

Optical Coherence Tomography

Nicholas Lee
Consultant The Hillingdon Hospital
& The Western Eye Hospital



The ROYAL
SOCIETY of
MEDICINE

lasers, tips, trips and technology

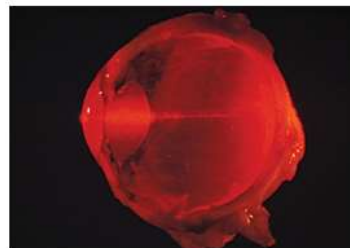
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Date Thursday 12 November 2015
Evening

Venue Royal Society of Medicine
1 Wimpole Street
LONDON
W1G 0AE

Organised by [Ophthalmology Section](#)

Accreditation 2 CPD points



agenda

5.30 pm Registration, tea and coffee

6.00 pm Welcome and introduction

Dr Elizabeth Wilkinson,
President, Ophthalmology
Section, Royal Society of
Medicine

6.10 pm Mechanisms in laser damage
and how we use them

Professor John Marshall,
Frost Professor of
Ophthalmology, University
College London, Institute of
Ophthalmology

6.30 pm Laser success: Diabetic
vasculopathy

Mr Robin Hamilton, Consultant
Ophthalmologist, Moorfields
Eye Hospital NHS Foundation
Trust

6.50 pm Laser future and the future:
Maculopathy

Ms Sharon Heng, University
College London

7.10 pm Laser controversy: Vitreolysis

Mr Coes Van Der Wilt,
Styrevand Hospital, Tiel,
Holland

7.30 pm Laser economics and the limits:
short pulses for big money
Dr Paul Rosen

7.50 pm Refractive revolution, past,
present and future

Professor John Marshall

8.10 pm Panel discussion

8.20 pm Completion of evaluation forms
and close of meetings

8.25 pm Drinks reception

Dyspraxia Foundation

Spring Ball

at The Royal Garden Hotel, Kensington
14th May 2016

Drinks reception 5.30pm
Dinner at 7.30pm
Followed by a Charity Auction,
Live Band, Dancing and Casino
Carriage at 12.30am

£130 per Ticket
Black Tie and Evening Dress
To book tickets
Telephone: 01462 455018
Email:
admin@dyspraxiafoundation.org.uk



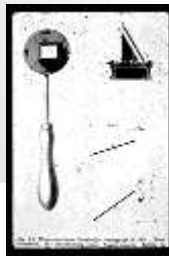
Registered Charity No. 1432962
Registered in England No. 1432962



- 1851 Hermann von Helmholtz
- 1871 Marc-Antoine Giraud-Teulon



Early Ophthalmoscope
Edouard Meyer 1873
(From W.M. History of Ophthalmology)





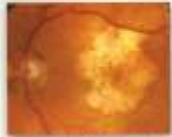







How we Use to Examine the eye 1987

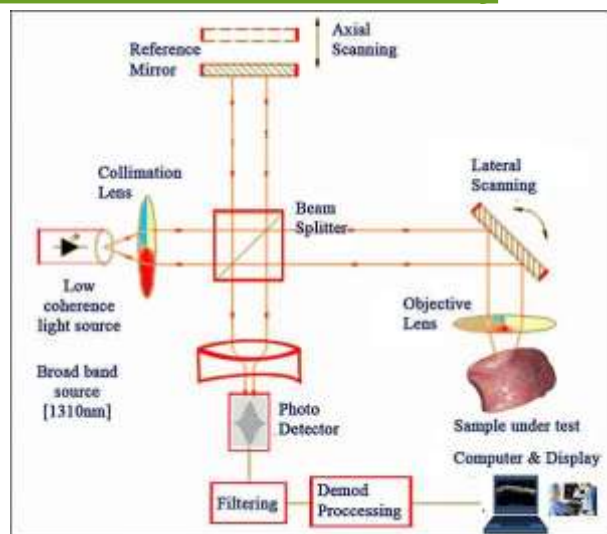
- 1919 Gullstrand slit lamp
- Ruby lenses
- Indirect Lenses - Volk
- Contact lenses
- Detailed binocular view of retina
- 1980+ Quality of optics improved considerably
- 2010 LED illumination



Slit Lamp Indirect Ophthalmoscopy Non-Medical Retina Ophthalmologists

<p>Untreatable AMD Requires retinal laser photocoagulation</p>  <p>Drusen are formed from the breakdown of retinal pigment epithelium (RPE) cells. The RPE cells which have degenerated and become apoptotic.</p>	<p>Drusen Balls of lipid and protein in form</p>  <p>Multiple drusen and pigment changes.</p>	<p>AMD</p> 	
			<ul style="list-style-type: none"> • Fundal Photography • Film • Polaroid • Digital • 3D • Holographic
			

- 1990 – First Fundal images Published
- low coherence interferometry



Academia **Start-up** **Carl Zeiss Meditec**

Year	Event	Generation
1980s	Basic Research	
1991	Patient Application	
1995	Early Prototype	
1996	OCT1 (lab tool)	1 st Generation
1997	OCT1	
2000	OCT2 (modified)	
2002	Sirius OCT	2 nd Generation
2007	Cirrus HD-OCT	3 rd Generation
2011	Software Upgrades	

• 2015 Swept source
• OCT angiography

ADVANCED DIAGNOSIS

DRI OCT-1 Atlantis

Swept Source
Optical Coherence Tomography
See, Discover, Explore

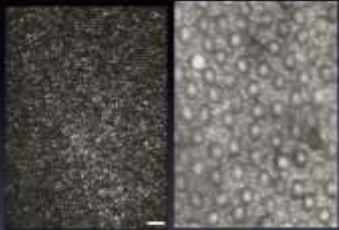
• **Topcon SS-OCT**

Year	Model	Approx. Sales (Units)
1999	Time Domain OCT	~10,000
2002	3D OCT-1000 (Evans & Sells OCT)	~20,000
2008	3D OCT-2000 (Spectral Domain OCT)	~40,000
2012	DRI OCT-1 (Swept Source OCT)	~100,000

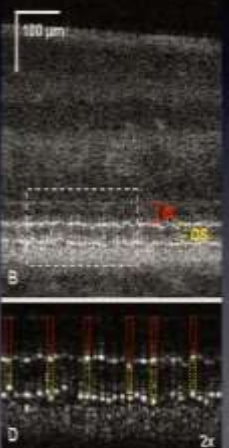
• http://www.topcon.co.jp/en/eyecare/products/product/diagnostic/oct/DRI_OCT-1_E.html

