# OPTICAL COHERENCE TOMOGRAPHY IN NICU

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## 2016 – 25 YEARS OF OPTICAL COHERENCE TOMOGRAPHY

It was first described by Huang and colleagues in 1991

- Huang D, Swanson EA, Lin CP, et al. Optical coherence tomography. Science. 1991;254(5035):1178-1181.

Ophthalmic applications have developed the earliest

- research
- clinical

It is estimated that there are now ~30 million OCT imaging procedures performed worldwide every year


## OCT UTILIZES A CONCEPT KNOWN AS INTERFEROMETRY

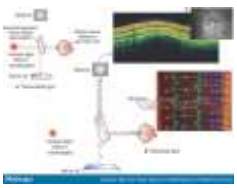
OCT works by projecting a broadband light into the eye

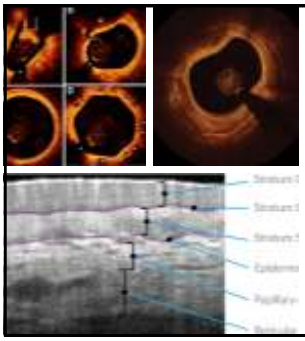
- Most systems centered around 840 nm wavelenght

Backscatttered light is combined for comparison with light reflected from a reference arm

The combination of both lights generates an interference signal

The interference patterns are processed to form the cross-sectional images of the retina





## APPLICATIONS FOR OCT

Skin

Major vessels

Heart

## THE FIRST AND MOST EXTENSIVE USE – THE EYE

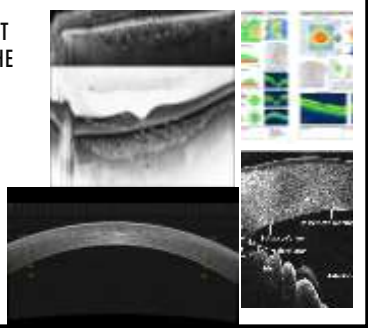
Cornea

Iridocorneal angle

Retina

Choroid

Optic nerve



## THE PRIMARY USE IN THE EYE - RETINA

Shows retinal architecture

- Differentiation of retinal layers
- Choroid
- Foveal shape
- Vitreous

Used extensively in the diagnosis

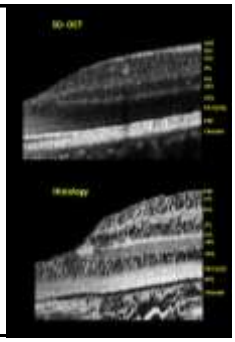
- Glaucoma
- Vitreoretinal disorders

## RETINA

OCT

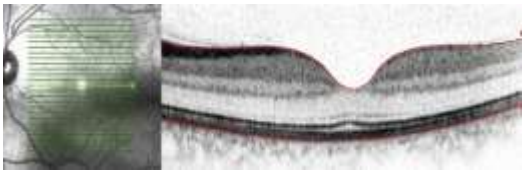
Comparative histological section of the fovea of a normal human eye

histology



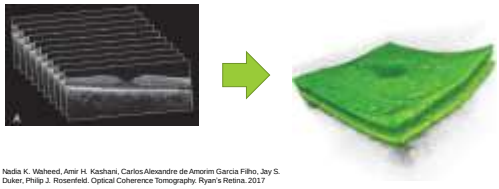
R.K. Murthy, Shamim Haji, Kumar Sambhav, Sandeep Grover, K.V. Chalam, Clinical applications of spectral domain optical coherence tomography in retinal diseases, In Biomedical Journal, Volume 39, Issue 2, 2016, Pages 107-120,

## AQUISITION OF A SERIES OF OCT SCANS



R.K. Murthy, Shamim Haji, Kumar Sambhav, Sandeep Grover, K.V. Chalam, Clinical applications of spectral domain optical coherence tomography in retinal diseases, In Biomedical Journal, Volume 39, Issue 2, 2016, Pages 107-120,

## THREE-DIMENSIONAL IMAGES



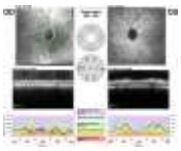
Nadia K. Waheed, Amir H. Kashani, Carlos Alexandre de Amorim Garcia Filho, Jay S. Duker, Philip J. Rosenfeld. Optical Coherence Tomography. Ryan's Retina. 2017

