September 2000

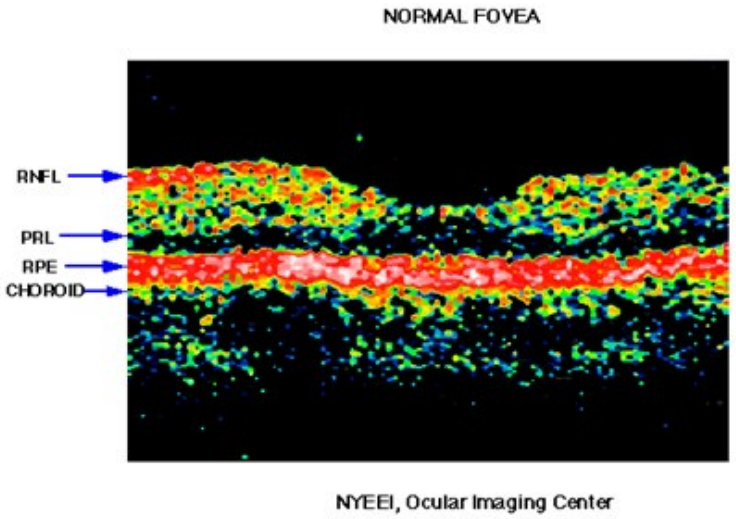
Optical Coherence Tomography & Ultrasound Biomicroscopy of the Eye

Tamim Qaum

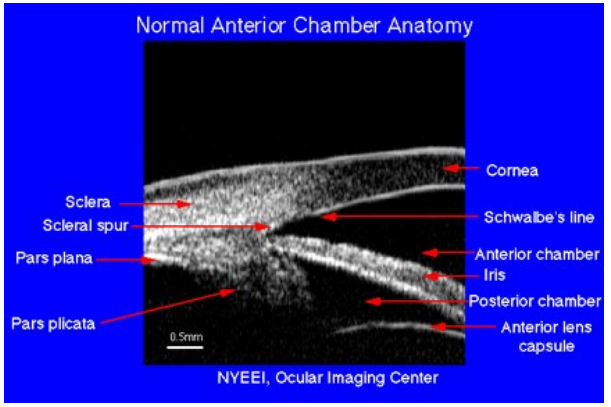
Harvard Medical School, Year-III

Two New Imaging Modalities

- Optical Coherence Tomography (OCT)

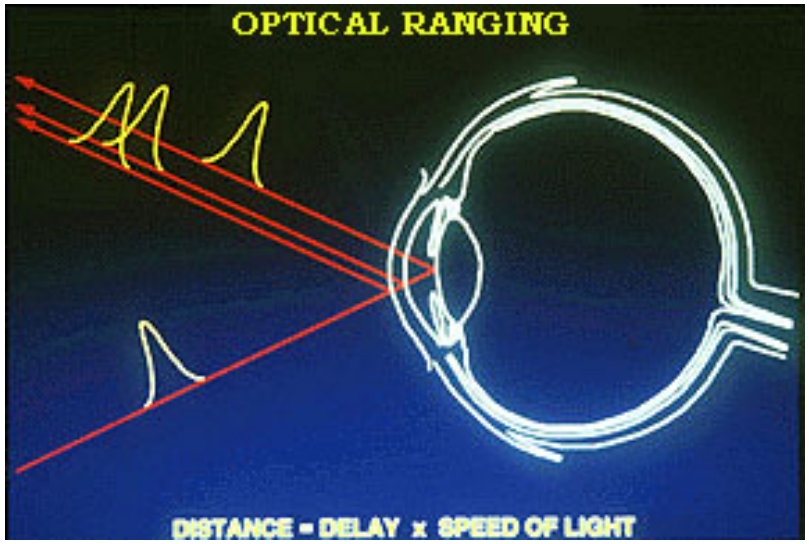


- Ultrasound Biomicroscopy (UBM)