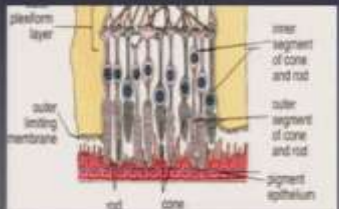
Adaptive Optics Imaging of Photoreceptors

AO - SLO



AO - OCT




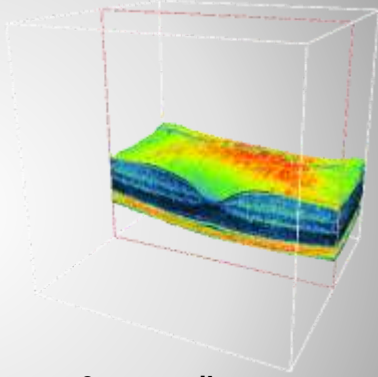


- Where Next? – Cellular Imaging
- Adaptive Optics
- Different Wavelengths
- Research Only Currently
- Cellular Markers

• Richard Rosen AAO 2011

Optical Coherence Tomography (OCT)





- Very versatile Scanner akin to MRI scans – 3mm pupil
- Pachymetry, Corneal
- Iris Angles for Closed or Narrow Angles
- Retina
- Optic nerve for glaucoma GDx

The Macula

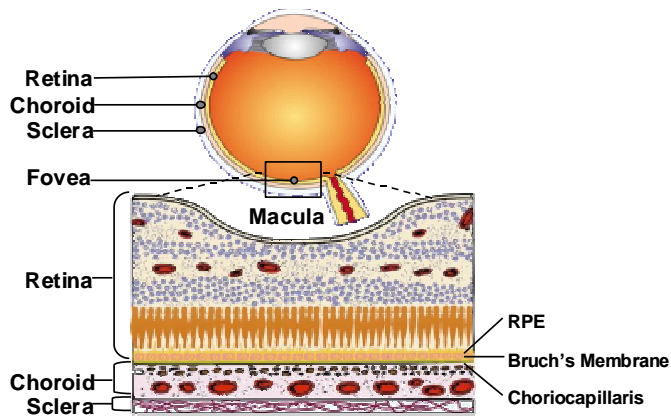
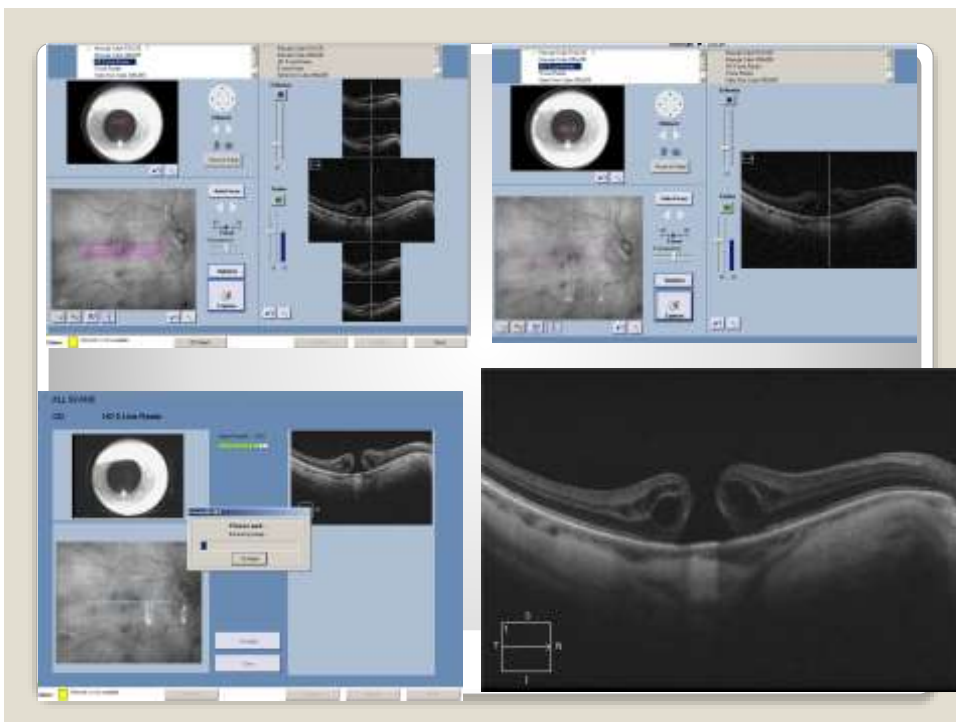
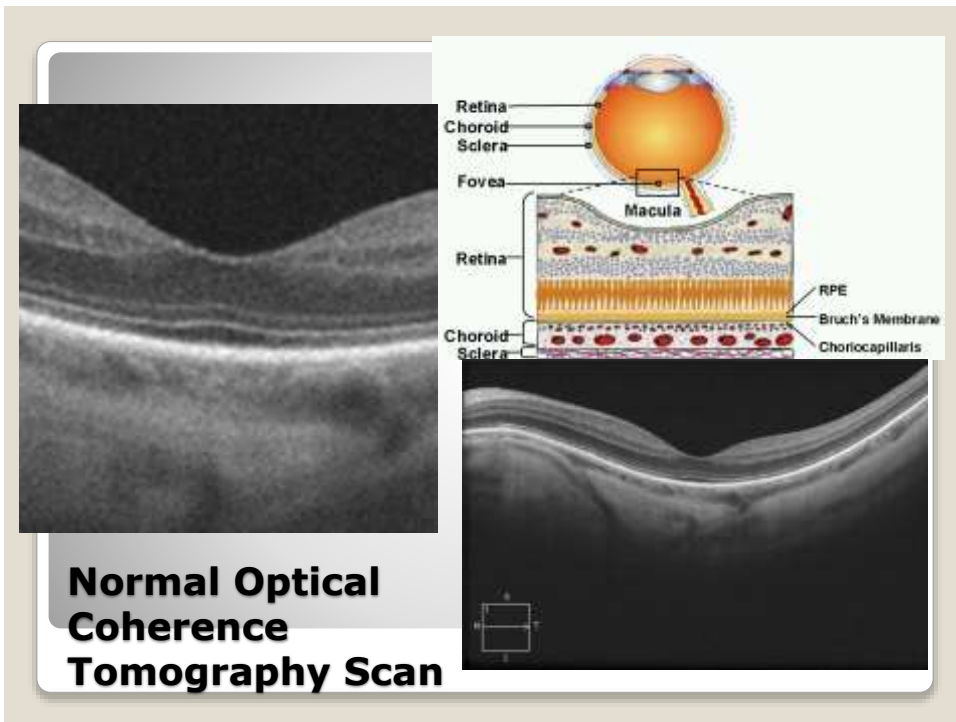
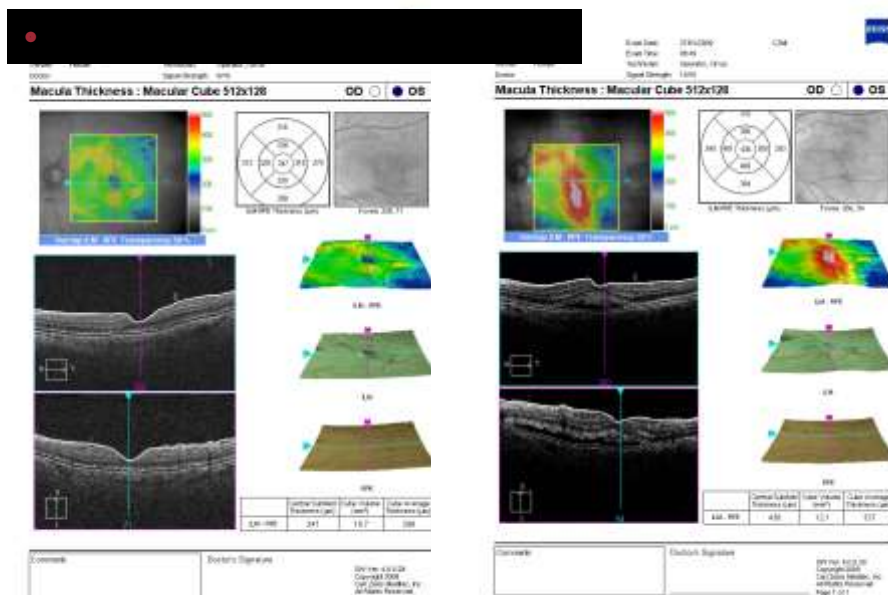
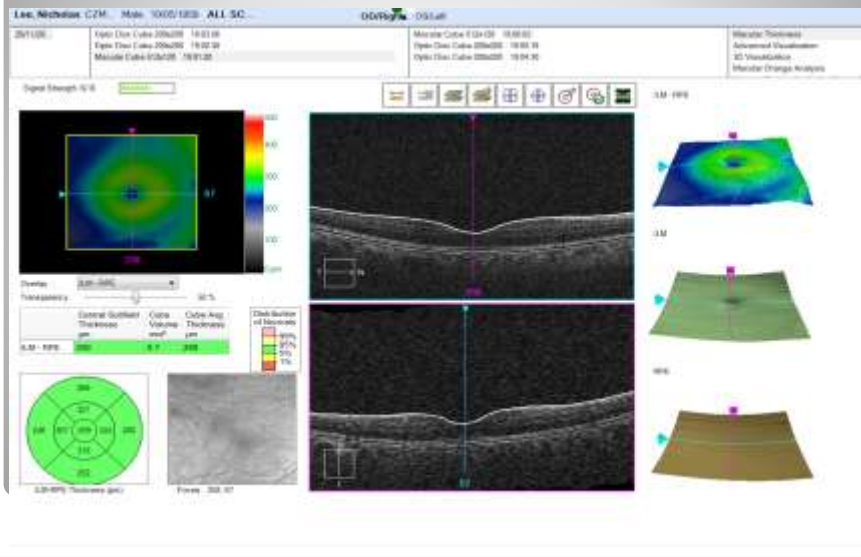


