RUSH UNIVERSITY MEDICAL CENTER

Optical Coherence Tomography

Rush Center for
Neuroendovascular surgery

RUSH UNIVERSITY MEDICAL CENTER

Disclosure Information

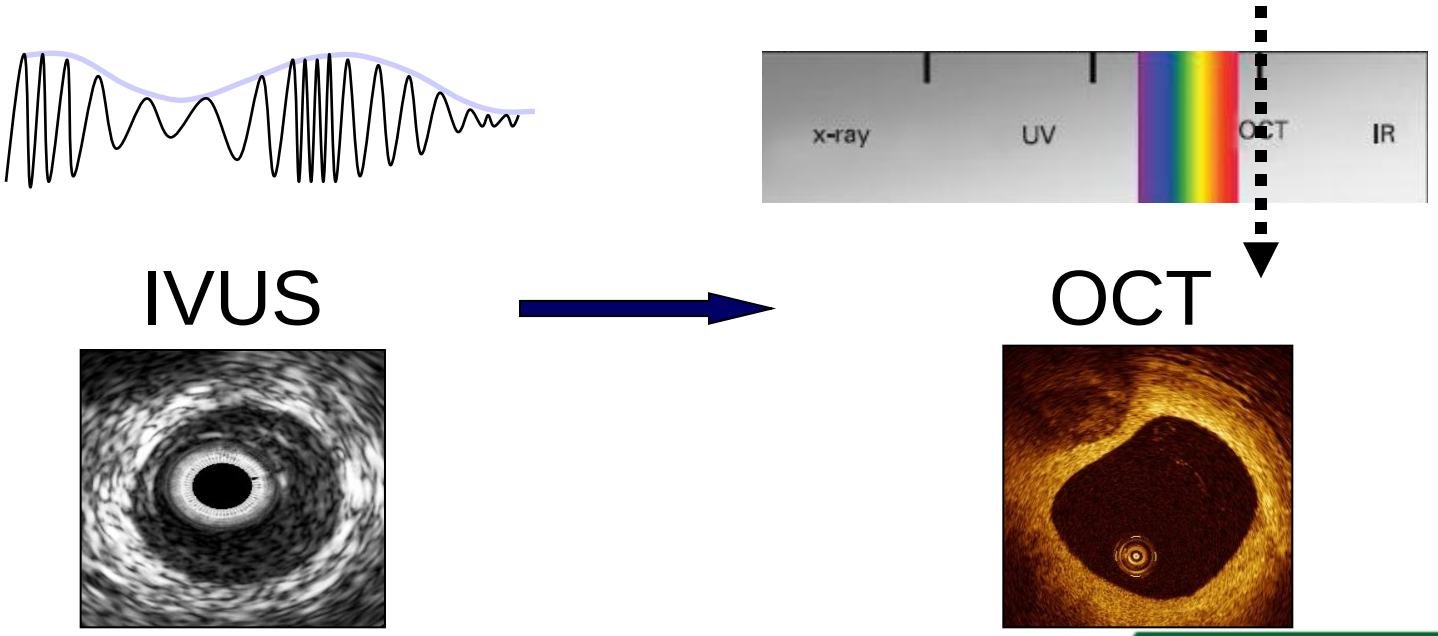
Demetrius Lopes MD

The following relationships exist related to this presentation:

University Grant/Research Support: Rush University
Industry Grant Support: Medtronic, Stryker, Blockade, Microvention, Siemens
Consultant Fee: Name of company(s): Medtronic, Penumbra, Stryker, Terumo
Stock or Shareholder: Blockade, Pulsar, MIVI, Crowdoptic, Three Rivers
Honorarium: Name of company(s): Penumbra, Medtronic, Stryker, Microvention
Speaker's Bureau: Name of company(s) : Penumbra, Medtronic, Stryker, Terumo, Siemens
Employee (any industry): Name of company(s) : None
Fiduciary Position: Name of company(s) : None
Other Financial or Material Support: Name of company(s) : None
Off label use of products may be discussed in this presentation.

