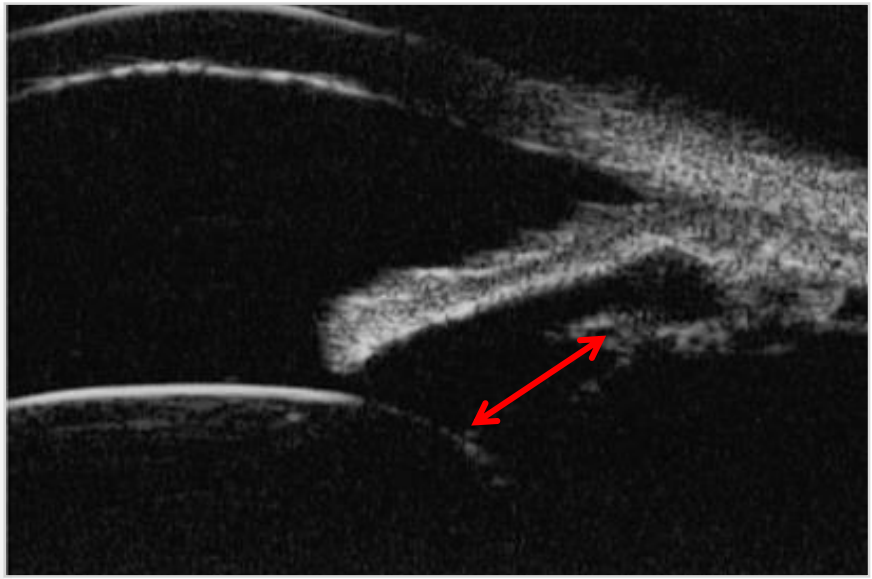
- ✓ Thickness and high reflectivity of cornea
- ✓ Shallow AC
- ✓ Iris bombe
- ✓ Enlargement and “vacuoles type” high reflectivity of lens
- ✓ anterior chamber angle closed

Subluxation (3rd degree)

- ✓ Displacement of lens into vitreous
- ✓ High reflectivity of lens - ”layered type”
- ✓ Slit-like ciliary body detachment

Zonular rupture

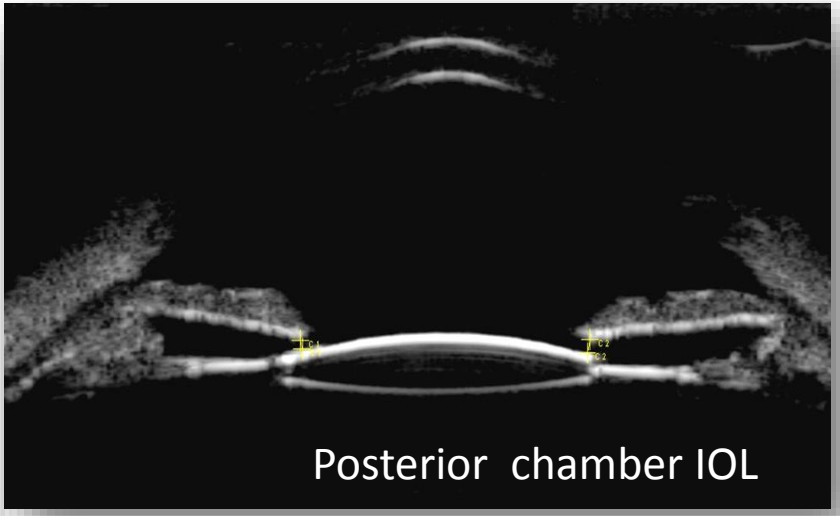


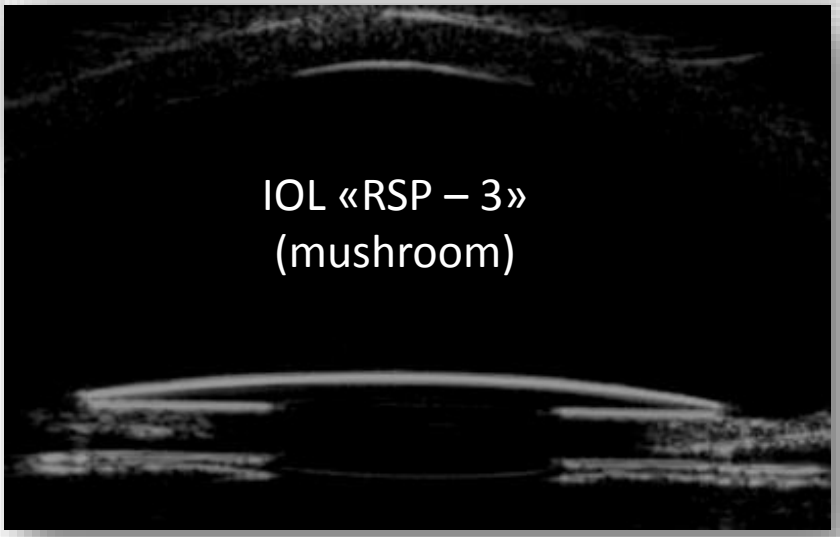


Cyst-like hernia of vitreous body with low reflectivity of its contents

- ✓ **Displacement of lens**
- ✓ **Equator lens-ciliary process distance > 1, 3 mm**

Intraocular lens position

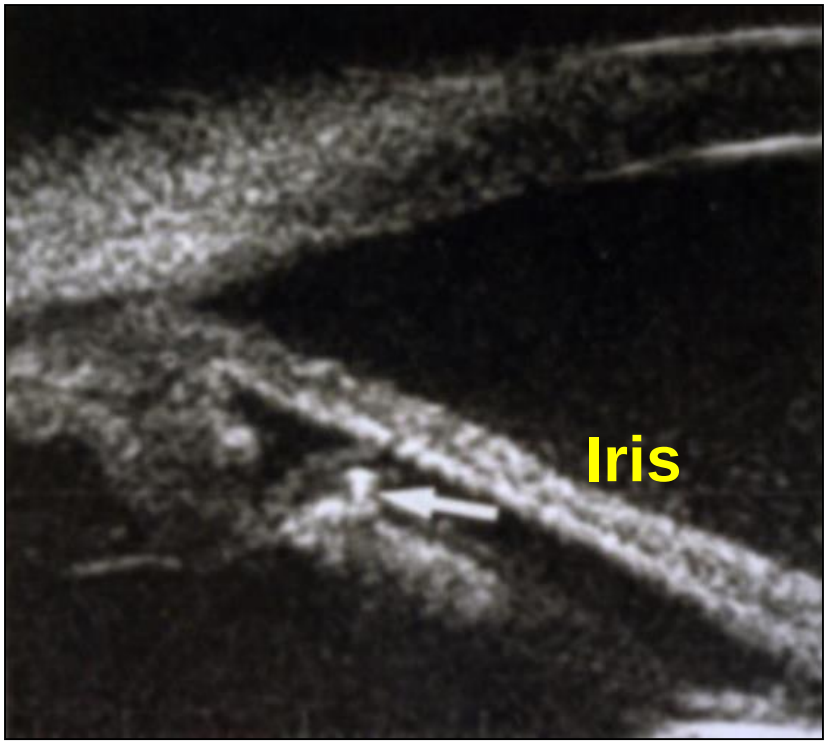




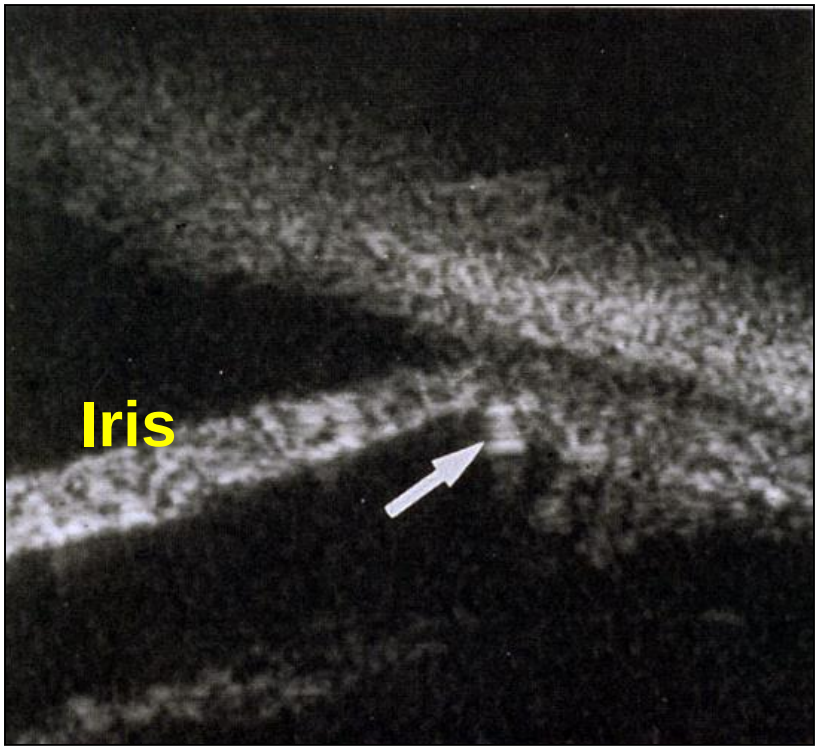
Assessment:

- ✓ **Location of optical part of IOL according to optical axis**
- ✓ **Position of haptic elements of IOL**

IOL Haptic Position

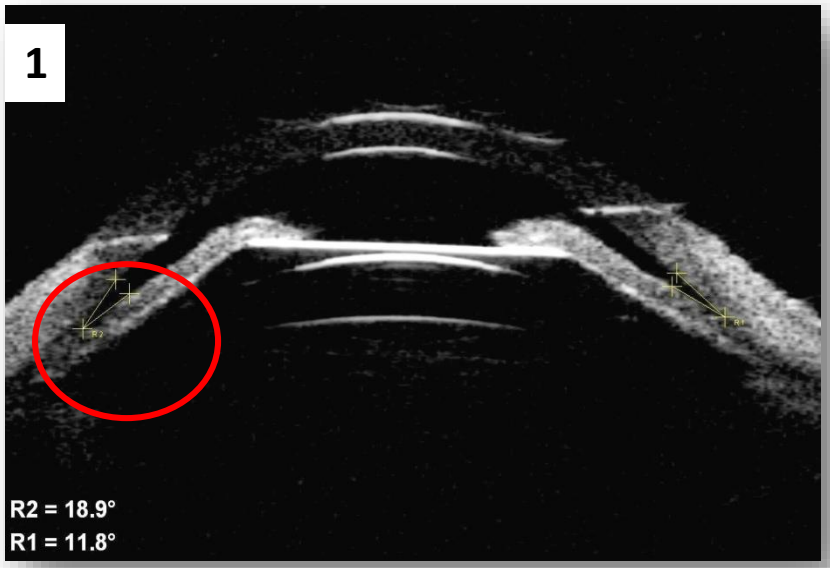


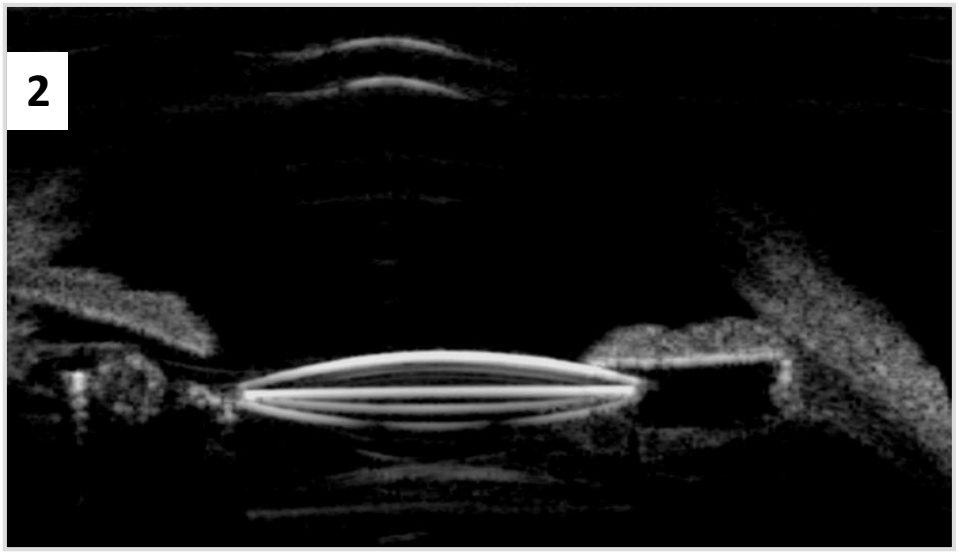
”In the bag”

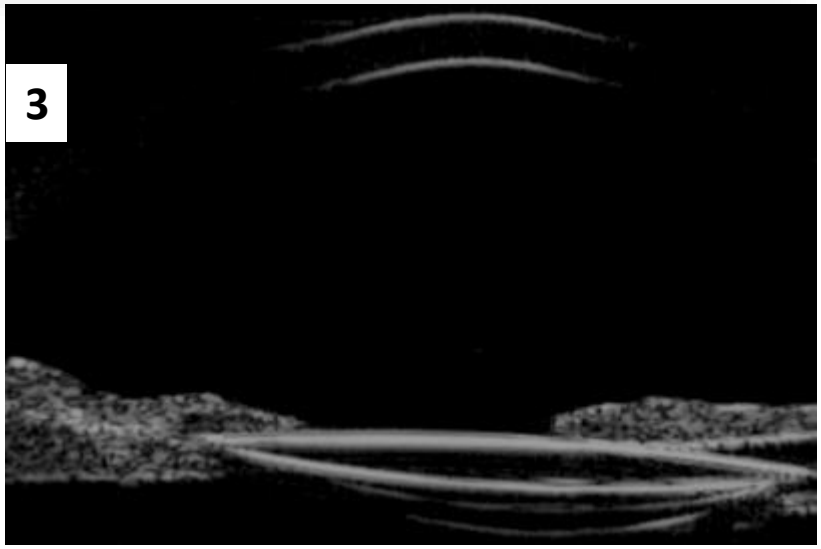


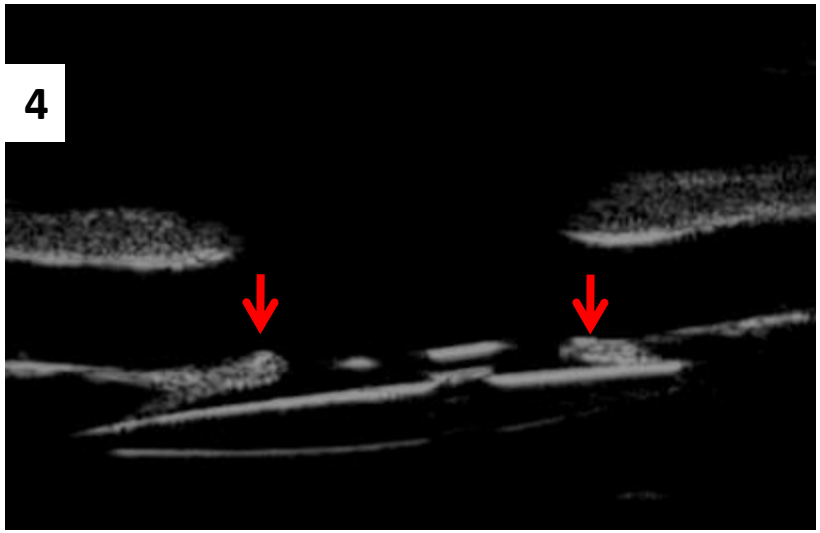
“In the sulcus”