Figure courtesy of Novartis.

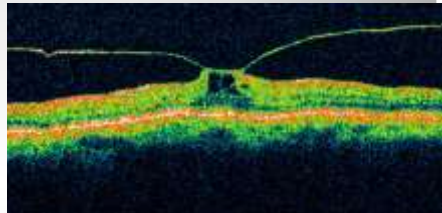




Standard Macular Analysis view

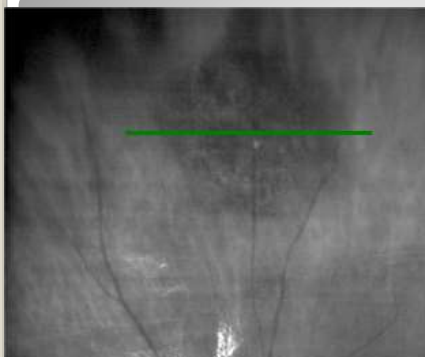


- Number with adhesion
- Exudative AMD 36%
- Dry ARMD 7%
- Controls 10%
- Chronic VR traction may lead to increased chemical changes leading to wet AMD.
- ? Injection of Microplasmin to separate VR? Role

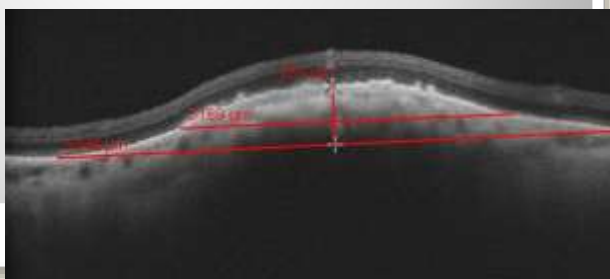


- ? Also pathogenesis of Macular holes
- Microplasmin Trials underway 12/08 -2010
- 125ug Microplasmin Intravitreal injection.

Central Vitreo-Retinal Adhesion Theory of Wet AMD Formation

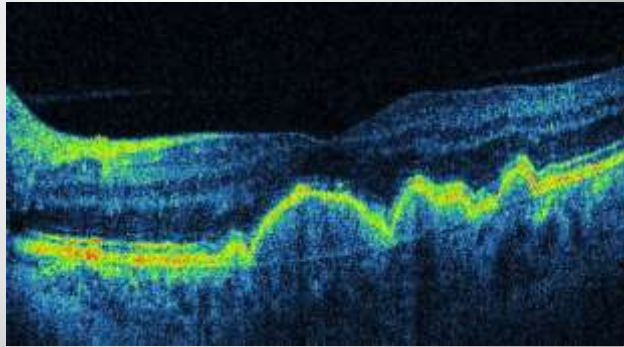


- Choroidal Naevi on HD Optical Coherence Tomography

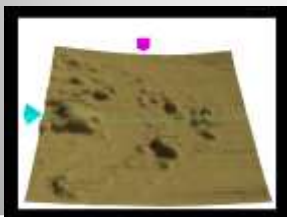
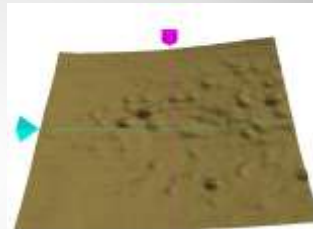