## THREE-DIMENSIONAL MOVIES

http://vsri.ucdavis.edu/research/retinal/oct

## SEGMENTATION OF THE RNFL LAYER

Glaucoma



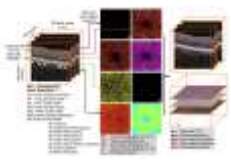
Optic neuritis

## ERYTHROCYTE MOTION DETECTION – SSADA ALGORITHM

*split-spectrum amplitude decorrelation angiography*

Detection of differences in B-scans

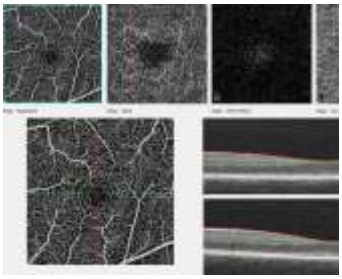
- Scans in the same location
- Scans in short intervals



## OCT ANGIOGRAPHY

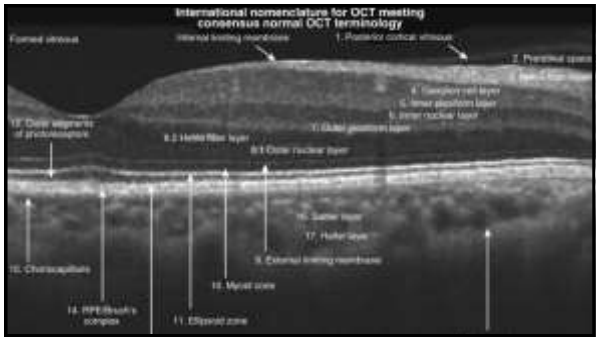
Visualization of vessels
- retina
  - Superficial capillary plexus
  - Deep capillary plexus
- choroid
- Optic nerve