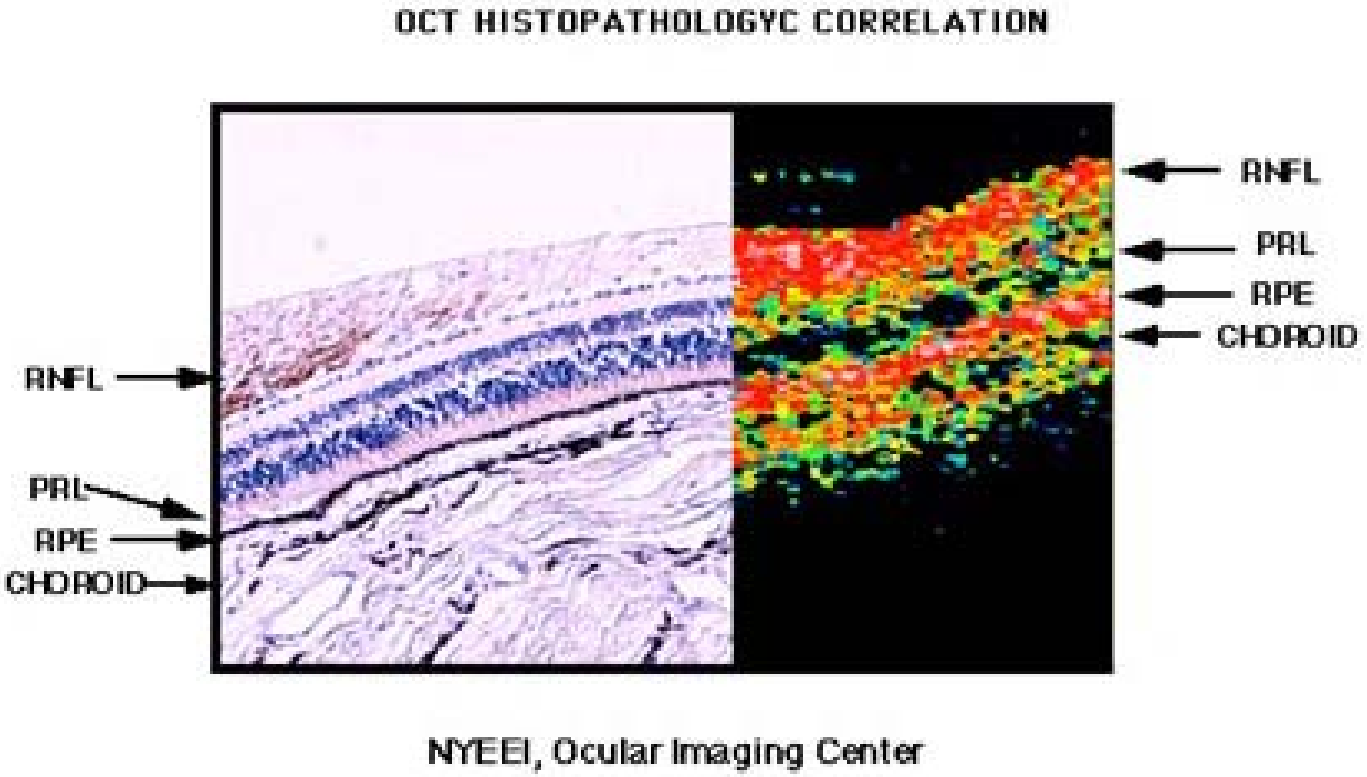


Optical Coherence Tomography (OCT)

- Introduced in 1991 by NEEC & MIT
- Analogous to ultrasound imaging
- Uses near infrared laser instead of sound waves
- Characterizes scatter variation



OCT Histopathologic Correlation



Advantages of OCT

- Non-invasive
- Non-contact
- Minimal cooperation needed
- Resolution ~ 10 μm (vs. US=150 μm; UBM=50 μm)
- Pick up earliest signs of disease
- Quantitatively monitor disease/staging

Disadvantages of OCT

- Best for optically transparent tissues
- Diminished penetration through retinal/subretinal hemorrhage
- Requires pupil diameter > 4 mm

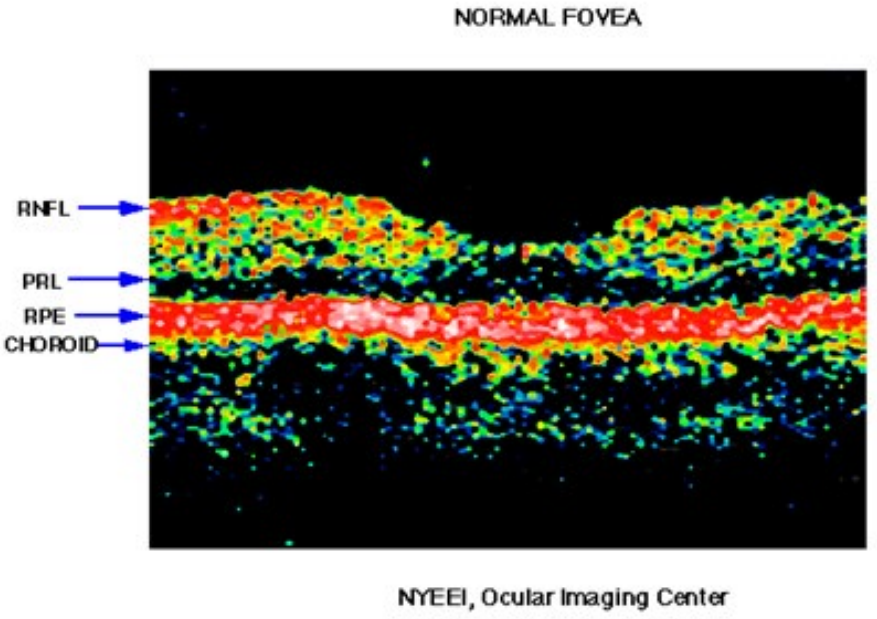
Sample Applications

- Macular holes (partial/complete absence of retinal tissue)
- Retinal pigment epithelial detachment
- Diabetic retinopathy and macular edema
- Central serous chorioretinopathy
- Age-related macular degeneration
- Epiretinal membranes