Drusen

- Beginning early in life,.
- Remnants of the incomplete degradation of abnormal molecules which have been damaged within the RPE cells or derived from phagocytized rod and cone membranes.
- Further deterioration of the RPE.
- Dry AMD
- Wet AMD

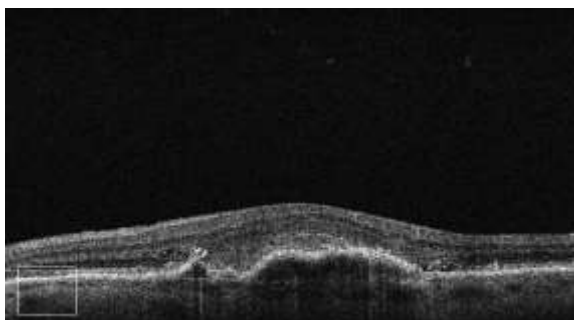
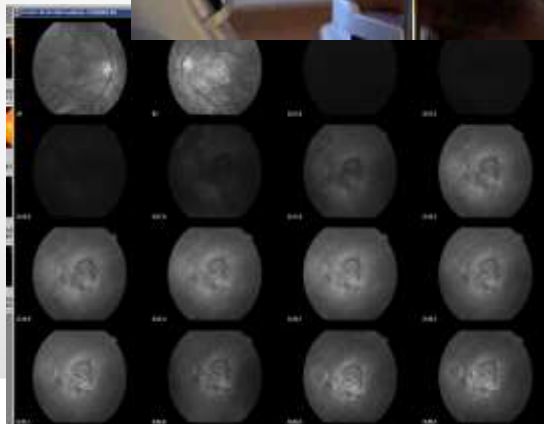


Change in drusen over one year



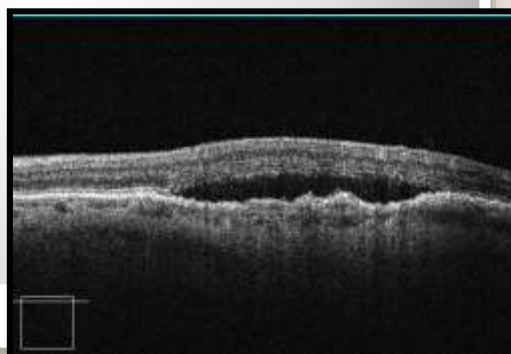
Fundus fluorescein angiography

- Key investigation
- Looks at Retinal circulation
- BUT do not delay treatment for FFA!



Wet AMD formation

**Rapid change
1 Week!
Warn Patients of
rapid Onset
DO not wait till next
appointment/exam**



**Lucentis / Avastin
Pre loaded**

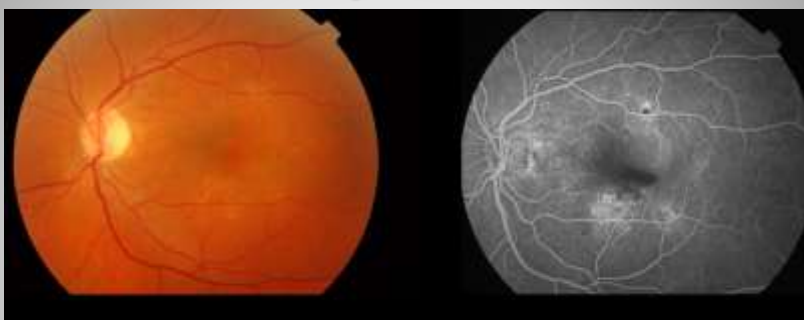
- 3 loading doses
- Variety of regimes
 - Monthly
 - PRN
 - Treat and Extend
 - X 3 on month apart ie repeat loading doses
 - Bi monthly or tri monthly
 - 2 weekly
 - Customised to patient

**Eyelea
Bottle**

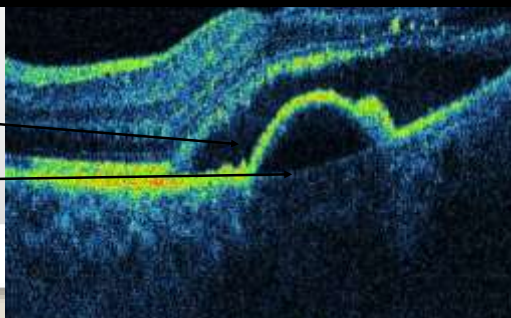
- 3 doses one month apart
- Every other month for 9 months ie 4 doses
- Review Month 12
- Bimonthly on PRN
- No option of monthly
- ?When to review
 - Other eye?

Regimes

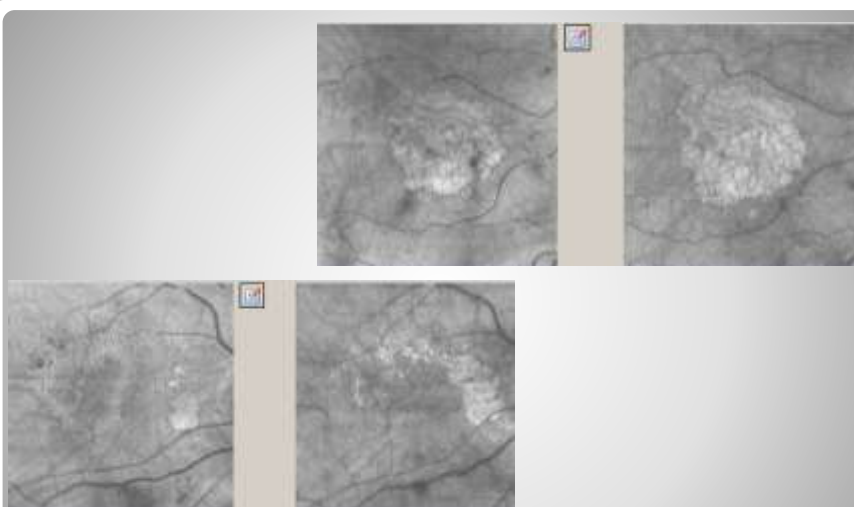
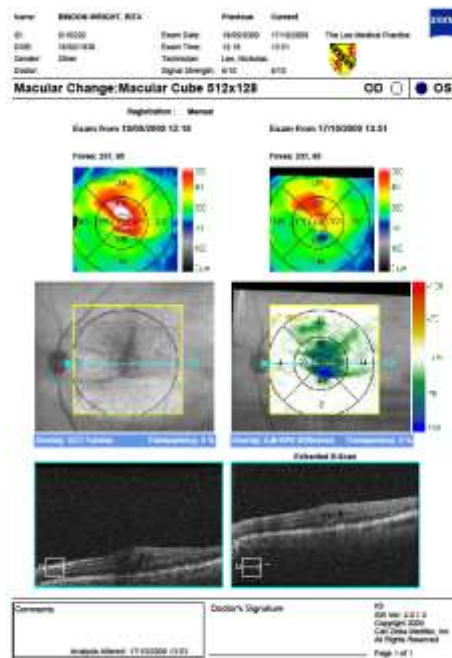
Wet AMD 6/12+2 62 F