Intraocular lens dislocation





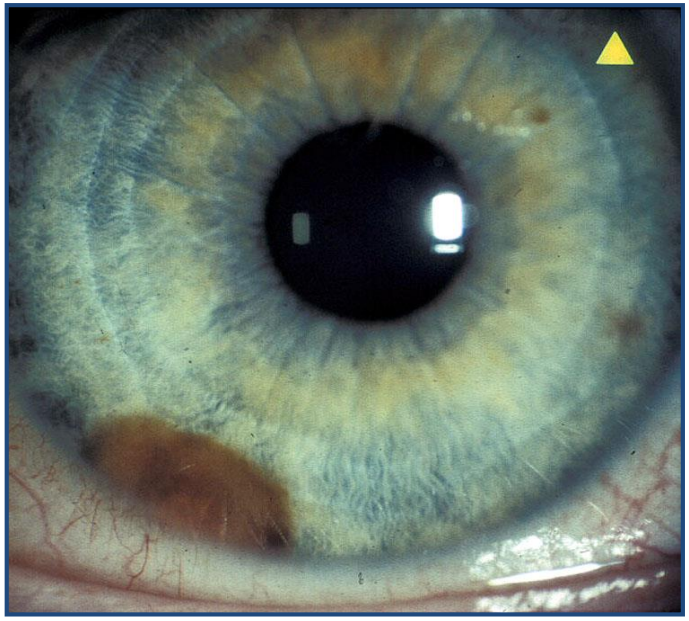




UBM in ocular oncology

The visualization of tumors

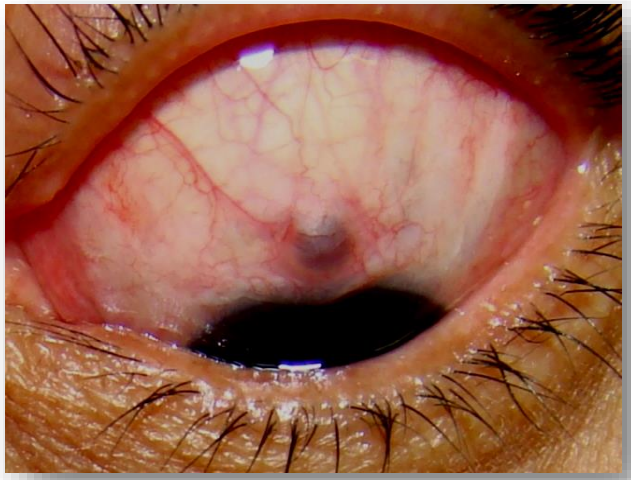
- ✓**Conjunctiva**
- ✓**Limbus**
- ✓**Iris**
- ✓**Ciliary body**
- ✓**Periphery of choroid**

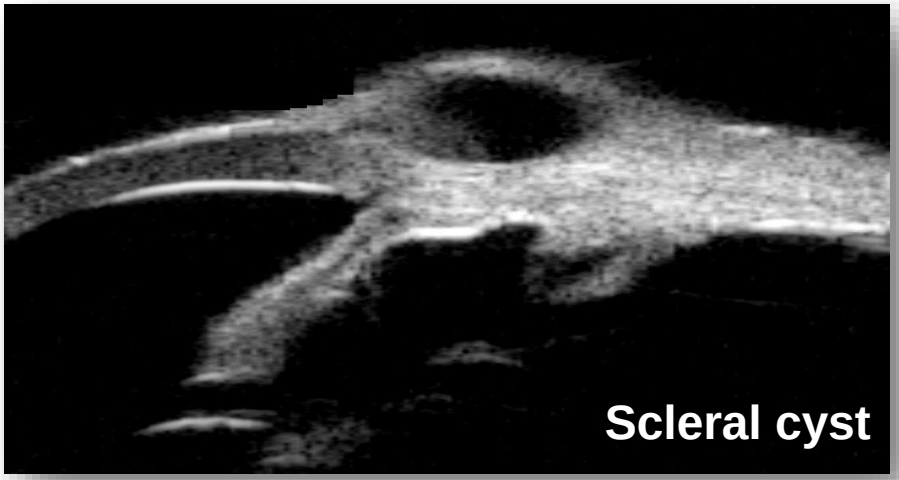


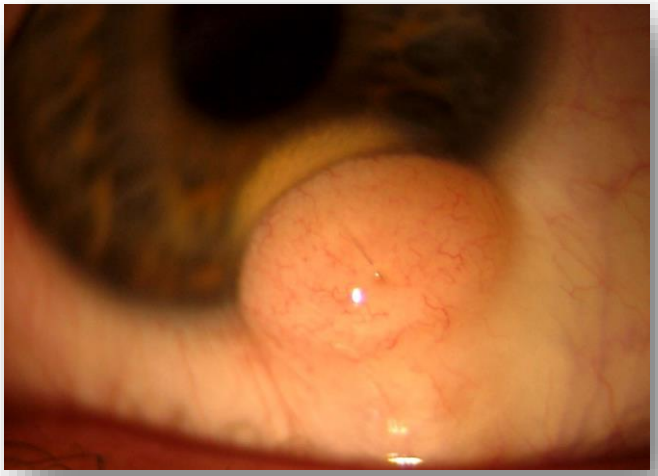
Purpose: to determine size, structure, interaction with surrounding tissues, degree of invasion

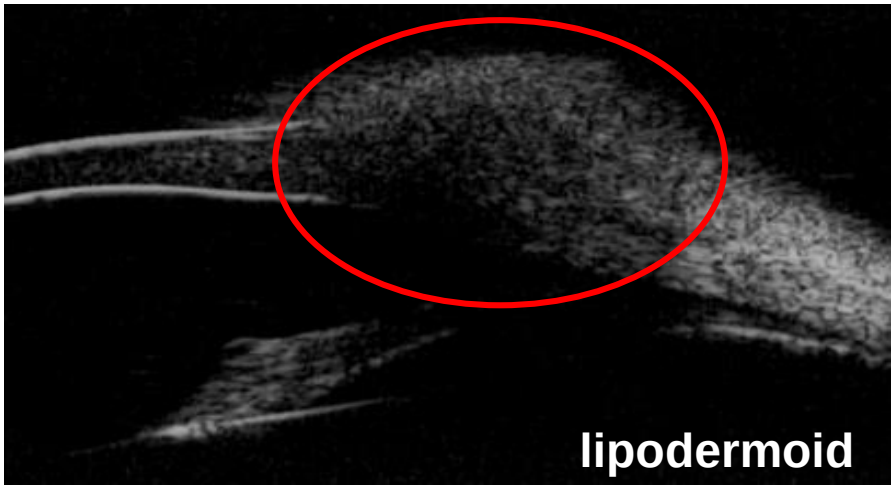
Development of treatment and assessment of efficacy of treatment