OCT - Normal Fovea

Visible Structures

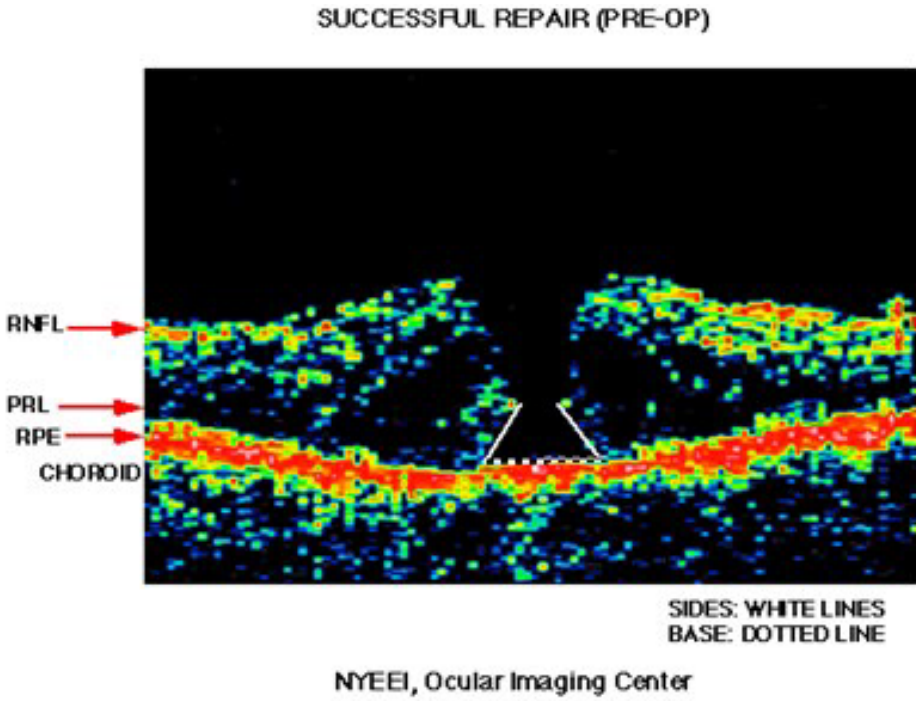
- Foveal depression
- Retinal Nerve Fiber Layer (RNFL)
- Photoreceptor Layer (PRL)
- Retinal Pigment Epithelium (RPE)
- Choroid



OCT - Macular Hole

DDx of Macular Hole

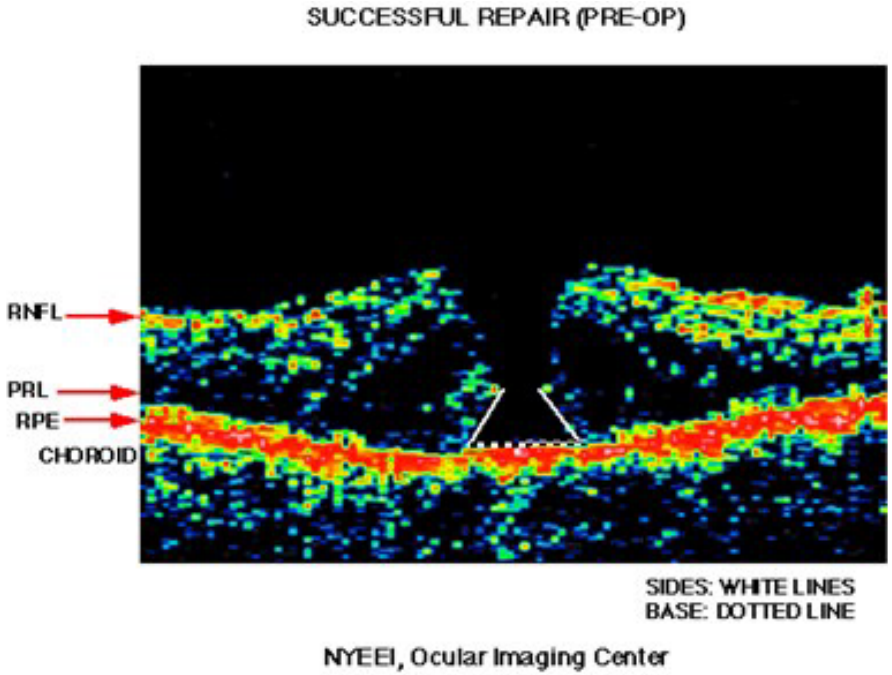
- Lamellar hole
- Macular cyst
- Epiretinal membrane with pseudohole
- Foveal detachment due to central serous retinopathy
- Vitreomacular traction syndrome

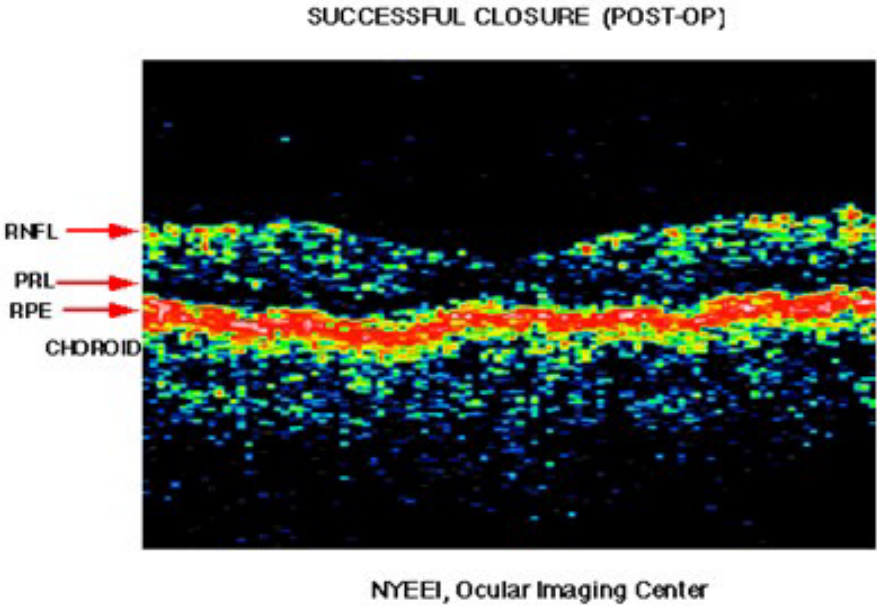


Alternative Tests - Macular Hole

- Slit-lamp biomicroscopy – meticulous, qualitative, low reproducibility
- CT & MR imaging - limited resolution
- Conventional ultrasound -resolution of only 150 μm
- UBM - limited to anterior segment
- Indirect ophthalmoscopy
- Florescein angiography