- Sub retinal Fluid
- PED
- Invisible to direct



Zeiss Cirrus HD-OCT Change analysis



Changes in Geographic atrophy Area measurements in V6 Lampalizumab

Retina

Advanced RPE Analysis - Using standard Cirrus macular cubes, your system can now identify and automatically measure the area and volume of elevations to the RPE layer comparing current to prior visits. It can also automatically segment and measure areas which the OCT beam penetrates and illuminates the tissue below the RPE. The distance of the closest such area to the Fovea can be measured.

Enhanced Depth Imaging (EDI) - A new mode available with the HD Raster scan enables optimal signal lower in the scan window and facilitates caliper measurements of the deeper layers:



HD Raster acquired in EDI mode



RPE Elevation Map

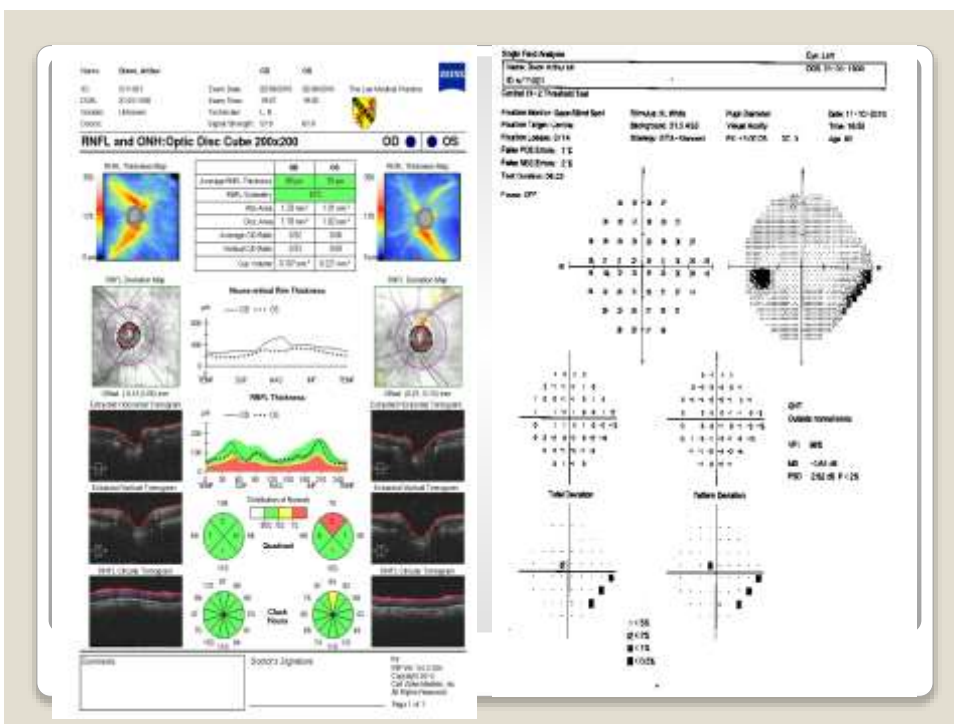


Areas of Sub-RPE Illumination

Version 6

- Mahalo II – 20% reduction in GA
 - Monthly – 18 months
 - No intraocular or systemic side effects
- Chroma / Spectri Phase III
 - IVT vs Sham 936 Patients -1 Year / 2 Years
 - Hillingdon, Southampton
 - 6/36, 1 – 7 Discs areas of GA
 - No wet AMD

Lampalizumab 10mg IVT
Roche



Glaucoma

Ganglion Cell Analysis - Evaluate the thickness of the ganglion cell plus inner plexiform layers using Cirrus macular cubes. The measurement grid is centred using FoveaFinder. Measurements and superpixels in Deviation Maps are compared to normative data.