Benign epibulbar tumors

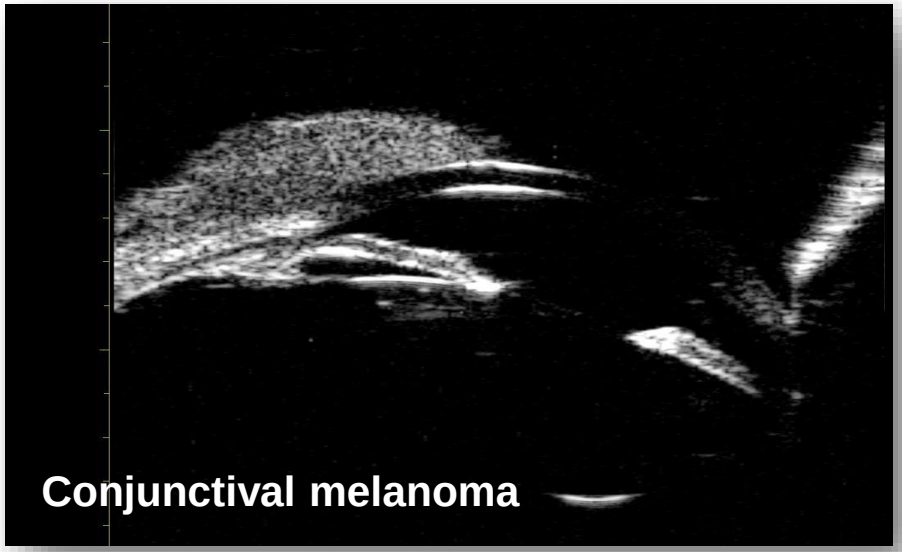


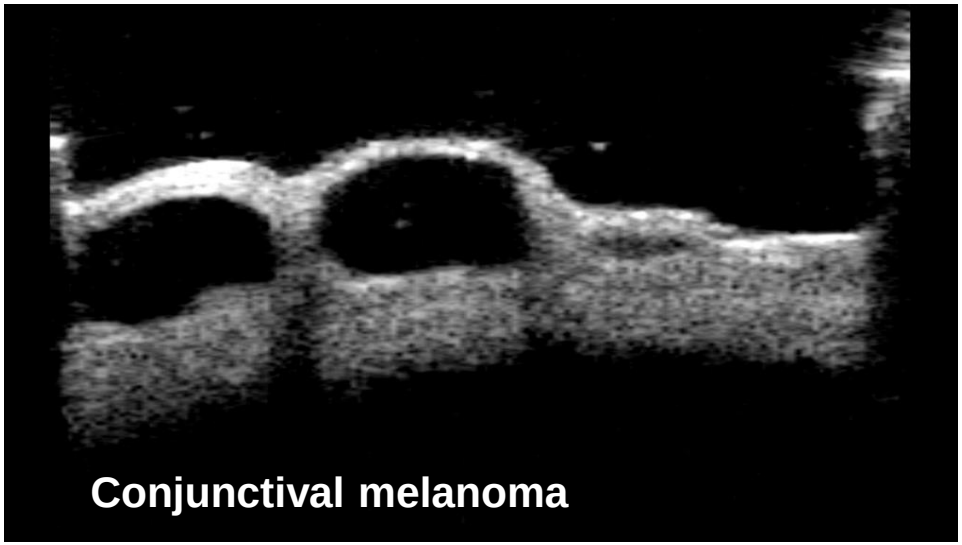






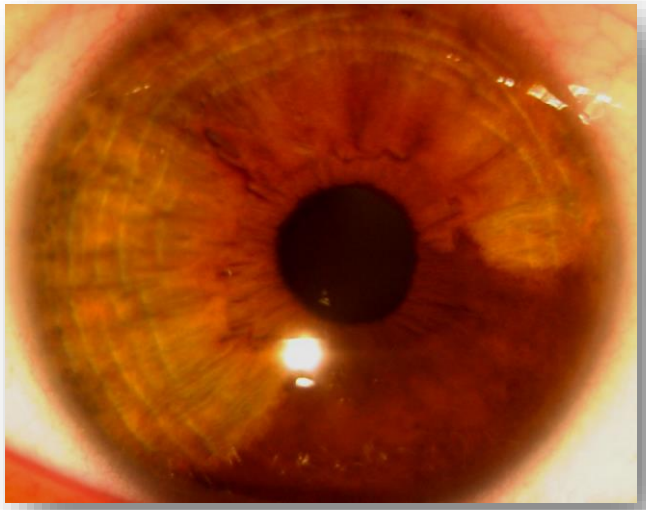
Malignant epibulbar tumors

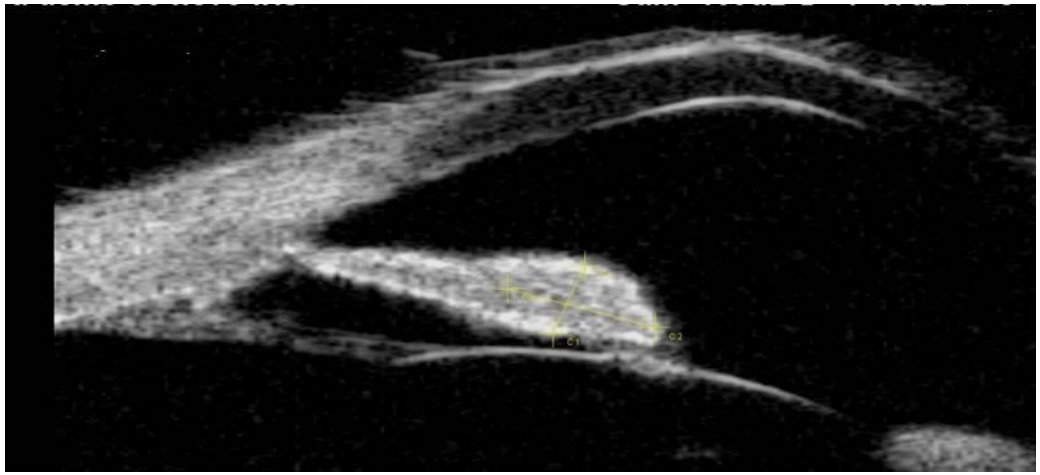


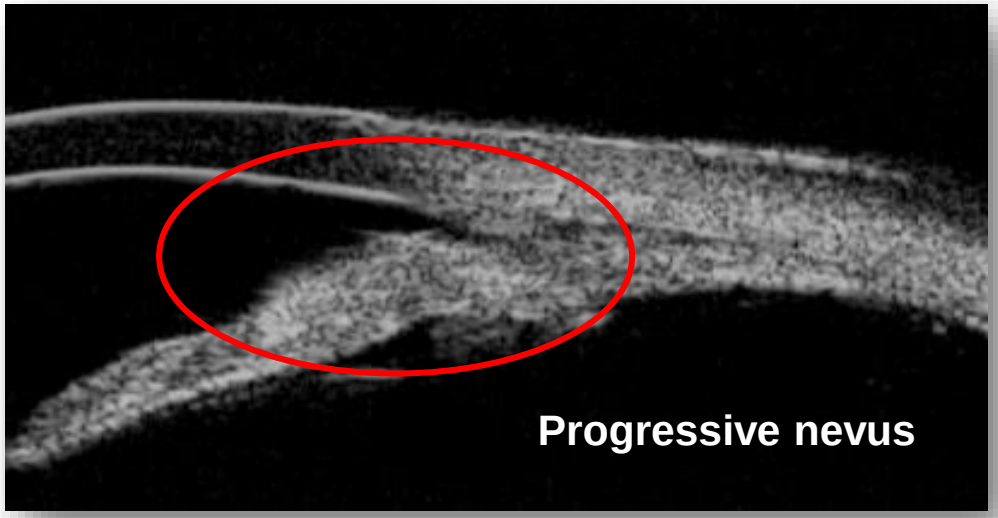


Benign iris tumors. Iris nevus

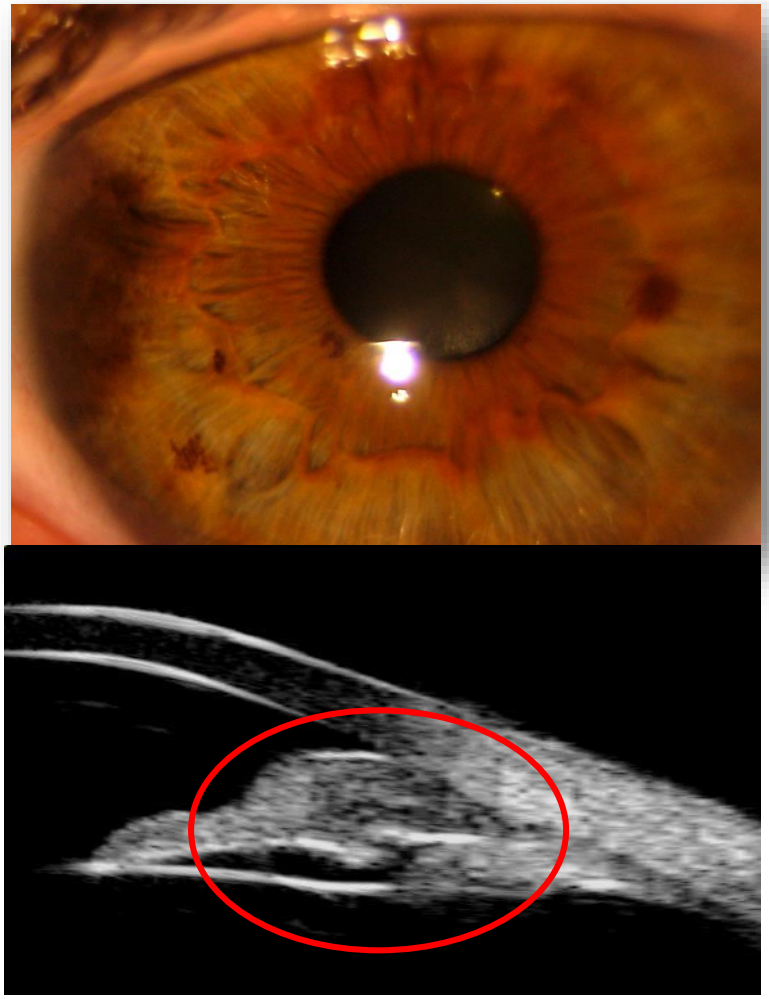
UBM: hypoechoic, hyperechoic or uniform reflectivity of local thickness of iris

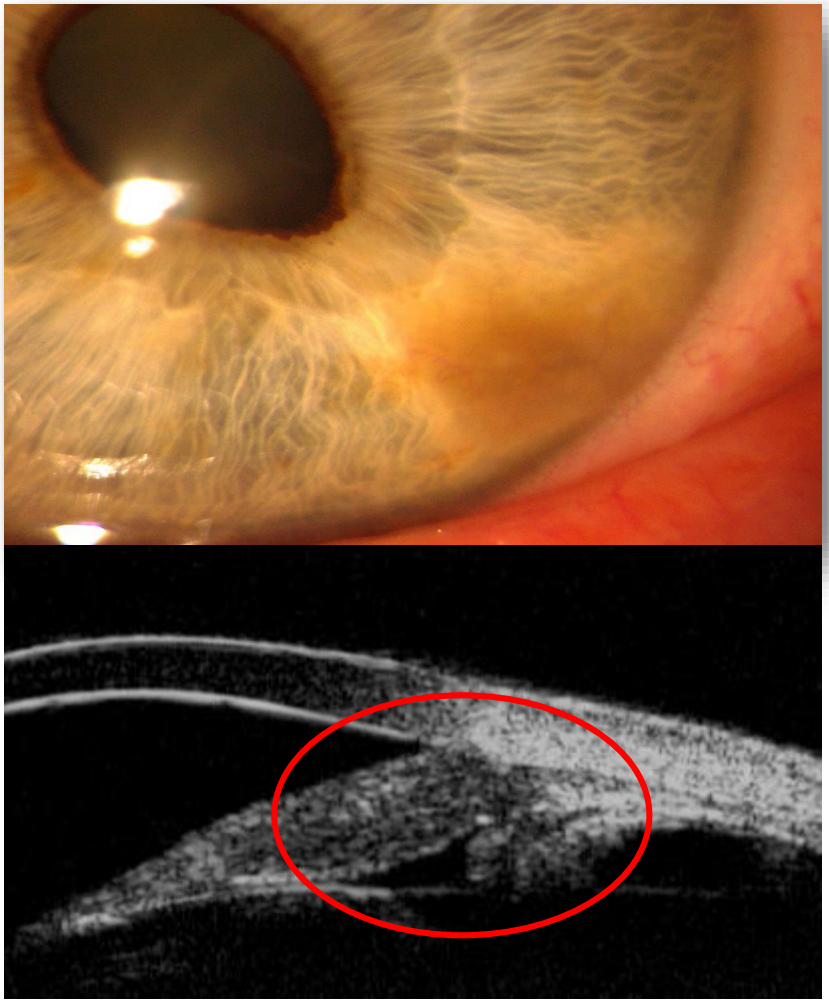






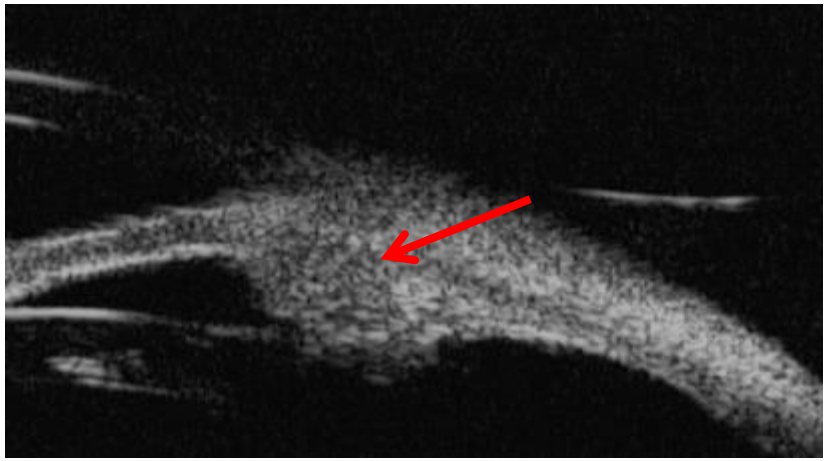
Iris melanoma

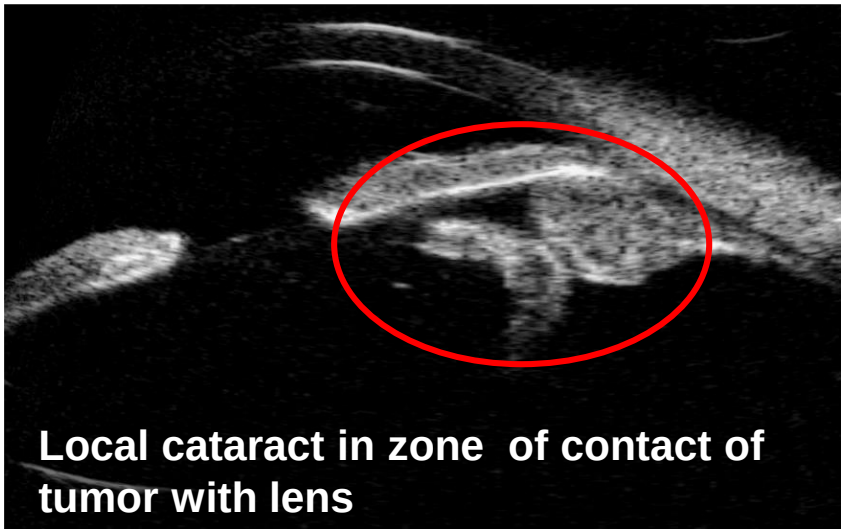


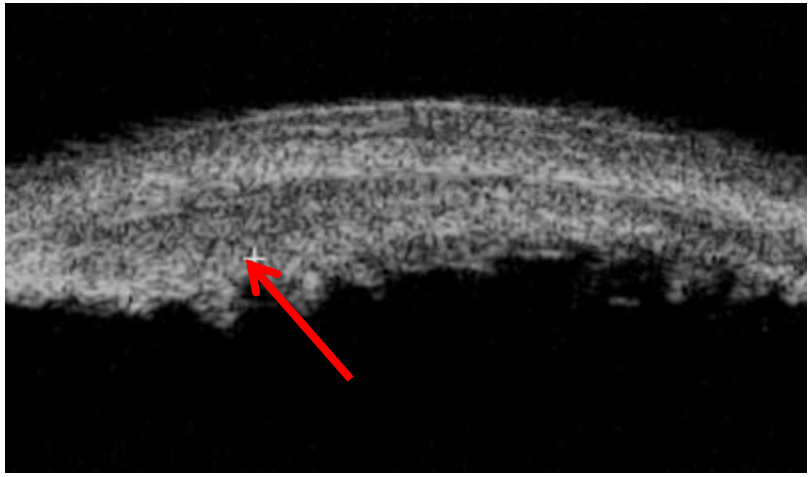


- ✓ **Local thickness of iris** with changes of anterior and/or posterior surface, low reflectivity in comparison to intact tissues

Ciliary body melanoma

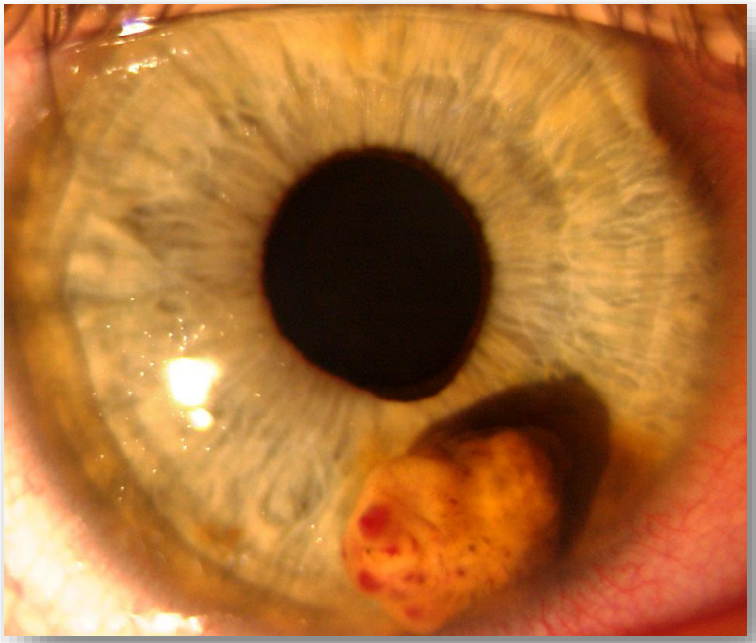


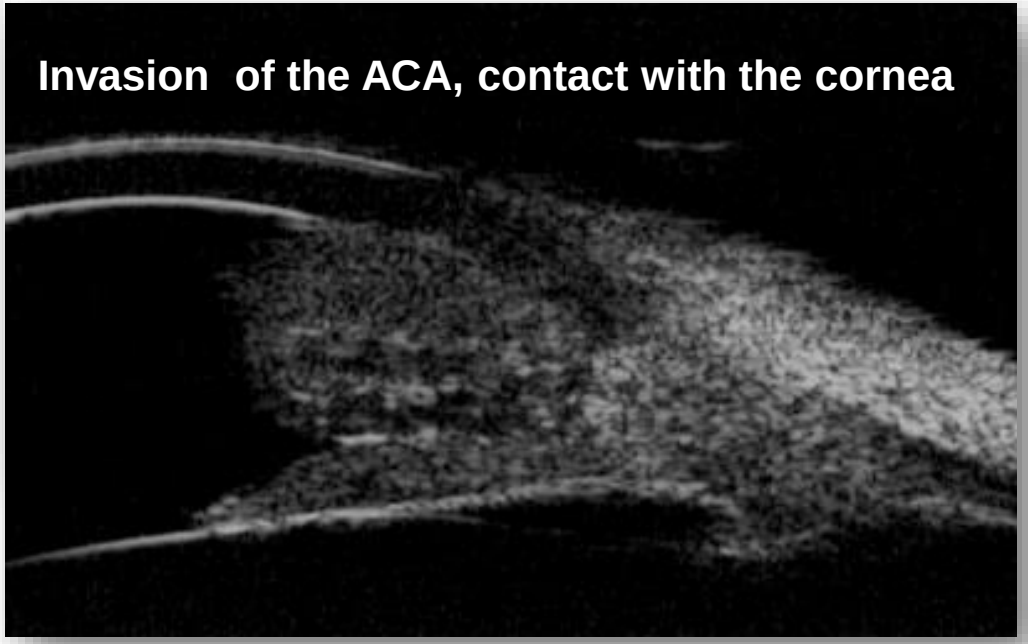




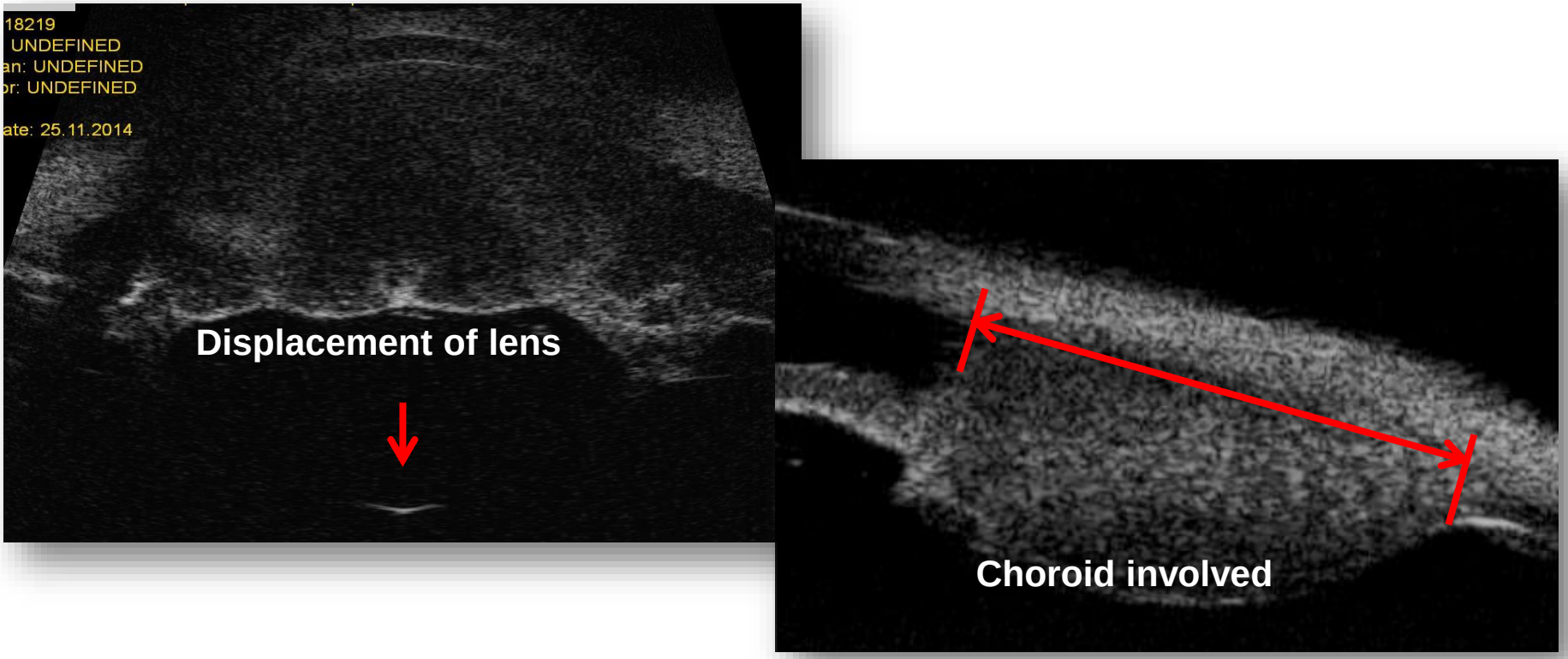
- ✓ Low reflectivity of local thickness of CB in comparison to intact tissues
- ✓ During the interaction with equator of lens local cataract can be formed