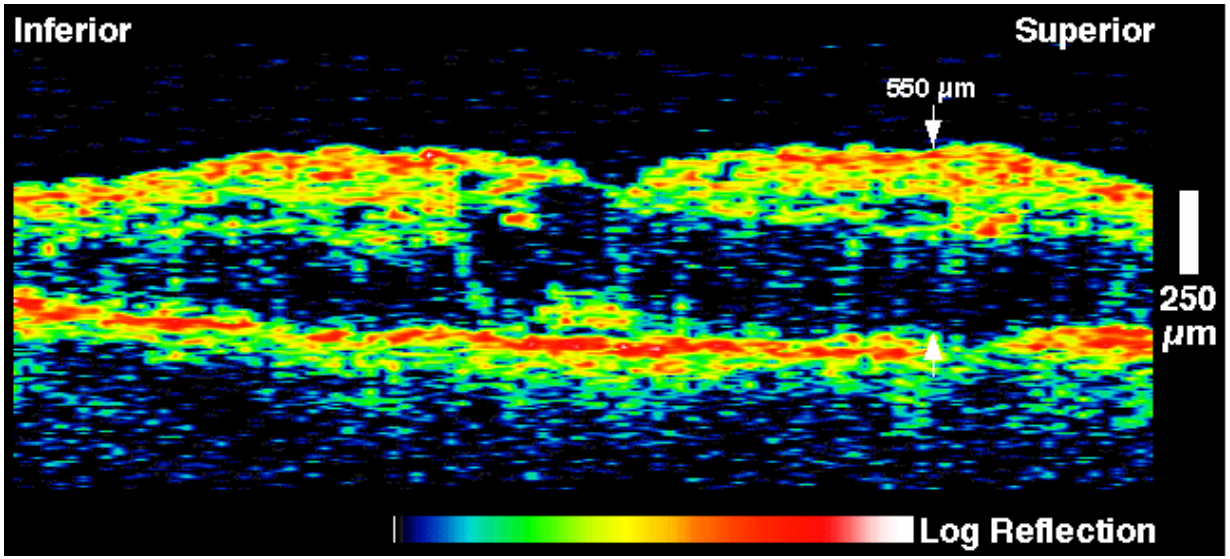
Macular Hole After Surgery





Nonproliferative Diabetic Retinopathy and Macular Edema

- Foveal thickness correlated with visual acuity
- Edematous neurosensory retina
- Diminished reflectivity

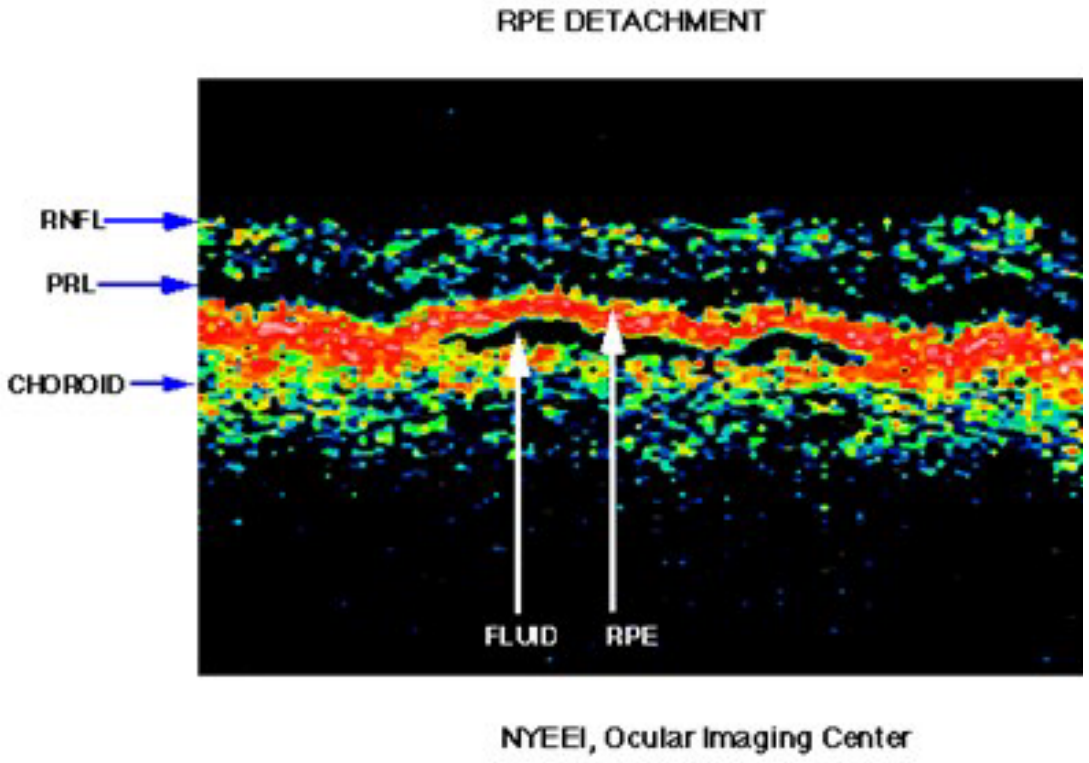


Alternative Tests - Diabetic Retinopathy

- Florescein angiography
  - gold standard
  - minimally invasive
  - qualitative detection
  - low reproducibility
  - leakage not correlated with visual function