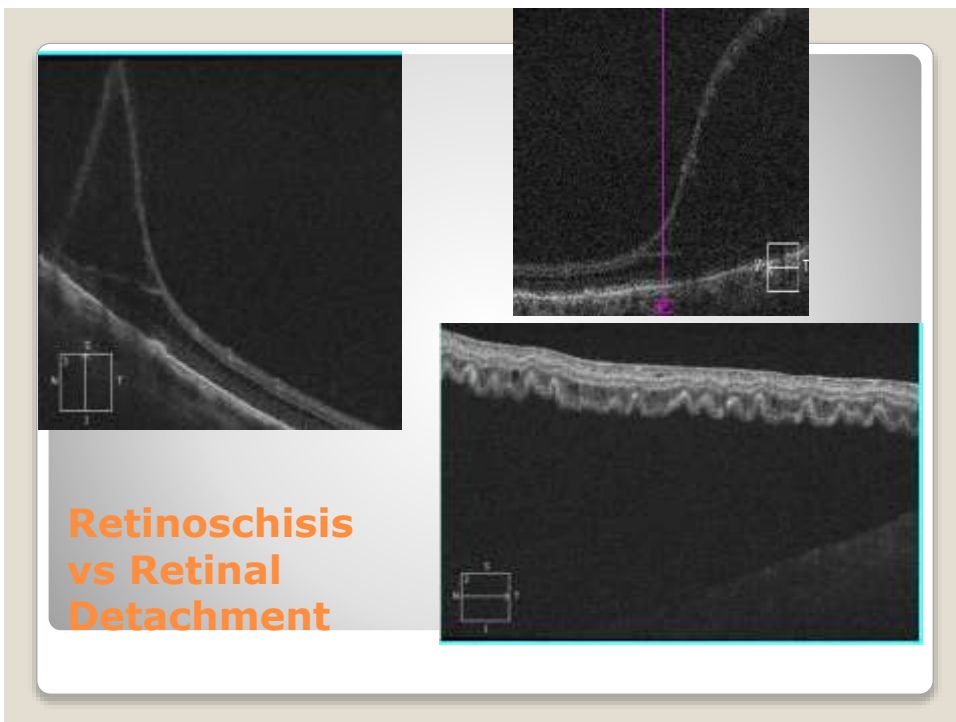
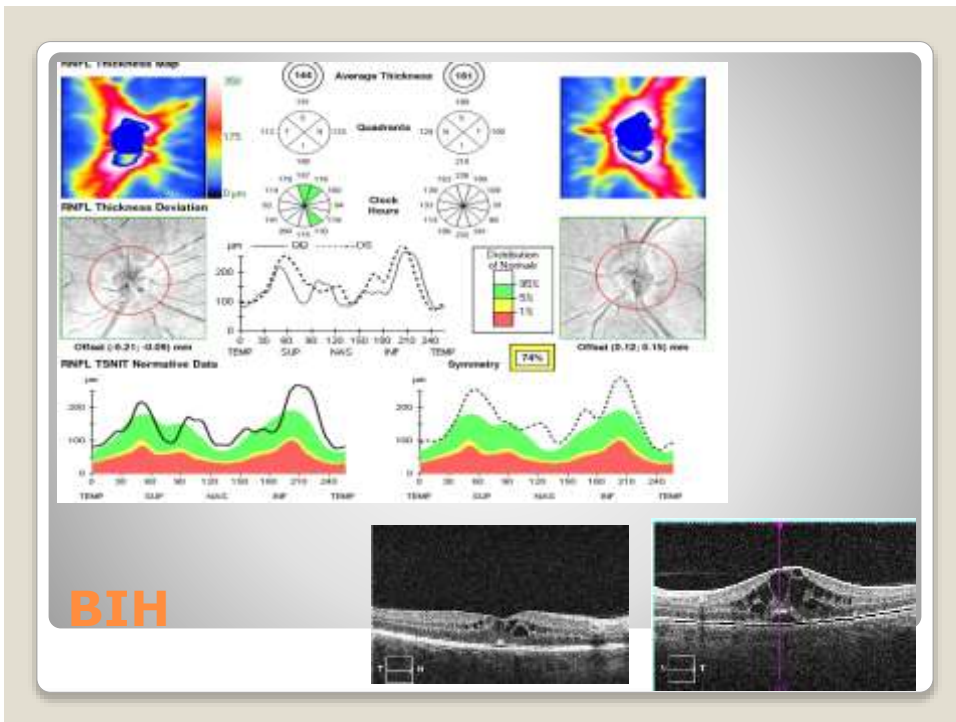
GPA now with Optic Nerve Head
Evaluate change in both RNFL and the optic nerve together. Data for all visits and parameters is now available on the report on an optional second page.

RNFL/ONH Summary OD

- RNFL Thickness Map Progression
- RNFL Thickness Profiles Progression
- Average RNFL Thickness Progression
- Average Cup-to-Disc Progression

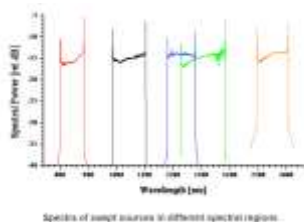
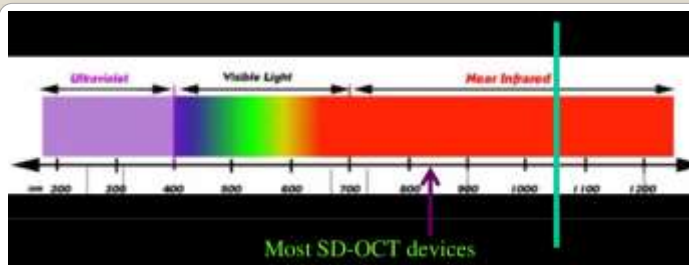
GPA with Optic Nerve Head

Version 6 release!

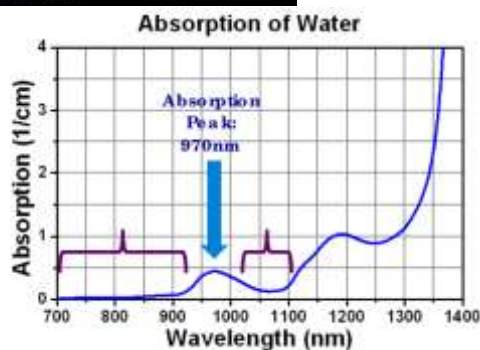


Swept Source 1050nm Next generation

- 100,000 to 200,000 Scans per second gives 7.5mm range at 6 um resolution
- Dual Spot 400,000 scans per second gives 4mm Range with 5.3um Resolution.
- Dual spot 2 – 20 x faster
- Can achieve up to 12mm x 12mm cubes.
- 1010 nm Vs 800nm
- Large areas Scanned Quickly
- 10x cheaper than SD OCT.



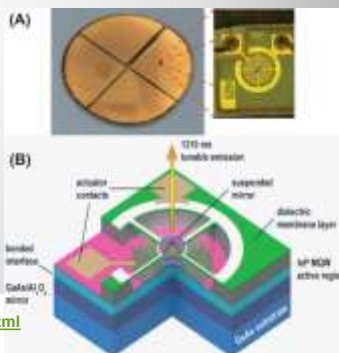
• <http://www.exalos.com/swept-source/>



<http://www.fiberbiz.com/images/Technology/WaterAbsorption.jpg>

- spectral-domain OCT (SD-OCT), uses a broadband light source along with an interferometer, a spectrometer, and a line-scan camera.
- swept-source OCT (SS-OCT), uses a wavelength-swept laser light source, that is, one whose emission sweeps back and forth across a range of wavelengths. An interferometer and a detector with a high speed analog-to-digital (A/D) converter complete the SS-OCT imaging system

- Deep tissue penetration
- Doppler OCT flow analysis
- Scanning speeds in MHz range!
- Low cost – Solid state
 - vertical-cavity surface-emitting laser (VCSEL)
 - Size of 1 Euro!