Iridociliary melanoma



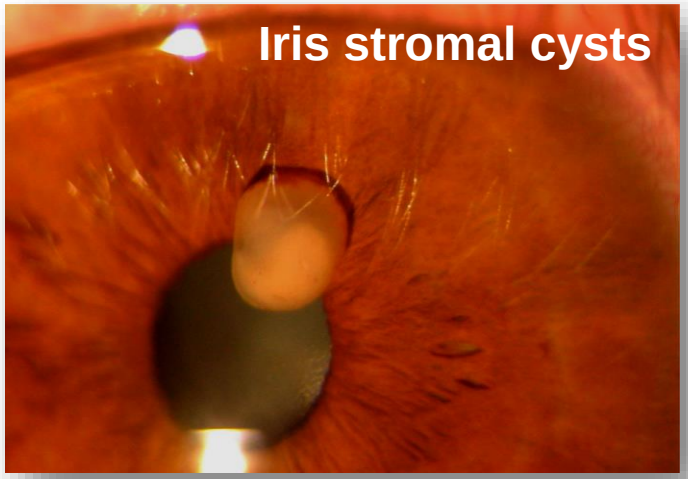


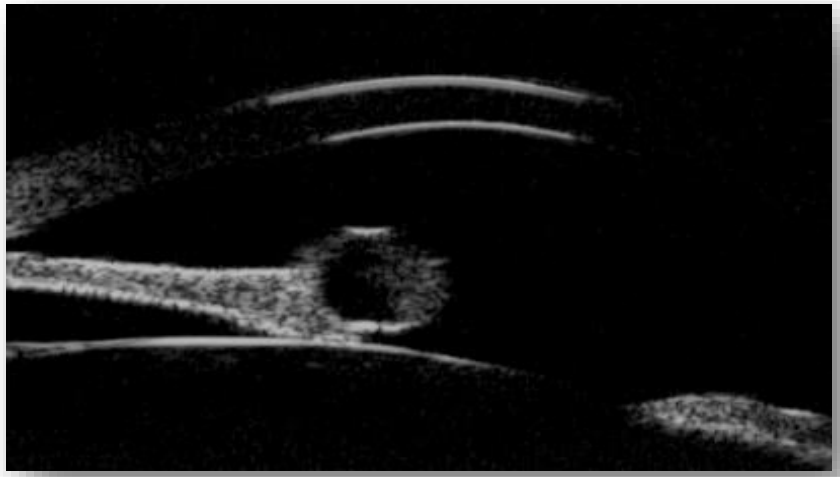
Iridociliary melanoma

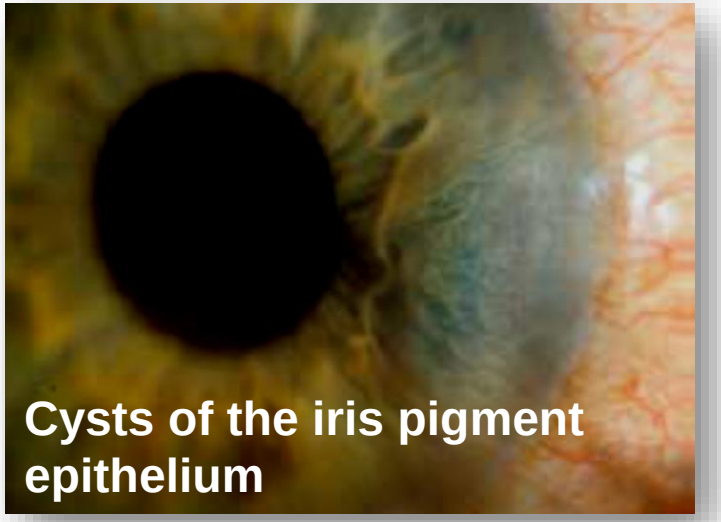


Iris cysts

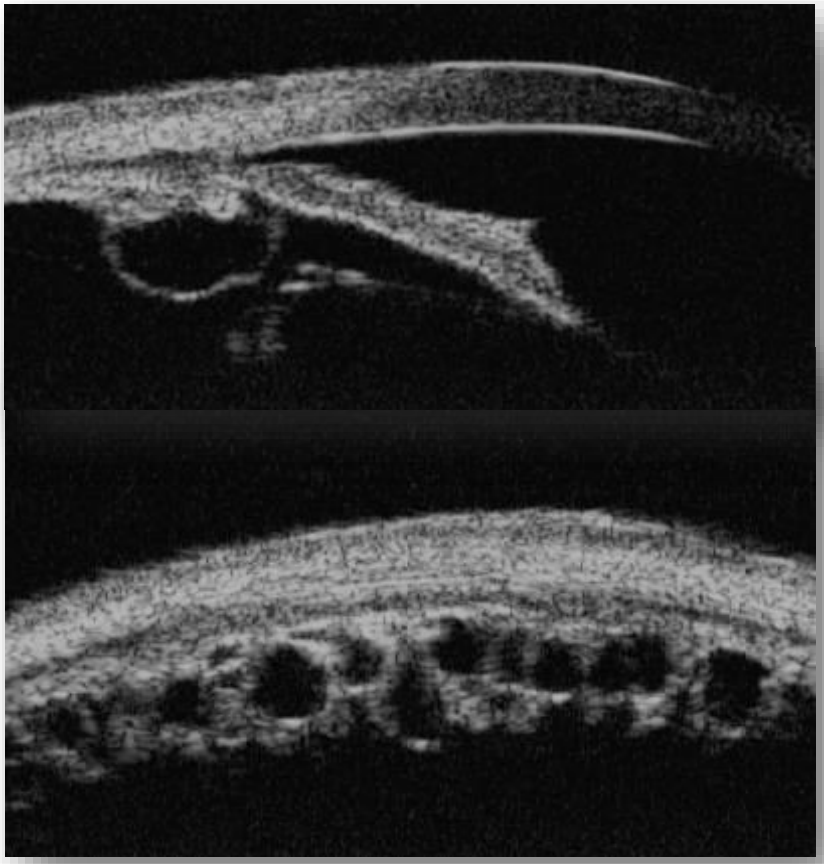
UBM appearance: thin-walled cysts with no internal reflectivity

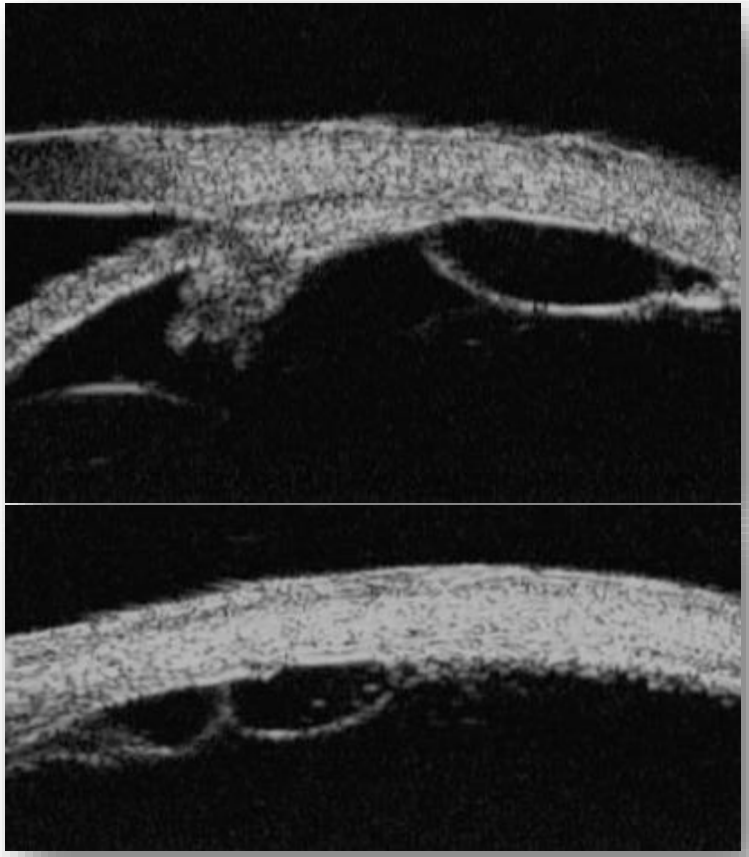






Ciliary body cysts





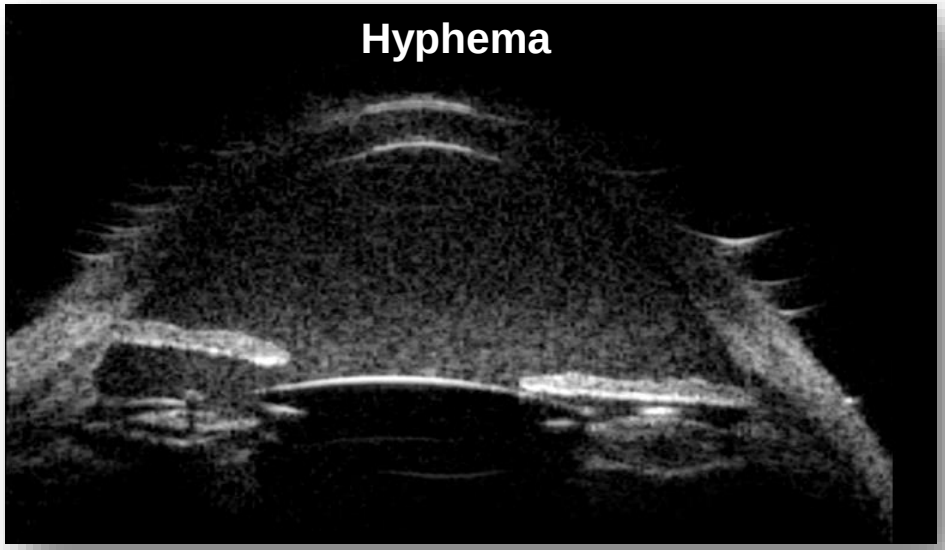
UBM and ocular trauma

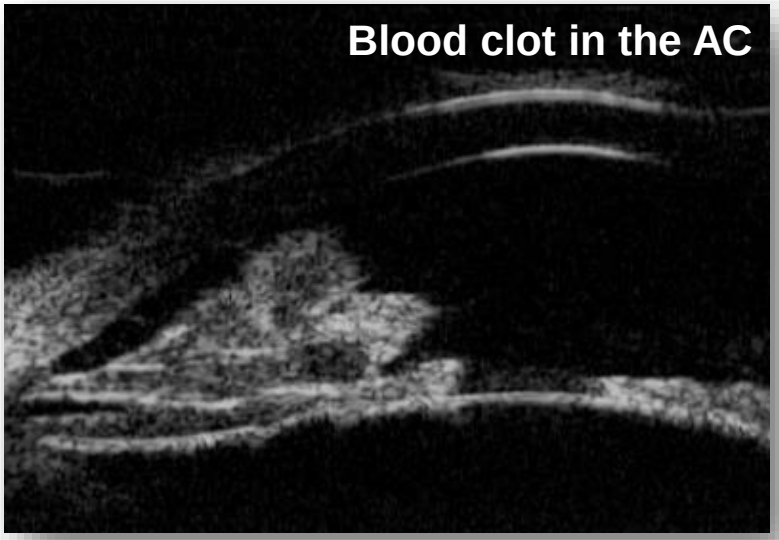
Anatomo - topographic relationships among the structures of anterior segment

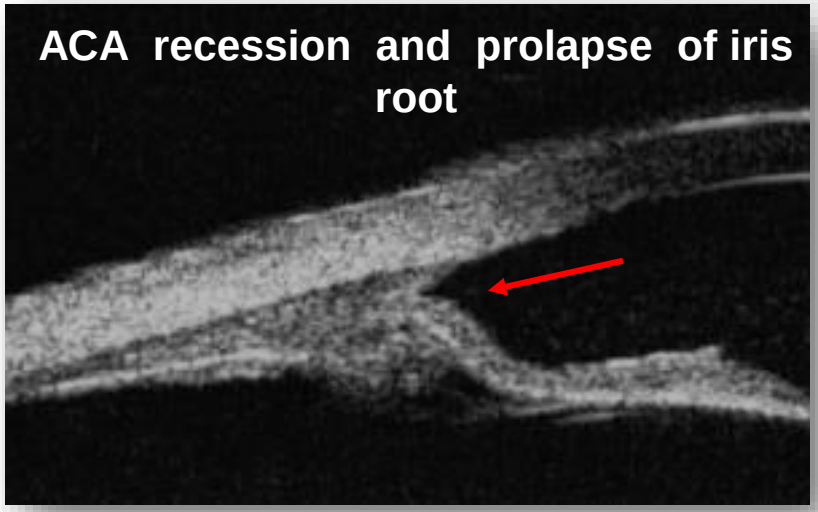
- ✓Cornea
- ✓Anterior chamber
- ✓Iridociliary zone (ICZ)
- ✓Posterior chamber
- ✓Lens
- ✓Zonule