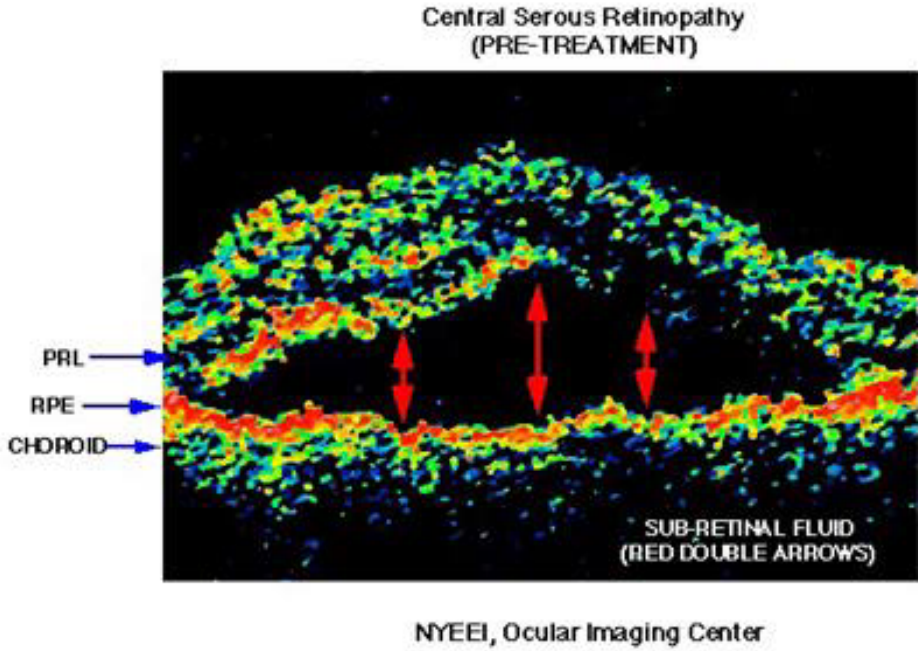
Retinal Pigment Epithelial Detachment

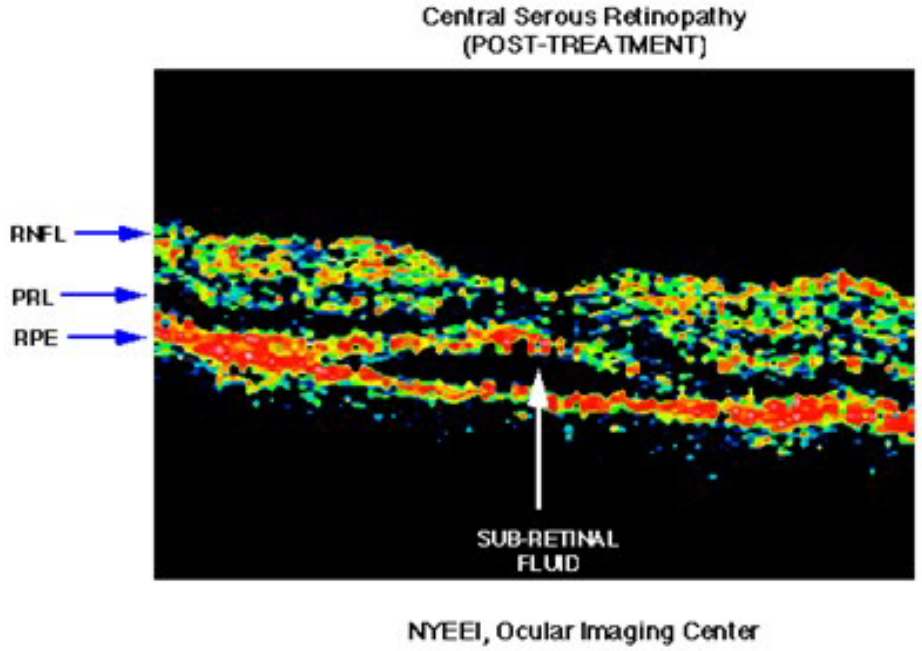
- Fluid between RPE and choroid



Central Serous Chorioretinopathy

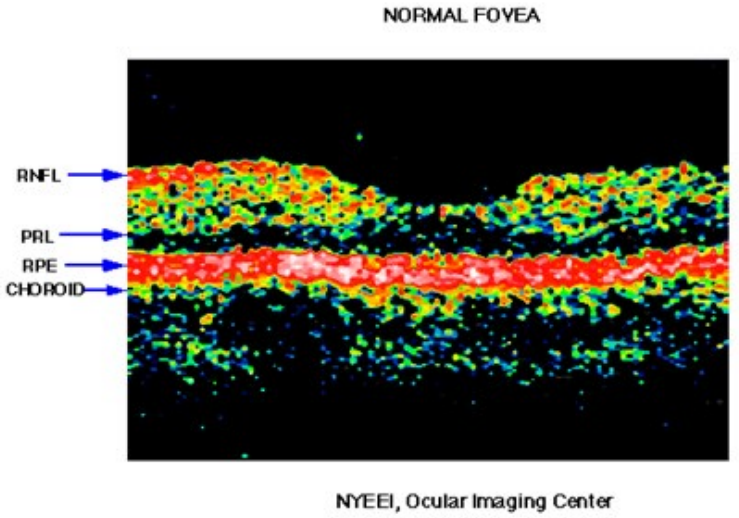
- Fluid between RPE and PRL



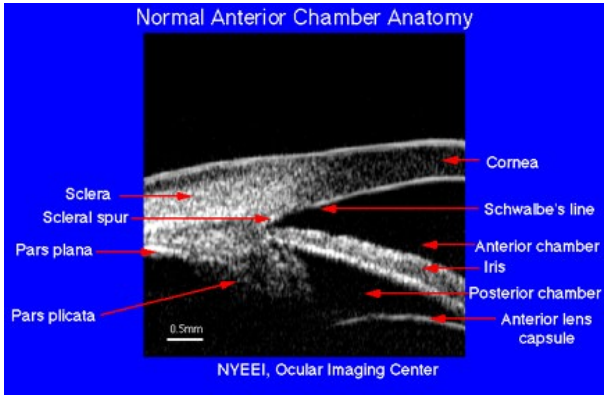


Two New Imaging Modalities

Optical Coherence Tomography (OCT)



Ultrasound Biomicroscopy (UBM)



Ultrasound Biomicroscopy (UBM)

- Introduced in 1990 by Princess Margaret Hospital, Canada
- Similar to conventional ultrasound imaging
- Uses high frequency ultrasound transducers 50 MHz (vs US 10 MHz)
- Patient in supine position with topical anesthesia
- 20 mm eye cup between eyelids filled with saline