Metoda
- fast
- Non-invasive



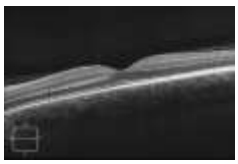
CRASH COURSES

CRASH COURSE IN RETINA FOR NEONATOLOGISTS | **OCT interpretation**




## RETINAL DETACHMENT

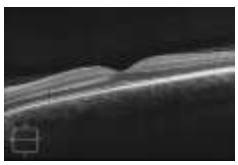
Normal



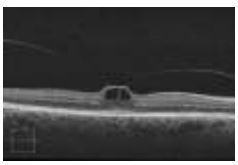
Pathology

## VITREOMACULAR TRACTION

Normal

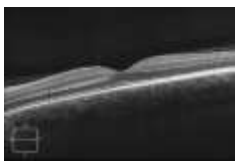


Pathology

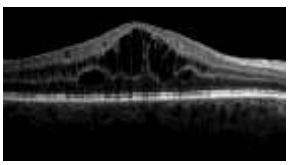


## CYSTOID MACULAR EDEMA (INTRARETINAL CYSTS)

Normal

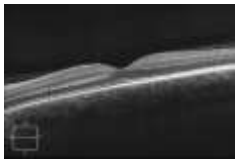


Pathology

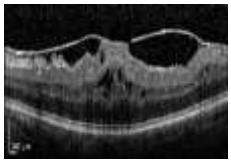


## EPIRETINAL FIBROSIS

Normal

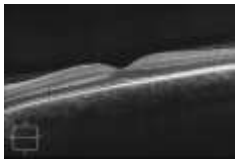


Pathology

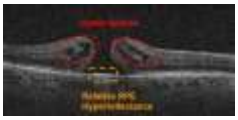


## MACULAR HOLE

Normal

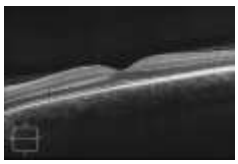


Pathology



## LAMELLAR MACULAR HOLE

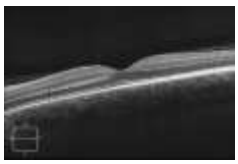
Normal



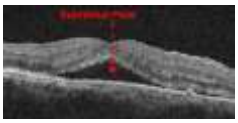
Pathology

## MACULAR DETACHMENT

Normal

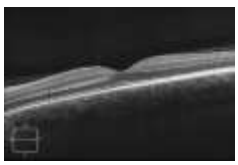


Pathology



## HARD EXUDATES (VASCULAR ACTIVITY)

Normal



Pathology

## NORMAL ADULT VS INFANT MACULAR OCT

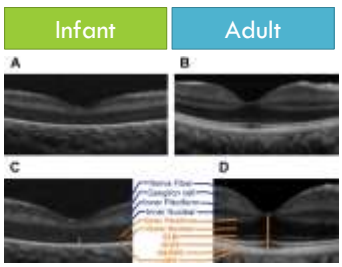
Thick inner retinal layers of the neonate

- Centrifugal migration

Thin outer retinal layers in neonates

- Centripetal growth

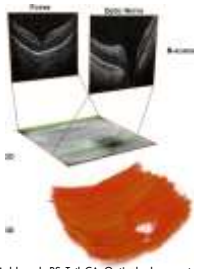
External limiting membrene (ELM), IS/OS and OS/RPE are not present in premature fovea




Maldonado RS, O'Connell RV, Sarin N, et al. Dynamics of human foveal development after premature birth. Ophthalmology 2011;118(12):2316

## TWO-DIMENSIONAL AND THREE-DIMENSIONAL IMAGES

Volumetric 6 x 6 mm SDOCT scan from a 31-week-old PMA infant

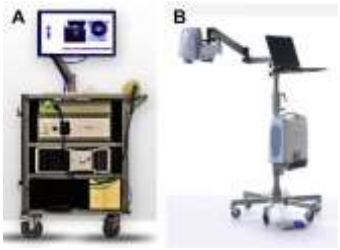


Maldonado RS, Toth CA. Optical coherence tomography in retinopathy of prematurity: looking beyond the vessels. Clin Perinatol. 2013 Jun;40(2):271-96.

## COMMERCIALLY AVAILABLE PORTABLE SDOCT SYSTEMS USEFUL FOR SUPINE IMAGING

(A) Bioptigen Envisu system. 0.9-kg (2-pound) handheld scanner

(B) Optovue iStand system with a 2.3-kg (5-pound) head scanner




## EXAMINATION TECHNIQUE

Technique seems to be without discomfort for the infant

No lid speculum necessary

No bright illumination

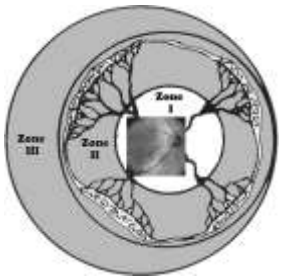
Infant continues sleeping and seems comfortable

- 24% sucrose solution (Tootsweet, Hawaii Medical, Pembroke, MA)

Maldonado RS, Toth CA. Optical coherence tomography in retinopathy of prematurity: looking beyond the vessels. Clin Perinatol. 2013 Jun;40(2):271-96.

## CURRENT SYSTEMS COVER TYPICALLY ZONE I

Cave!!!

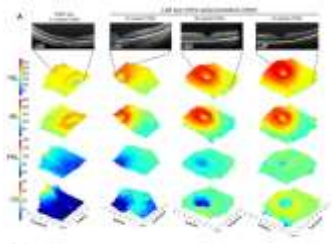



## APPLICATION OF OCT IN NICU

- Photoreceptor development
- Macular edema of prematurity
- Retinal vasculature
- Optic nerve and nerve fiber layer

## PHOTORECEPTOR DEVELOPMENT

Three-dimensional maps of human foveae from 31–43 weeks PMA



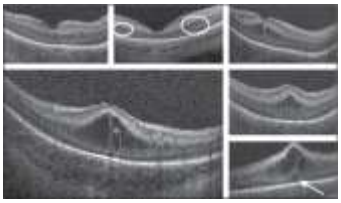
Rothman AL, Mangalesh S, Chen X, Toth CA. Optical coherence tomography of the preterm eye: from retinopathy of prematurity to brain development. Eye Brain. 2016 May 27;8:123-133.