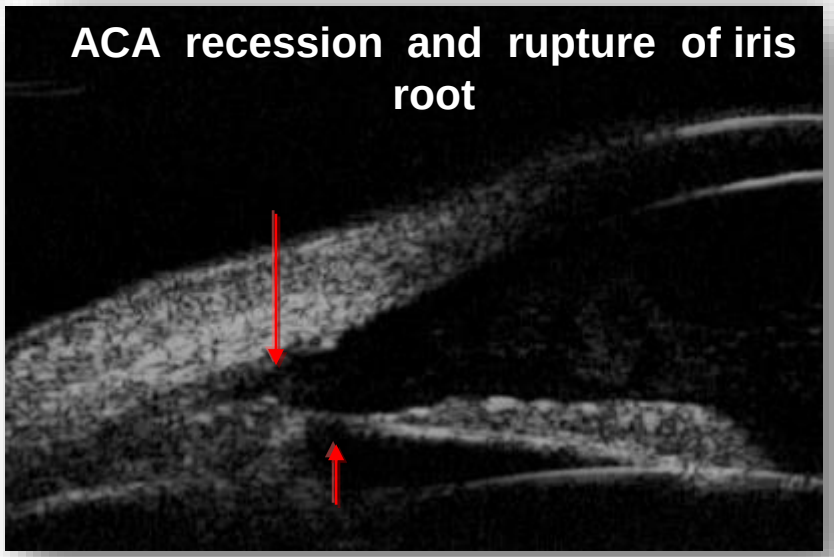
Following up the patients after treatment

Ocular blunt trauma

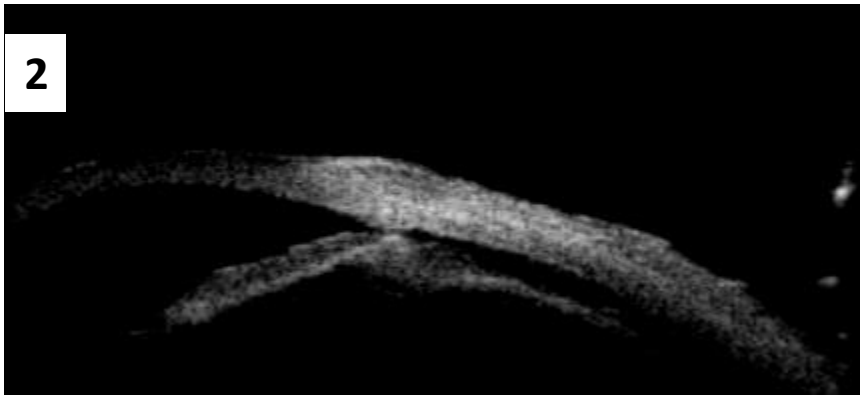




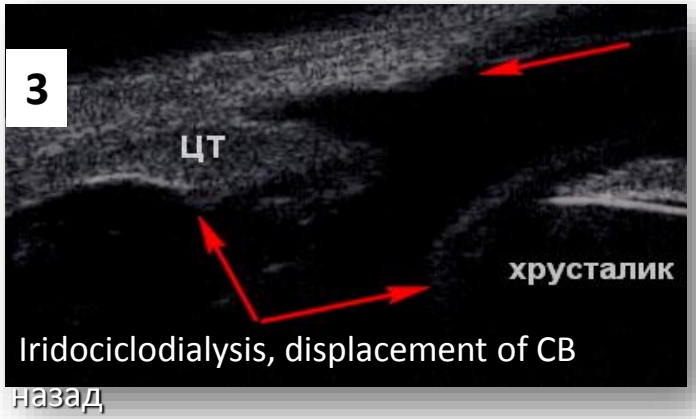


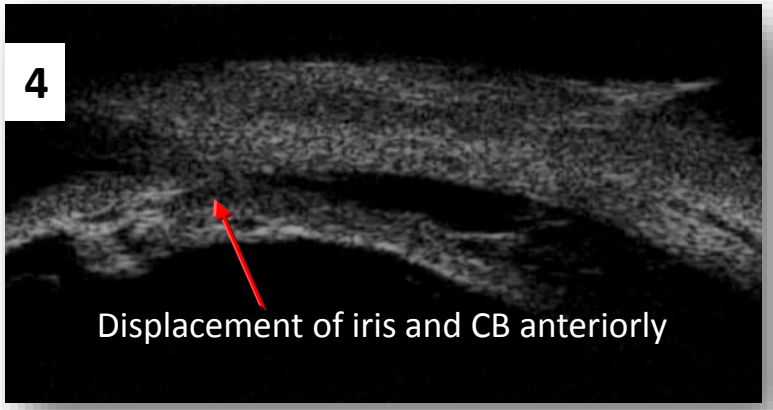


Ocular blunt trauma. Changes of ICZ



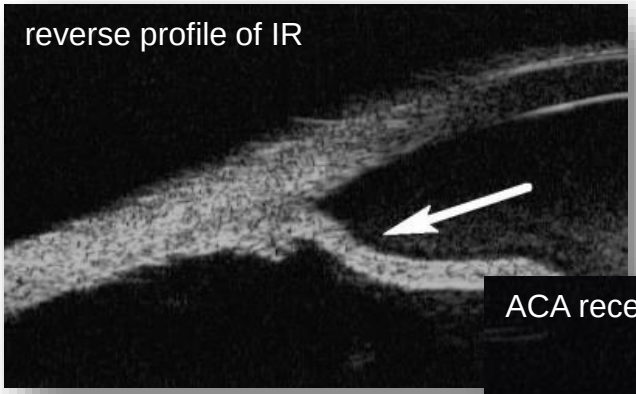
1- 2 – slit-like fistula between AC and suprachoroidal space (cyclodialysis cleft)

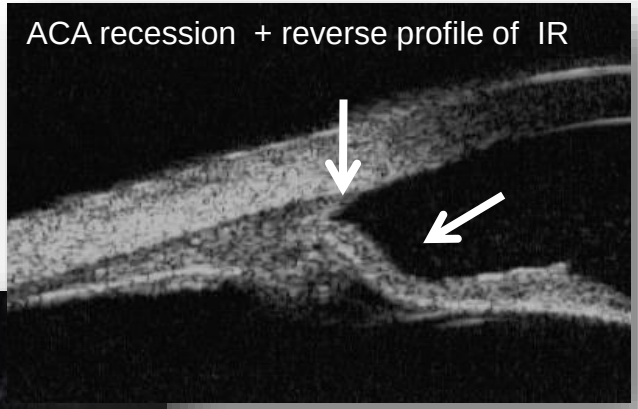


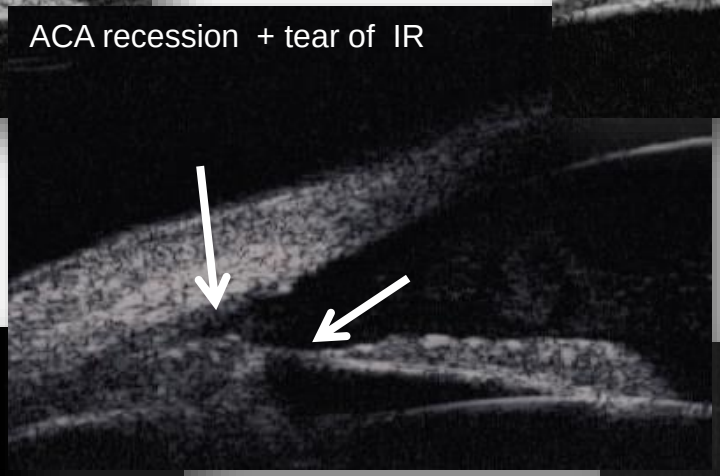


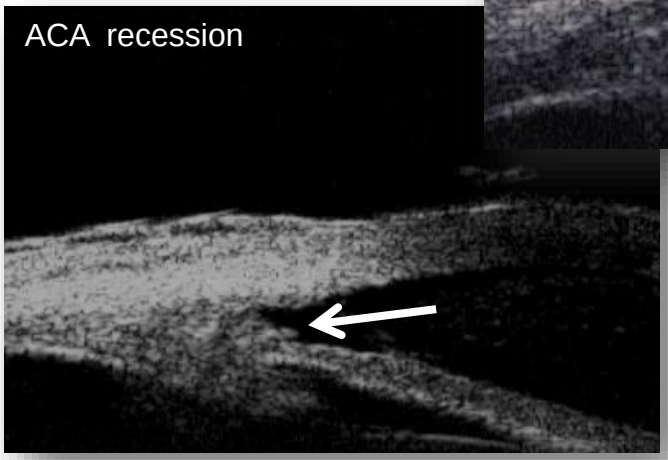
3 – 4 – shallow , uneven AC + exposure of the scleral spur + displacement of iris and CB + CB detachment