- Probe placed into eye cup

Advantages of UBM

- Resolution of ~ 50 μm (vs US=150 μm)
- Anterior segment of the eye
- Not limited to optically transparent tissues (i.e. opaque corneas)

Disadvantages of UBM

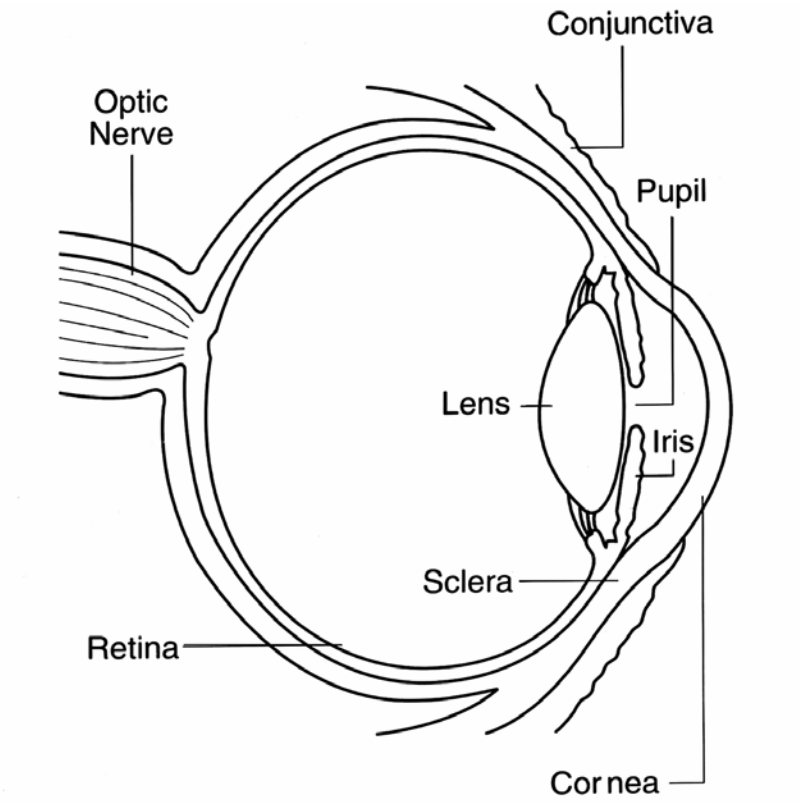
- Direct contact
- Penetration of only 4-5 mm
- Image influenced by
  - Plane of section
  - Distance to anterior chamber
  - Orientation of the probe
  - Room illumination
  - Fixation
  - Accommodative effort

Sample Applications

- Pupillary block angle-closure glaucoma
- Ciliary body tumors
- Ocular trauma
- Pigment dispersion syndrome & pigmentary glaucoma
- Intraocular lens position
- Failing filtering blebs