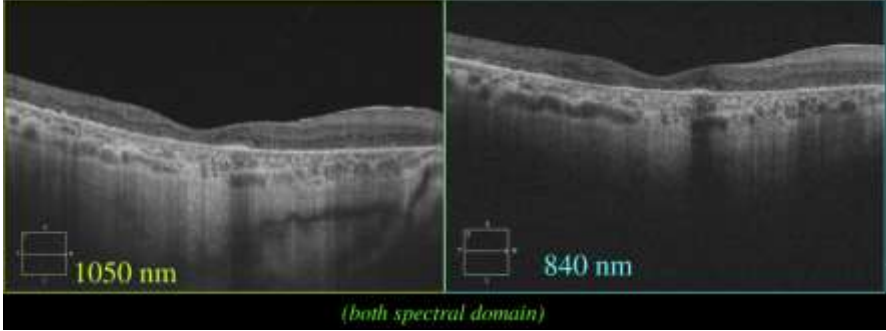
- http://english.ioe.cas.cn/ns/Sciencenews/201208/t20120828_90302.html
- <http://www.exalos.com/swept-source/>

Choroidal Visibility: 1050 vs 840

Comparison Study at Doheny of 1050nm vs 840nm

Results:

- Even when the choroid was fully-visible at 840nm, considerable additional detail was visible at 1050nm



(both spectral domain)

12 x 9 mm volume scans are also easy



Large field OCT Imaging

12 mm B-scans are easy to obtain

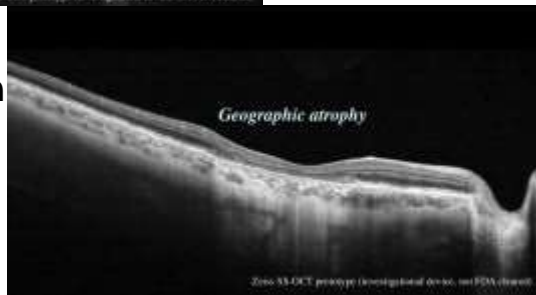


Zuo, SS-OCT prototype (transversal device, not FDA cleared)

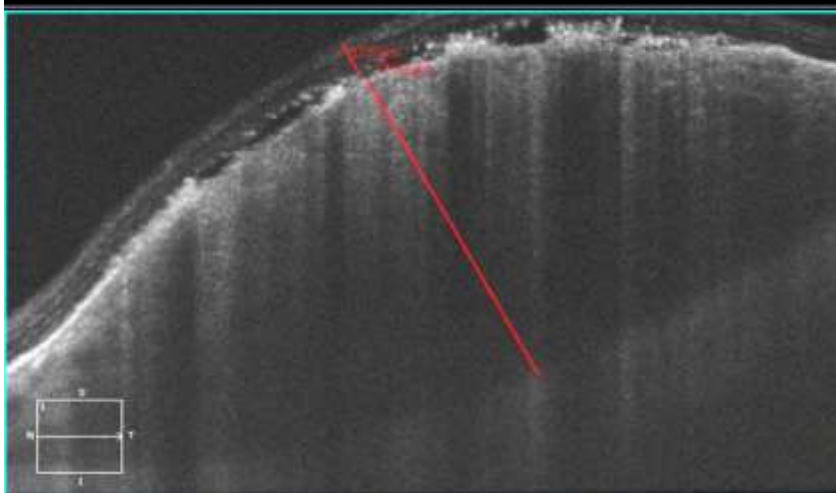
- Very little sensitivity loss with depth with swept source OCT
 - Better signal-to-noise ratio
- Enhances visualization of outer retinal structures, and deep pathologies



Wider view
Less Mag though
Larger File size



1.7mm Choroidal Melanoma



Vitreous imaging with SS-OCT

Abstract and Introduction

Observation of Posterior Pre-cortical Vitreous Pocket Using Swept-Source Optical Coherence Tomography

Hirohiko Nakano, Shoji Kishi, Hiroshi Ts, and Hiroshi Shimizu

Department of Ophthalmology, Tohoku University, School of Medicine, Miyagi, Japan


Background: Posterior pre-cortical vitreous pocket (PPVP) using swept-source optical coherence tomography (SS-OCT).

Objective: We performed SS-OCT to detect PPVP in patients with macular degeneration. The purpose of this study was to determine whether SS-OCT could detect PPVP in patients with macular degeneration. A total of 103 eyes were included in the study. The vitreous cavity was imaged from 10 to 150 micrometers (µm) from the retina. The vitreous cavity was imaged from 10 to 150 micrometers (µm) from the retina. The vitreous cavity was imaged from 10 to 150 micrometers (µm) from the retina.

Results: SS-OCT revealed the PPVP in 10 patients (9.7%) in the macular degeneration. All vitreous pockets were located in the posterior pre-cortical vitreous. The vitreous cavity was imaged from 10 to 150 micrometers (µm) from the retina. The vitreous cavity was imaged from 10 to 150 micrometers (µm) from the retina.

Conclusion: SS-OCT revealed the PPVP in 10 patients (9.7%) in the macular degeneration. All vitreous pockets were located in the posterior pre-cortical vitreous. The vitreous cavity was imaged from 10 to 150 micrometers (µm) from the retina. The vitreous cavity was imaged from 10 to 150 micrometers (µm) from the retina.

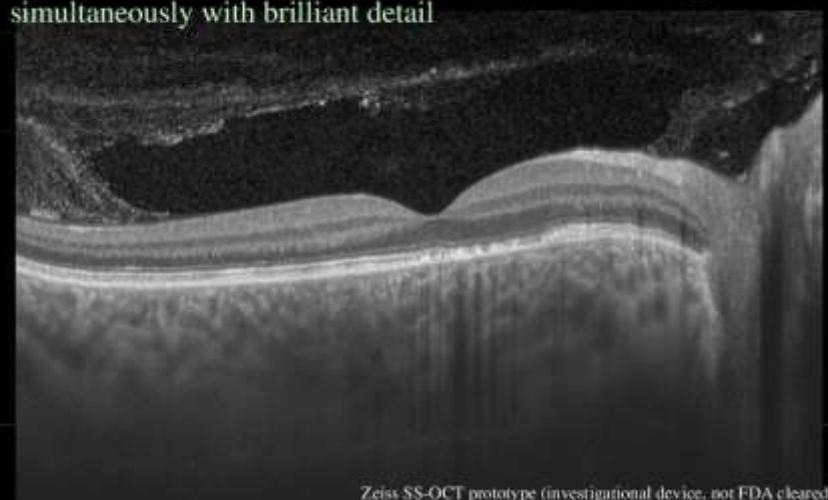
Better sensitivity means better visualization of subtle structures



- Better evaluation of vitreo-macular interface disease and normal vitreous dynamics
- Possibility of quantification of vitreous cell

Vitreous imaging with SS-OCT

With SS-OCT, both the vitreous and choroid can be imaged simultaneously with brilliant detail



Zeiss SS-OCT prototype (investigational device, not FDA cleared)

(A) Cornea, Iris, Lens, 1310nm

(B) 1310nm

(C) Nerve Fiber Layer, Sclera, Choroid, Photoreceptor Layer, 1065nm

- http://english.ioe.cas.cn/ns/Sciencenews/201208/t20120828_90302.html
- <http://www.tomey.com/Products/OCT/SS-1000CASIA.html>

Function Bleb

Case report I Limbal-based incision: 79-year-old woman with normal tension glaucoma



Filtration bleb having some vascular and avascular areas.[10 months post-surgery]
 The internal aqueous space is clearly visible under the medium intensity of filtration bleb walls.
 In the anterior chamber, sections of trabeculectomy and iridectomy are observed connecting with the aqueous space under the scleral flap.