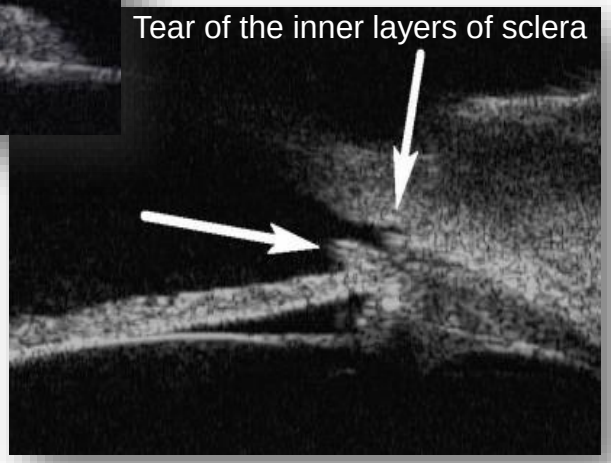
Ocular blunt trauma. Changes of ICZ



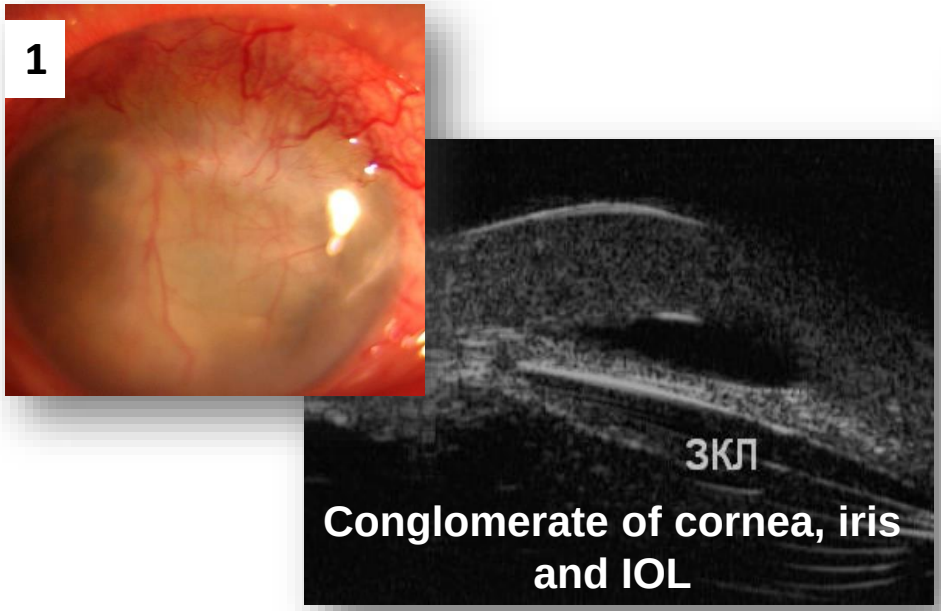


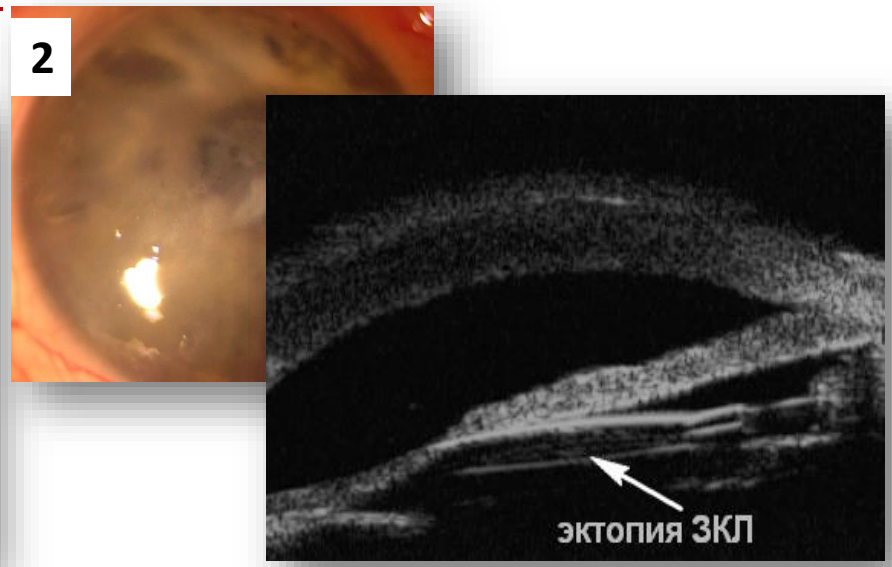


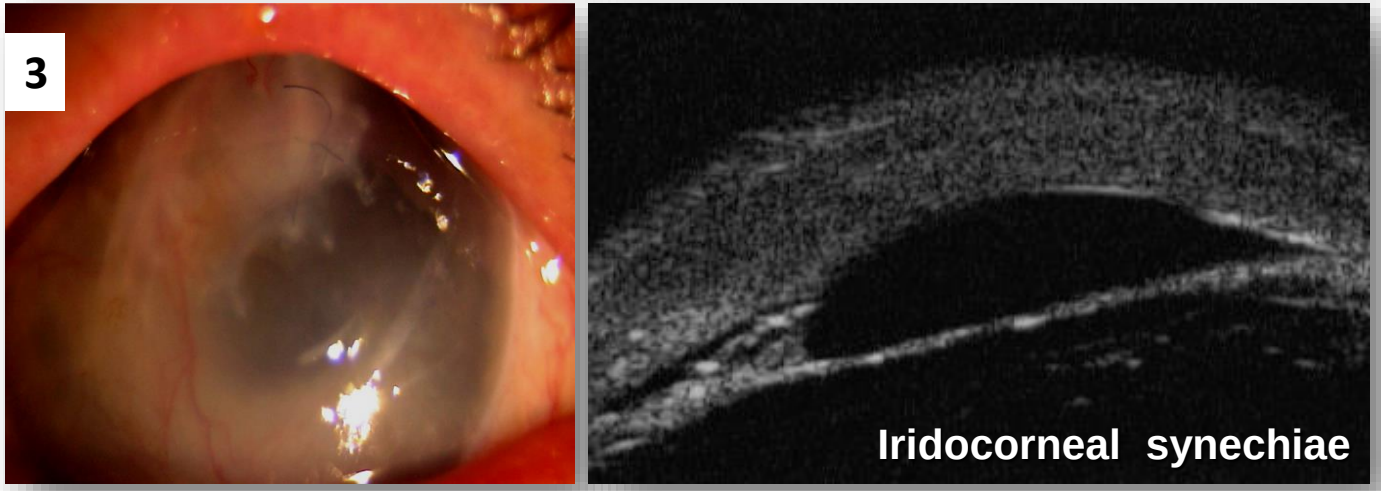




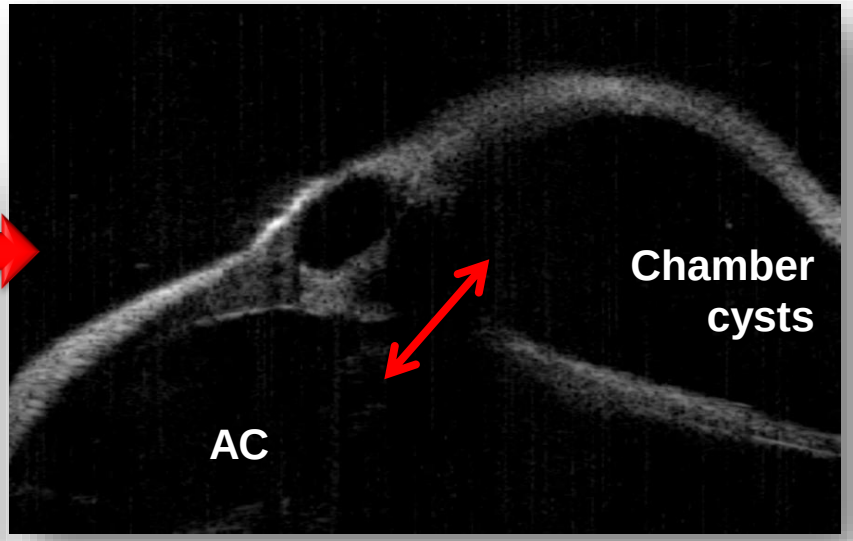
Complications of penetrating trauma

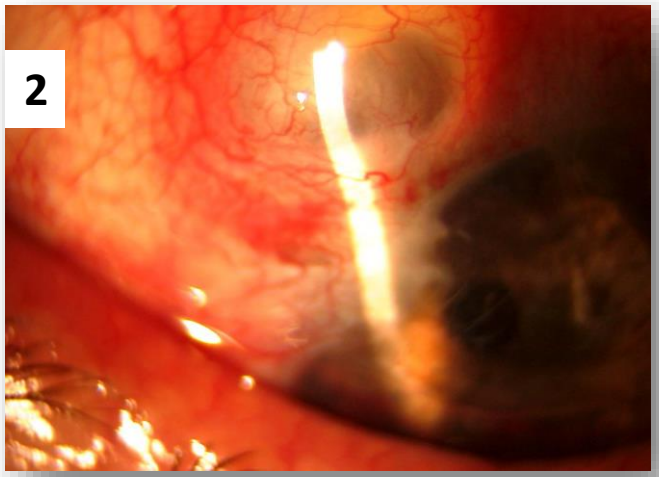


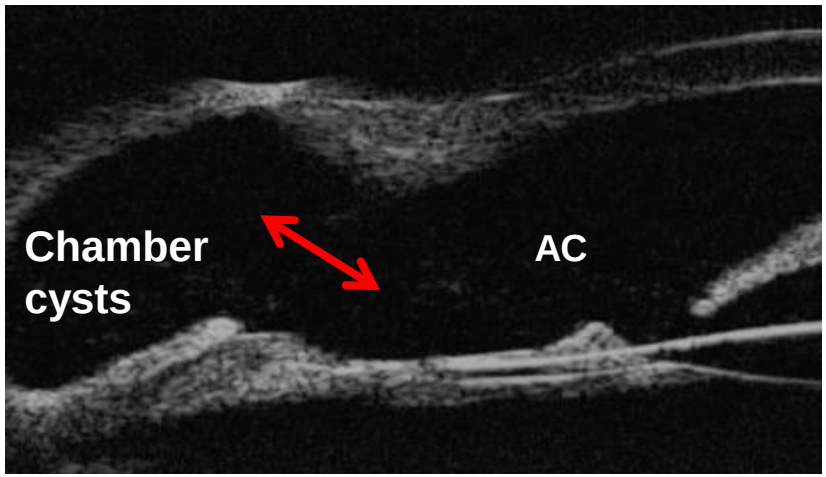




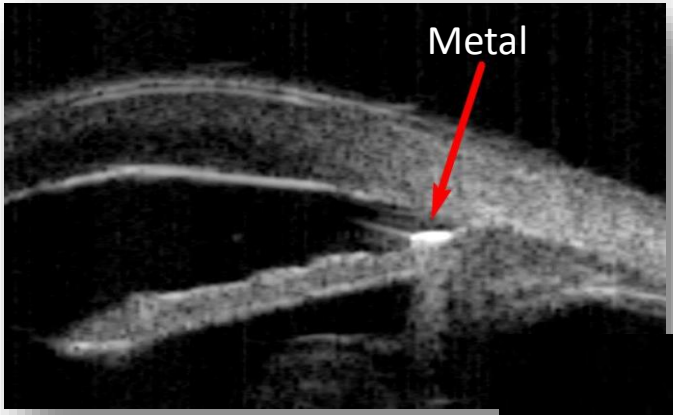
Complications of penetrating trauma: clinical cases