Normal Eye

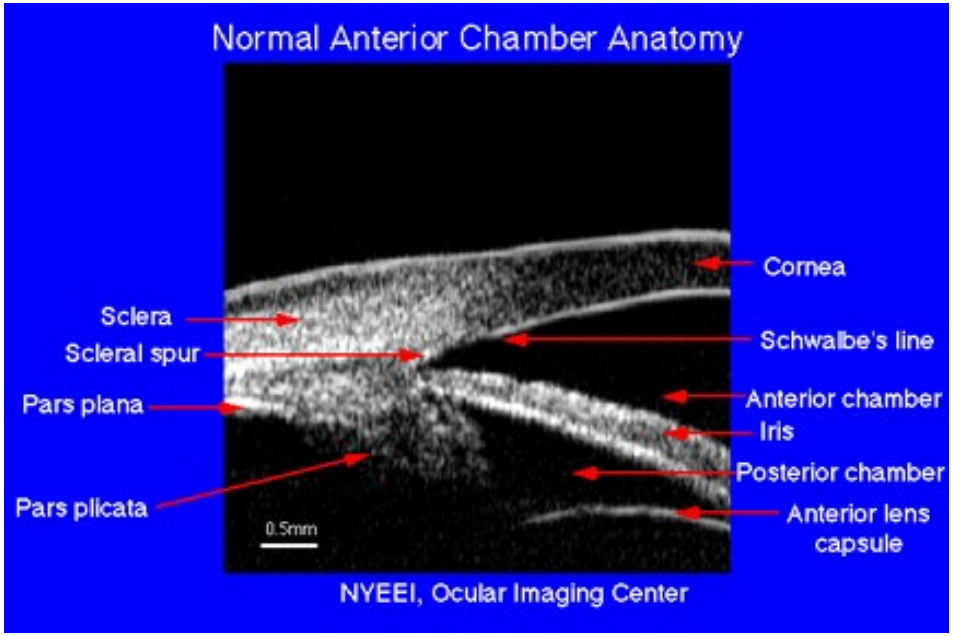
- Aqueous humor flows through pupil and into Canal of Schlemm



Normal Eye Using UBM

Visible Structures

- Cornea
- Sclera & scleral spur
- Ciliary body
- Schwalbe's line (end of Descemet's membrane)
- Anterior chamber & angle
- Iris
- Posterior chamber
- Anterior lens capsule



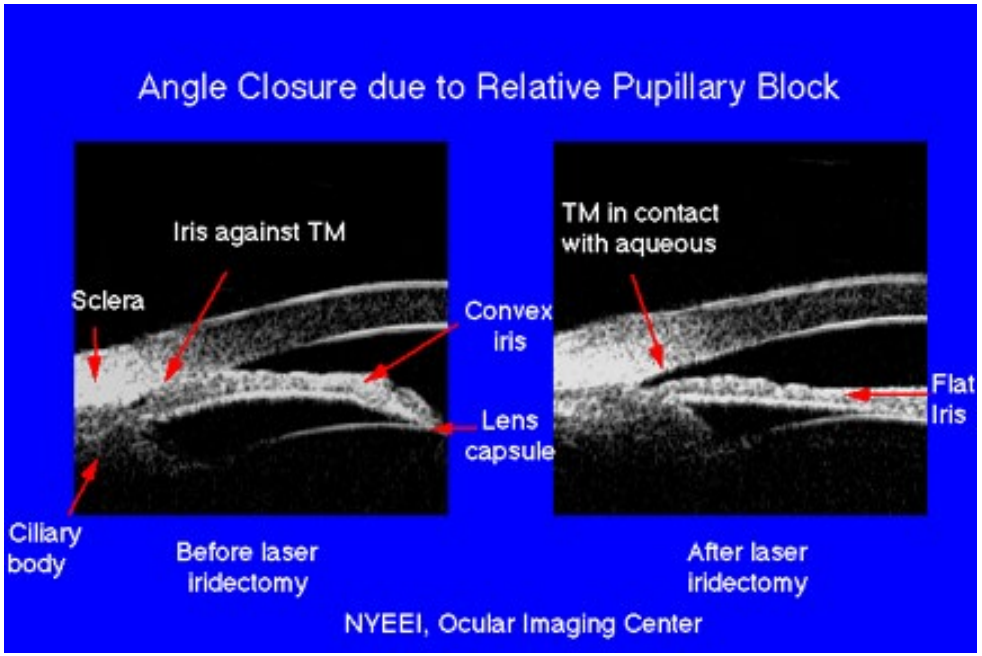
Pupillary Block Angle-Closure Glaucoma

- Most common angle-closure glaucoma
- Mechanism

  -Aqueous made in posterior chamber unable to pass through pupil

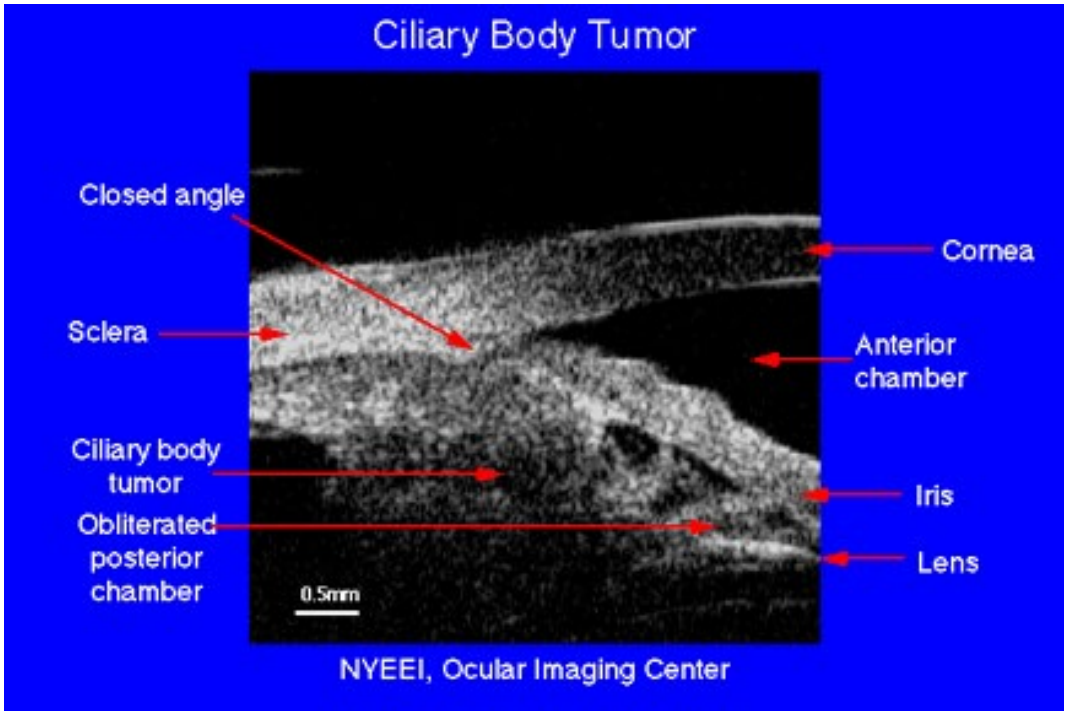
  -Pressure gradient develops behind iris