## MACULAR EDEMA OF PREMATURITY

a unique representation of cystoid macular edema (CME)

the macular edema is:

- Bilateral
- Symmetric
- isolated to the inner nuclear layer
- typically causes foveal bulging with elongation of hyperreflective septae



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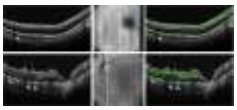
## RETINAL VASCULATURE

OCT as an effective tool to characterize the retinal vasculature

Vascular Abnormality Score by OCT (VASO) to quantify abnormalities graded on OCT such as

- vessel elevation
- hyporeflective vessels
- scalloping of retinal layers
- perivascular spaces

(ROP) zone II, stage 3, and normal vasculature

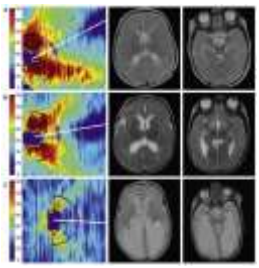


ROP zone II, stage 3, and plus disease

Rothman AL, Mangalesh S, Chen X, Toth CA. Optical coherence tomography of the preterm eye: from retinopathy of prematurity to brain development. Eye Brain. 2016 May 27;8:123-133.

## OPTIC NERVE AND RETINAL NERVE FIBER LAYER

Average RNFL thickness may be a promising biomarker of brain pathology and subsequent neurodevelopment as an adjunct clinical tool to brain MRI



Rothman AL, Mangalesh S, Chen X, Toth CA. Optical coherence tomography of the preterm eye: from retinopathy of prematurity to brain development. Eye Brain. 2016 May 27;8:123-133.

## CASE 1 (TOTH ET AL.)

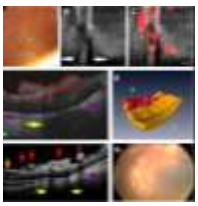
650-g, 23-week postmenstrual age (PMA)

received confluent laser to both eyes at 32 weeks PMA

The patient had aggressive posterior ROP, zone I with severely immature retinal development and plus disease

- preretinal structures traced in red
- Green arrow indicates retinal detachmen

Retcam fundus photograph demonstrates tractional retinal detachment 1 month after SD OCT imaging

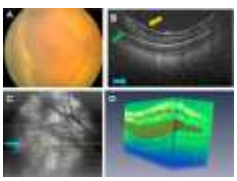


## CASE 2 (TOTH ET AL.)

A former 750-g, 24-week PMA, male infant was referred for diode laser treatment of both eyes at 38 weeks

Indirect ophthalmoscopy demonstrated 4 quadrants of plus disease in both eyes, stage 4A in the right eye

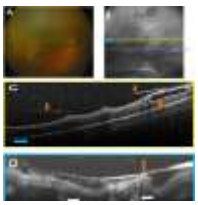
- Cross-sectional spectral domain optical coherence tomography (SD OCT) image shows retinal detachment (green arrow) and subclinical retinoschisis



## CASE 3 (TOTH ET AL.)

A former 650-g, 23-week PMA, Caucasian male was evaluated for progressive ROP despite laser photocoagulation in both eyes.

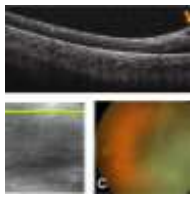
- thick membrane complex over the macula creating prominent retinal folds, and tractional retinal detachment.



## CASE 3 (TOTH ET AL.)

At 37 weeks PMA, he had lens sparing vitrectomy in the left eye for a stage 4A detachment

- Patient 3's left eye 4 days after vitrectomy surgery
- Cross-sectional spectral domain optical coherence tomography (SD OCT) image demonstrates retinal detachment ( green arrow ) and retinoschisis ( brown arrow )



## TAKE HOME MESSAGES

Fundus examination with indirect ophthalmoscopy remains the gold standard for monitoring patients with ROP

SD OCT can evaluate subclinical pathology such as

- preretinal structures
- Retinoschisis
- retinal detachment in patients with advanced ROP
- Retinal cysts
- Vitreomacular traction

It can serve to monitor

- Macular development
- Resolution of macular edema of premaurity
- Vascular activity (VASO)
- Progresion of retinal detachment into the macula
  - Stage 4A
  - Stage 4B