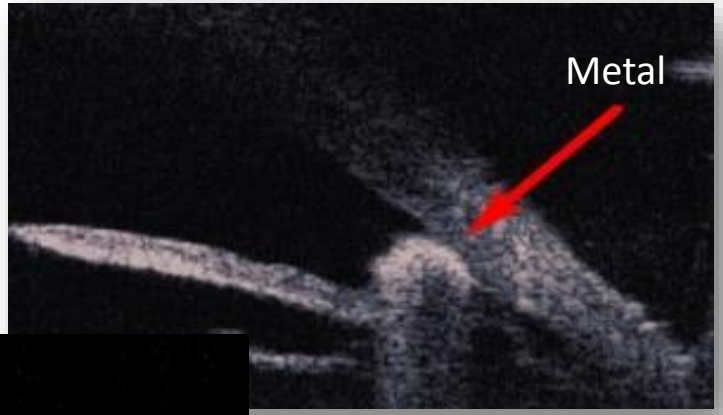


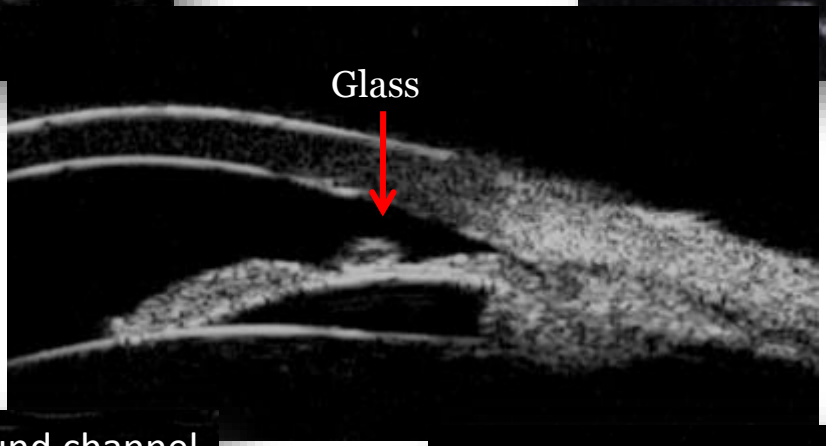


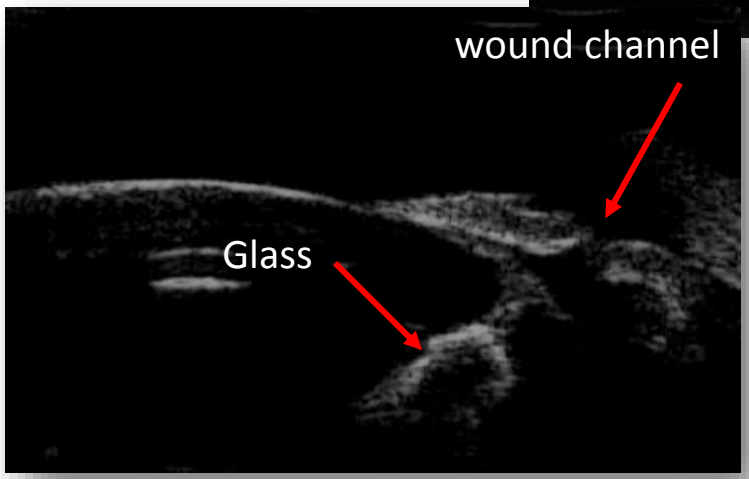


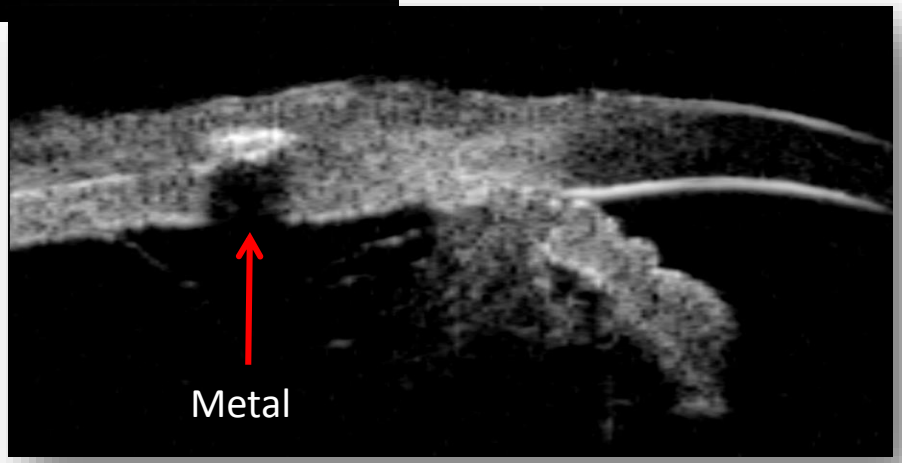
Foreign bodies in the anterior chamber



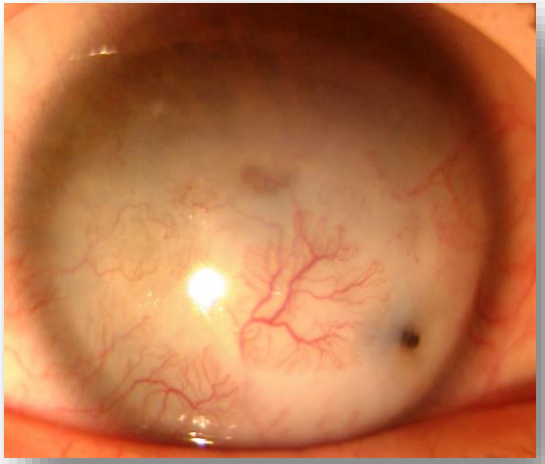


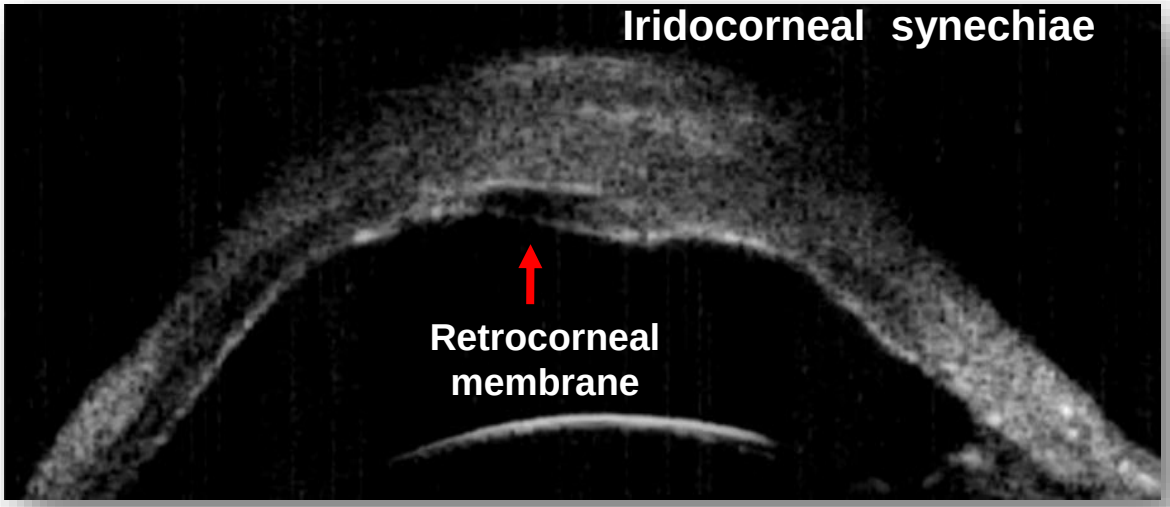


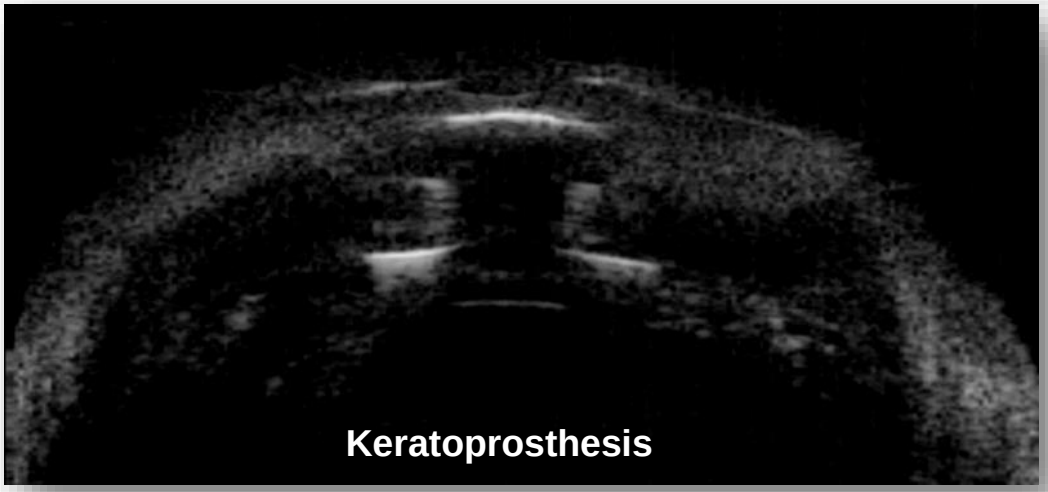




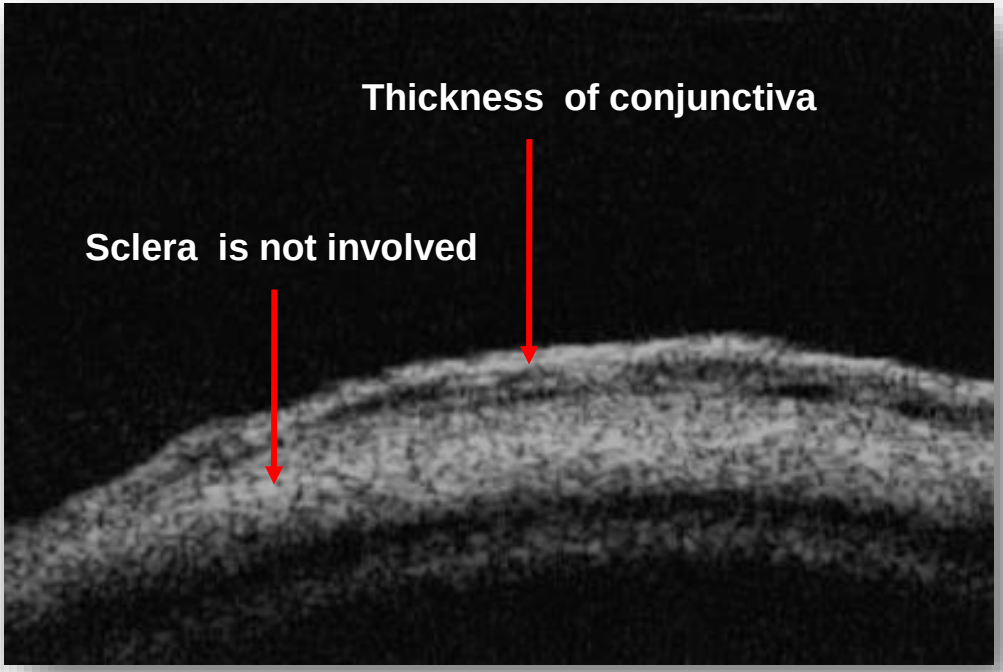
Outcomes of ocular burns



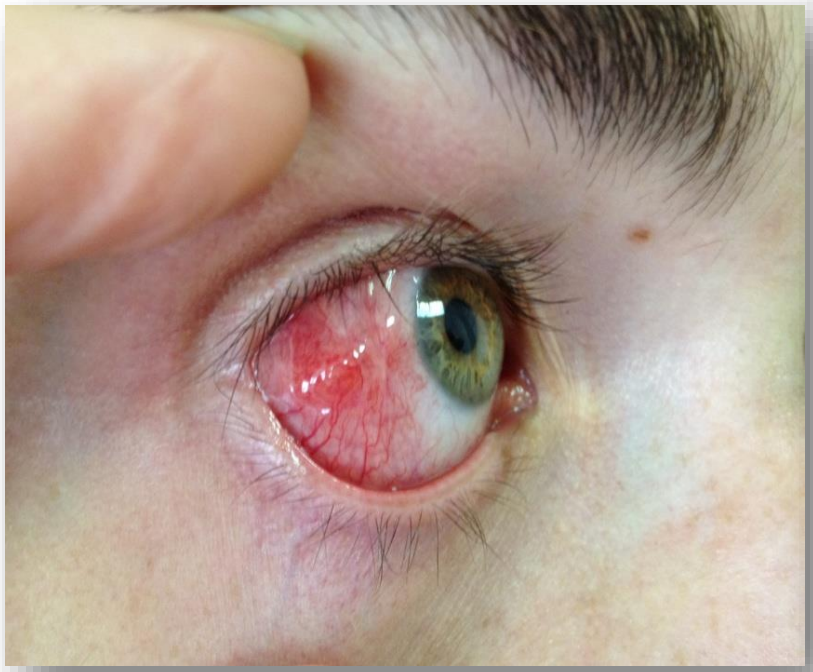


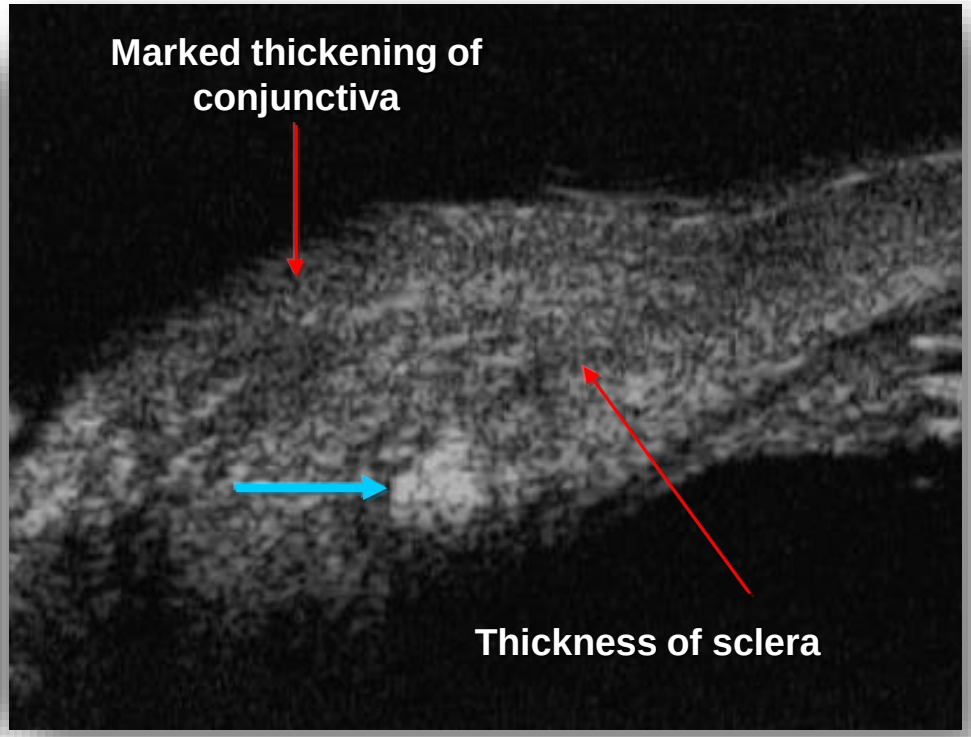


Episcleritis

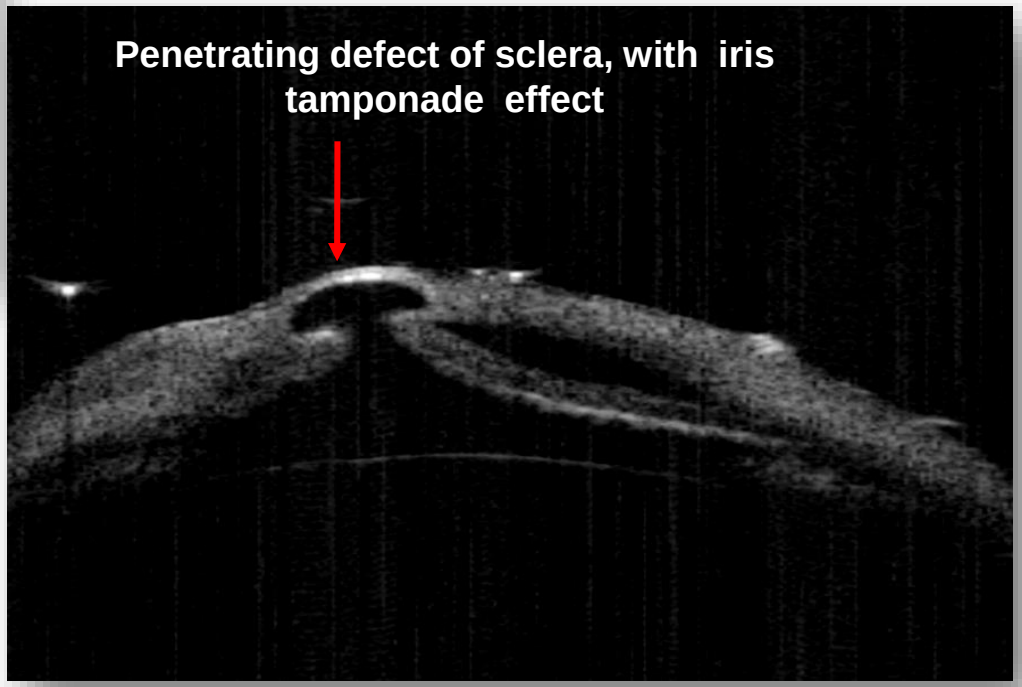


Scleritis

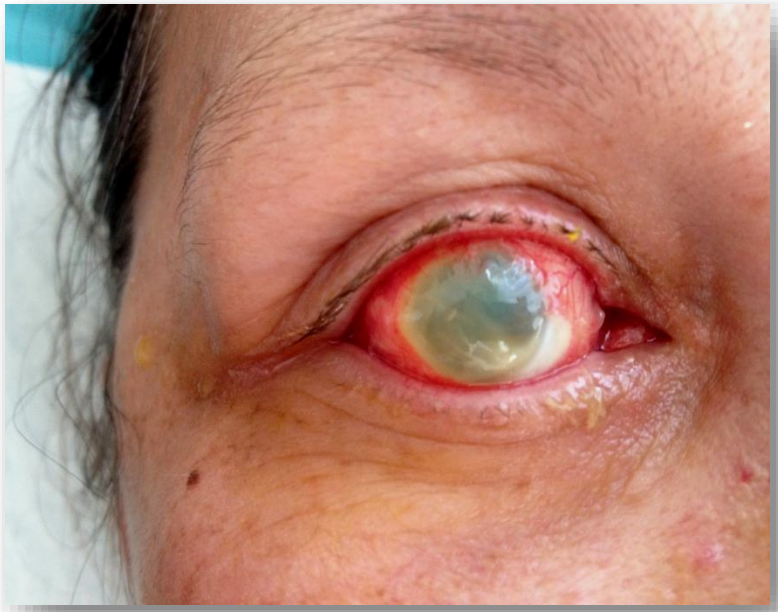


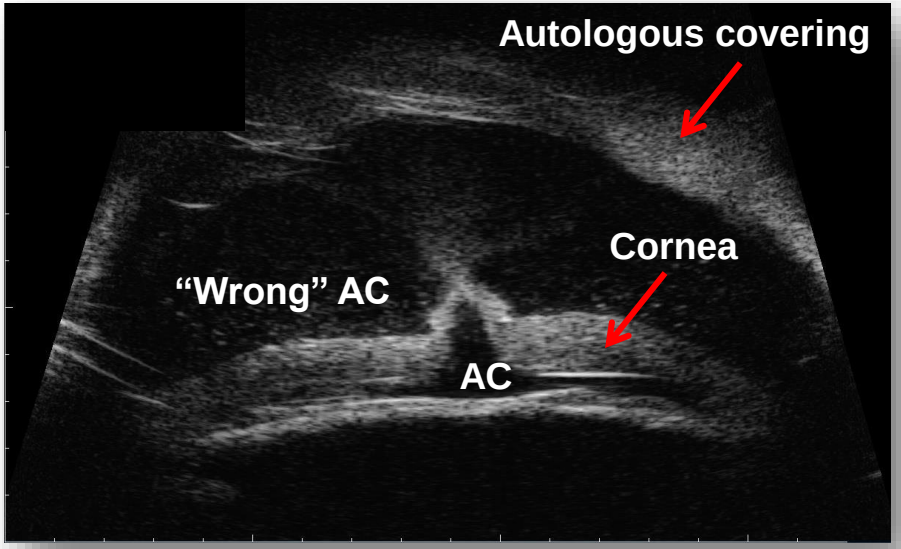


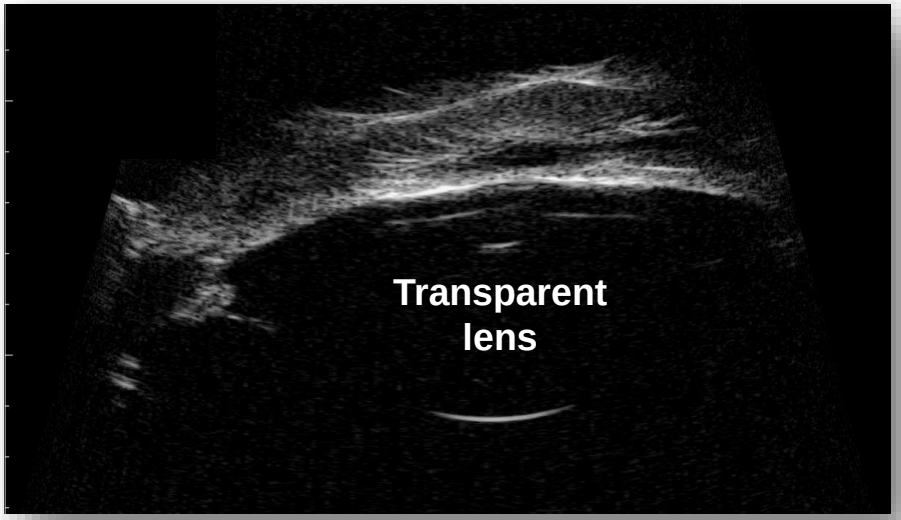
Outcome of scleritis in rheumatoid arthritis