  -Pushes iris against trabecular meshwork
- Treatment: laser iridotomy (tiny hole at side of iris)



Ciliary Body Tumors

- Can cause angle-closure
- Uneven acoustic echoes



Ocular Trauma – Angle Recession

- Tear into ciliary body
- Iris insertion appears posterior

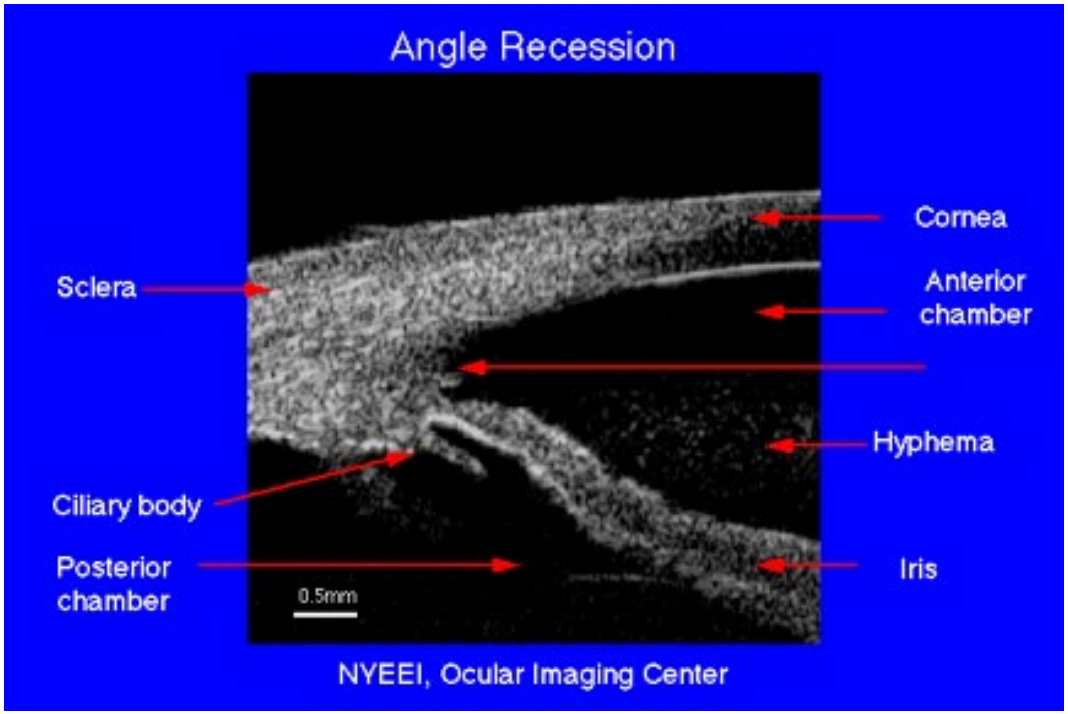


Image References

Two New Imaging Modalities

- Optical Coherence Tomography (OCT) http://www.nyee.edu/glaucoma/octnorm.htm
- Ultrasound Biomicroscopy (UBM) http://www.nyee.edu/glaucoma/ubmnorm.htm
- Optical Coherence Tomography http://www.neec.com/oct_lecture/slidea02.htm
- OCT Histopathologic Correlation http://www.nyee.edu/glaucoma/octother.htm
- OCT - Normal Fovea http://www.nyee.edu/glaucoma/octnorm.htm
- OCT - Macular Hole http://www.nyee.edu/glaucoma/octholes.htm
- Macular Hole After Surgery http://www.nyee.edu/glaucoma/octholes.htm
- Nonproliferative Diabetic Retinopathy and Macular Edema http://www.neec.com/medical/OCT.html
- Retinal Pigment Epithelial Detachment http://www.nyee.edu/glaucoma/octfluid.htm
- Central Serous Chorioretinopathy http://www.nyee.edu/glaucoma/octfluid.htm
- Normal Eye http://www.nei.nih.gov/photo/eyean/index.htm
- Normal Eye using UBM http://www.nyee.edu/glaucoma/ubmnorm.htm
- Pupillary Block Angle-Closure Glaucoma http://www.nyee.edu/glaucoma/ubmclose.htm
- Ciliary Body Tumors http://www.nyee.edu/glaucoma/ubmclose.htm
- Ocular Trauma – Angle Recession http://www.nyee.edu/glaucoma/ubmtraum.htm

Optical Coherence Tomography & Ultrasound Biomicroscopy of the Eye

Tamim Qaum

Core Radiology/September 18, 2000

HMS III