CASIA
 SS-1000



• <http://www.tomey.com/Products/OCT/SS-1000CASIA.html>

- 19 D – Adjust for Refraction
- A scan Ultrasound
- Immersion Ultrasound
- Laser – A Scan – IOL master
- Swept Source B Scan – IOL Master 700

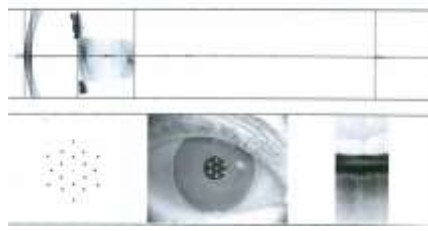


Biometry



Mean central curvature of the right eye is 0.22 mm longer than mean central curvature of left eye. Note the check measured values.

OD		Analysis	
Measured values		Refractivity values	
AL: 24.34 mm	(SD = 3 µm)	R: 7.88 mm	(SD = 3 µm)
ACD: 3.68 mm	(SD = 5 µm)	Rc: 6.95 mm @ 81°	(SD = 4 µm)
LT: 2.88 mm	(SD = 16 µm)	SL: 1.75 mm @ 81°	(SD = 7 µm)
Central corneal thickness		White-to-white values	
ECT: 495 µm	(SD = 4 µm)	WTW: 11.9 mm	(S: +0.4 mm) (S: +2.1 mm)
		W: 5.8 mm	(P: +0.3 mm) (P: +0.8 mm)



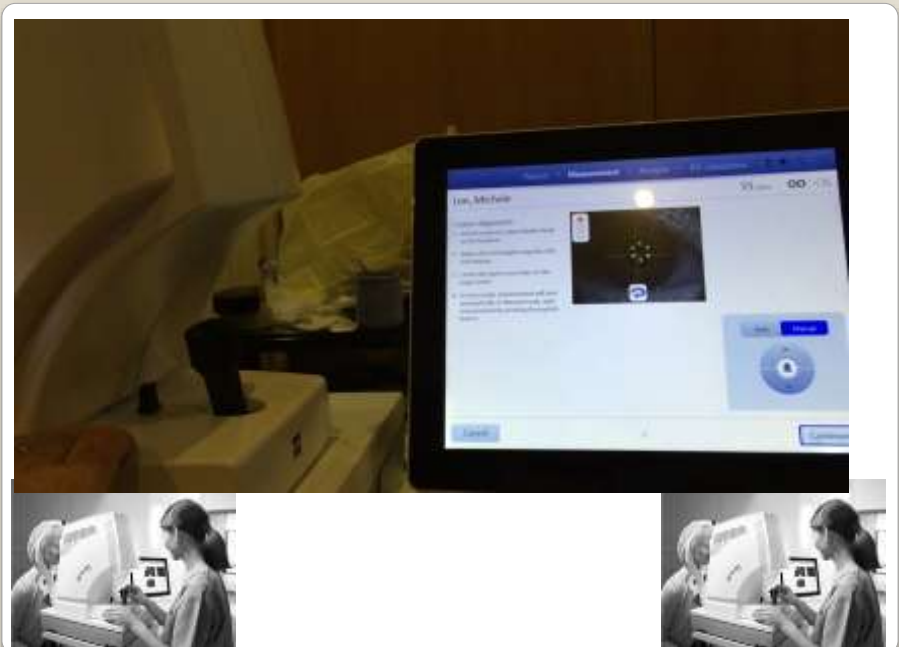
Mean central curvature of the right eye is 0.55 mm longer than mean central curvature of left eye. Note the check measured values.

OD		Measured values		OS	
right		left		right	
18.00 mm (SD = 3 µm)		18.00 mm (SD = 3 µm)		18.00 mm (SD = 3 µm)	
8.00 mm @ 174° (SD = 4 µm)		8.00 mm @ 174° (SD = 4 µm)		8.00 mm @ 174° (SD = 4 µm)	
7.75 mm @ 61° (SD = 7 µm)		7.75 mm @ 61° (SD = 7 µm)		7.75 mm @ 61° (SD = 7 µm)	
+5.00 @ 81°		+5.00 @ 81°		+5.00 @ 81°	
7.38 mm		7.38 mm		7.38 mm	
+1.88 @ 81°		+1.88 @ 81°		+1.88 @ 81°	
7.05 mm		7.05 mm		7.05 mm	
+1.87 @ 81°		+1.87 @ 81°		+1.87 @ 81°	
7.58 mm		7.58 mm		7.58 mm	
+1.08 @ 81°		+1.08 @ 81°		+1.08 @ 81°	
388 µm (SD = 4 µm)		388 µm (SD = 4 µm)		388 µm (SD = 4 µm)	
415 µm		415 µm		415 µm	
438 µm		438 µm		438 µm	
458 µm		458 µm		458 µm	
11.0 mm (S: +0.2 mm) (S: +0.5 mm)		11.0 mm (S: +0.2 mm) (S: +0.5 mm)		11.0 mm (S: +0.2 mm) (S: +0.5 mm)	
5.4 mm (P: +0.3 mm) (P: +0.8 mm)		5.4 mm (P: +0.3 mm) (P: +0.8 mm)		5.4 mm (P: +0.3 mm) (P: +0.8 mm)	
Refractive range		Refractive range		Refractive range	

Ability to cut through very dense cataracts is impressive.



K Axis – Toric IOL



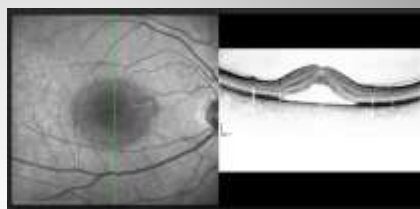
The main image shows a patient in an operating room. A large monitor displays a software interface with a central image of an eye and various control buttons. Below the main image are two smaller, identical black and white photographs of a person operating a surgical microscope.

- Space: the final frontier. These are the voyages of the starship Enterprise. Its five-year mission: to explore strange new worlds, to seek out new life and new civilizations, to boldly go where no man has gone before



[www. Nicholaslee.co.uk](http://www.Nicholaslee.co.uk)

- Zeiss Cirrus 4000
- Zeiss Cirrus 400
- Heidelberg Spectralis
 - 7 Models to choose from
- Topcon 3D-OCT
- [Nidek RS-3000](#)
[OCT/SLO](#)



OCT Choices