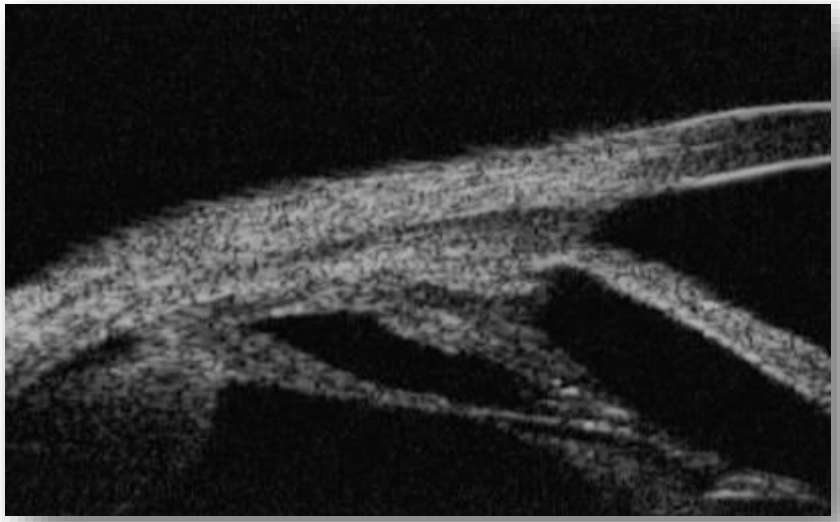
Outcome of fungal keratitis

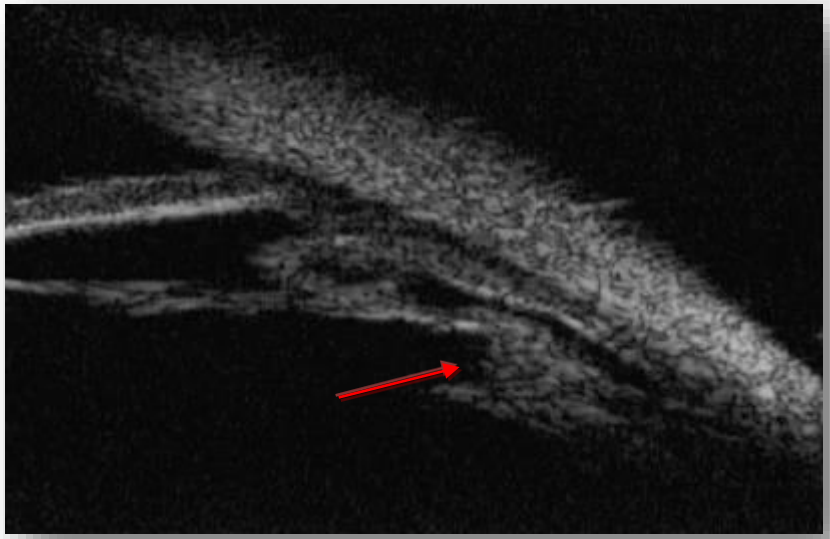


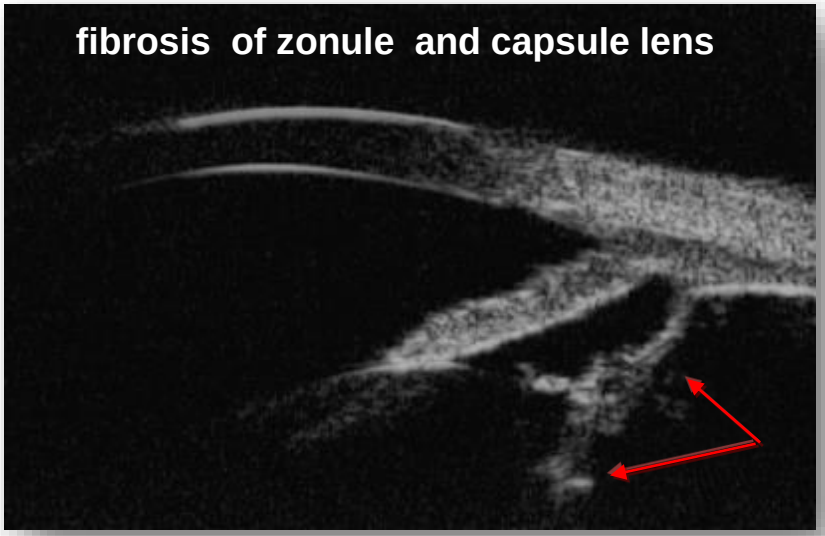




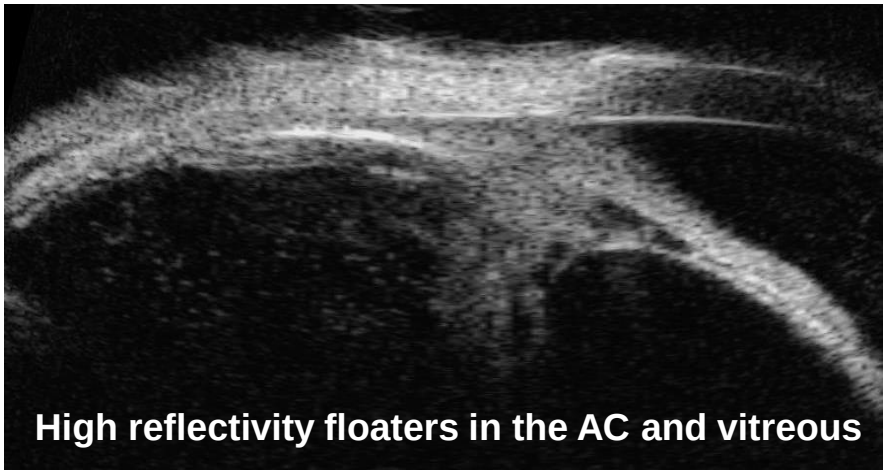
Outcome of pars planitis

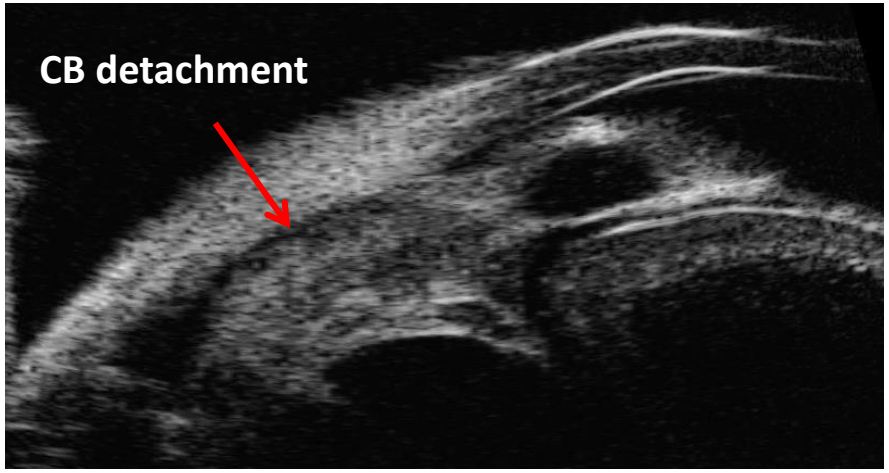


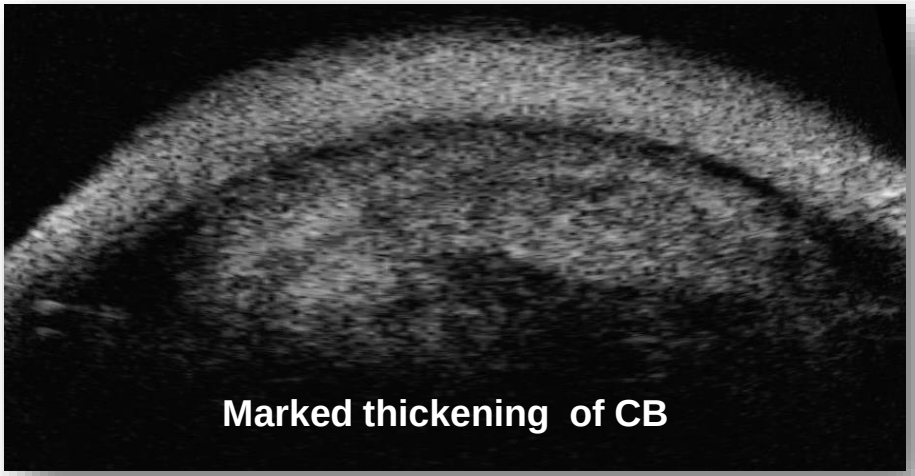




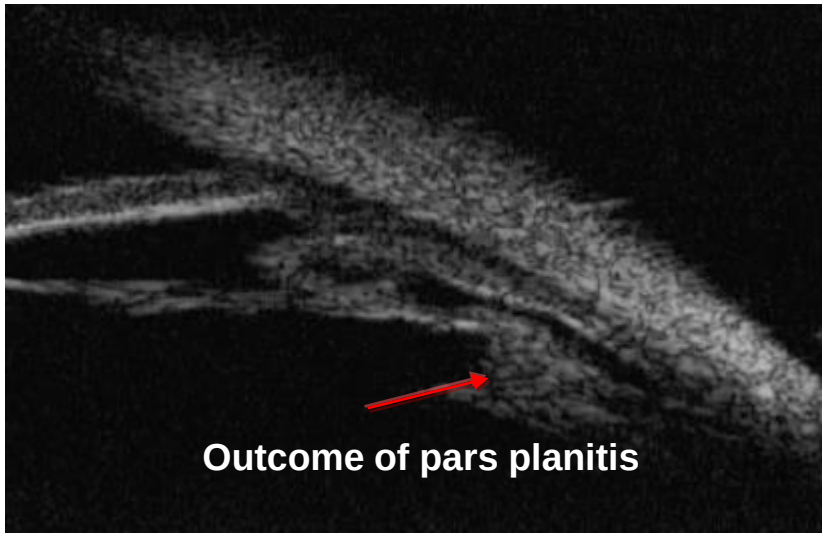
Acute anterior uveitis

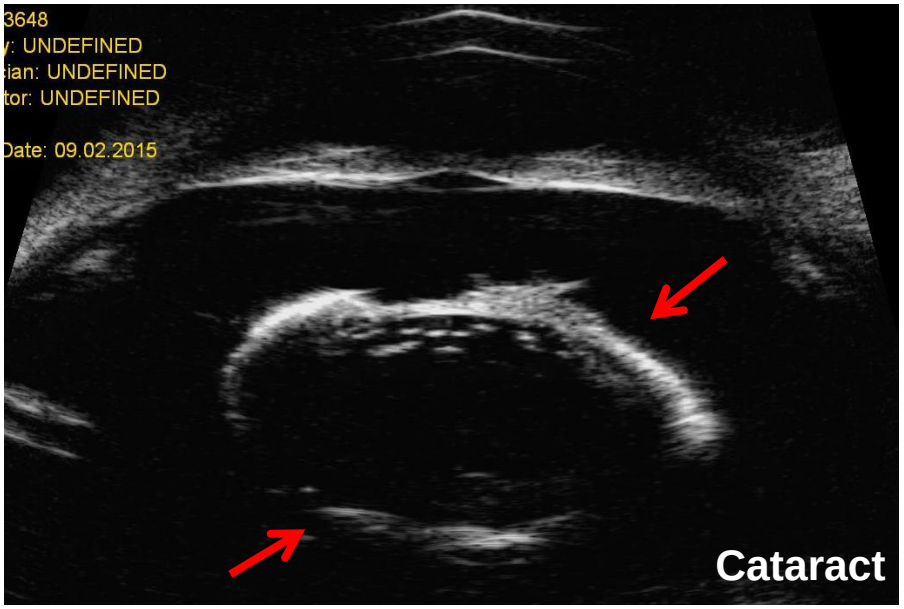


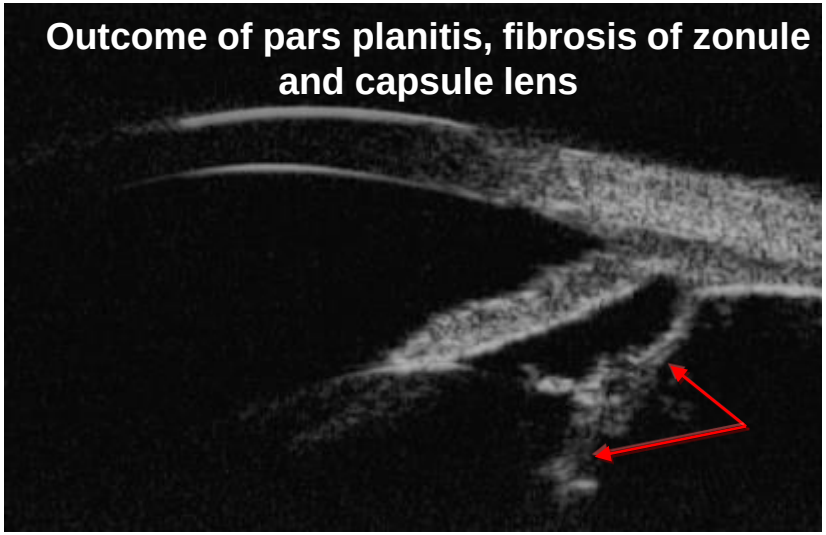




Chronic anterior uveitis

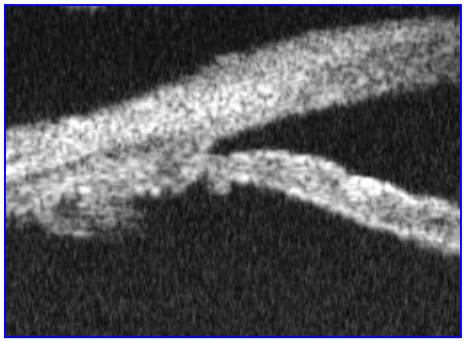


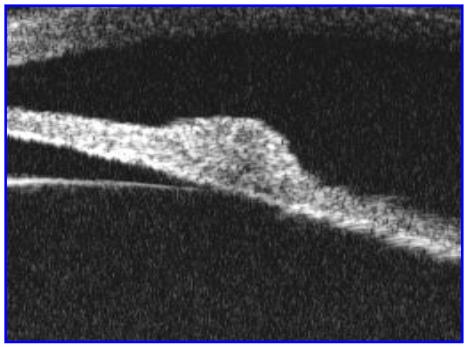




Current Limitation

- Immersion “water bath” technique
- Cost & Availability
- Limited penetration
- Narrow field
- Resolution ?
- No “tissue diagnosis”

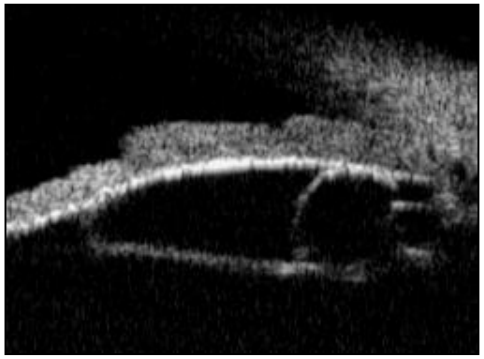




Contraindication to UBM

- Open eye injury
- Recent eye surgery
- Corneal ulcer
- Infective surface eye disease
- Uncooperative patient

Conclusion



UBM is…

- **New innovation in ultrasound**
- **In vivo imaging of anterior seg.**
- **Near microscopic resolution**
- **Wide & expanding applications**
- **Further modifications needed**

Thank you for attention!

BIOMETRIC PARAMETERS OF ANTERIOR SEGMENT

- **a – trabecular meshwork**
- **б – scleral spur (SS)**
- **1 – central anterior chamber depth (CACD; mm);**
- **2 – iris root (IR, mm);**
- **3–4 – angle opening distance at 250 μm and 500 μm from scleral spur (AOD 250, 500; mm);**
- **5–6– trabecular–ciliary process distance at 250 μm and 500 μm from scleral spur (TCPD 250, 500; mm);**
- **7–8 – iris-ciliary process distance at 250 μm and 500 μm from scleral spur (ICPD 250; 500; mm);**
- **9 – posterior chamber depth (PCD, mm);**
- **10 – central corneal thickness (CCT; mm);**
- **11 – paracentral anterior chamber depth (PaACD; mm);**
- **12 – maximum ciliary body thickness (CBTmax; mm);**
- **13 – anterior chamber angle (ACA; °).**