- Optical Coherence Tomography (OCT) is an imaging modality able to provide high-resolution images of vessels *in vivo*

- While intravascular ultrasound (IVUS) uses backscattered ultrasound, OCT uses reflected light to create cross sectional images of the vessel



RUSH UNIVERSITY MEDICAL CENTER

The C7-XR™ OCT Imaging System

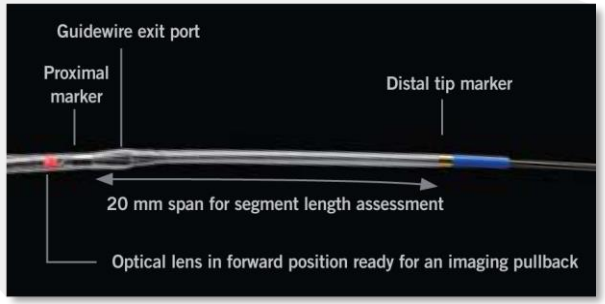
Dual monitors and remote output for multiple sight lines

Easy mouse and keyboard control

Multiple export options including RW/DVD

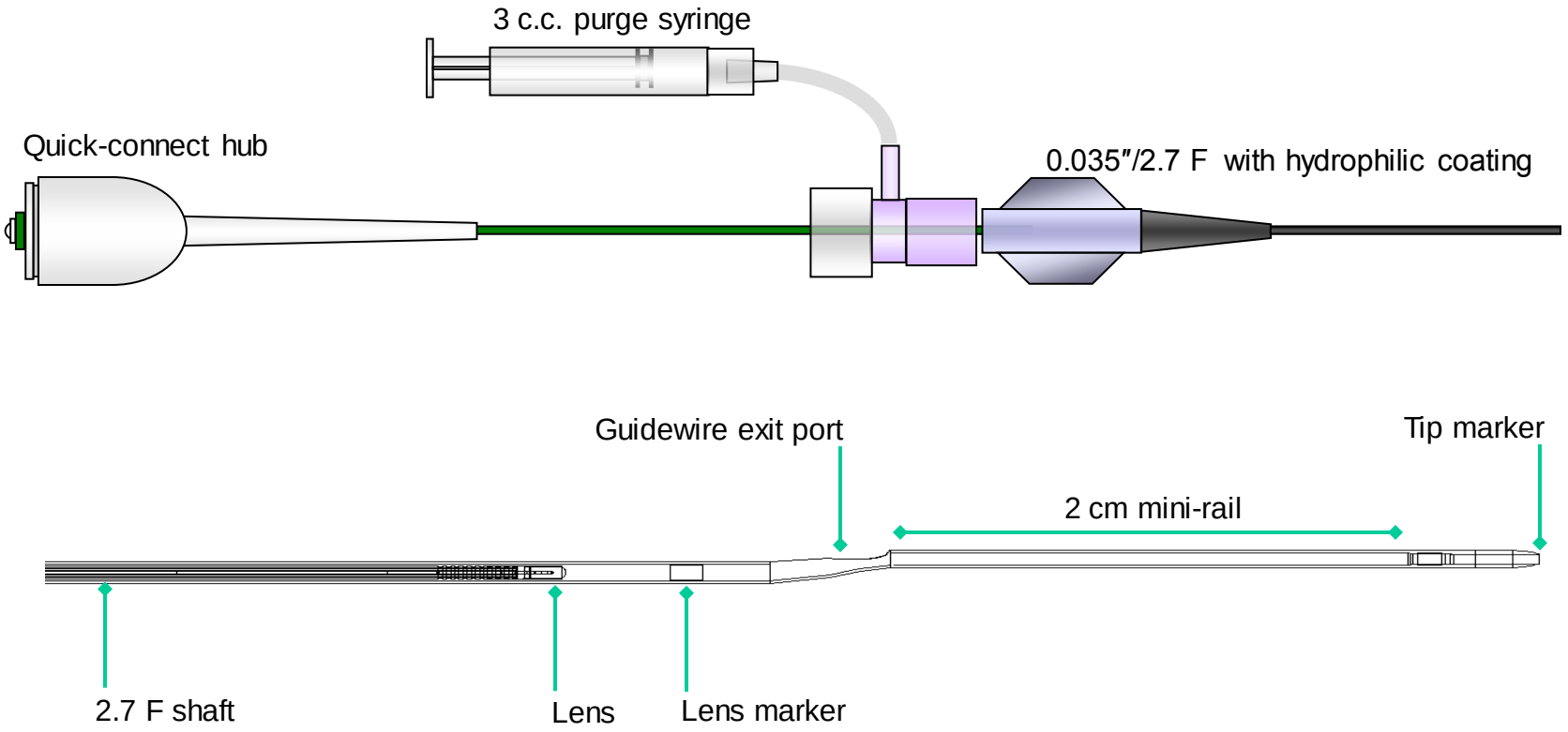
Small footprint for easy placement

C7 Dragonfly™ Imaging Catheter



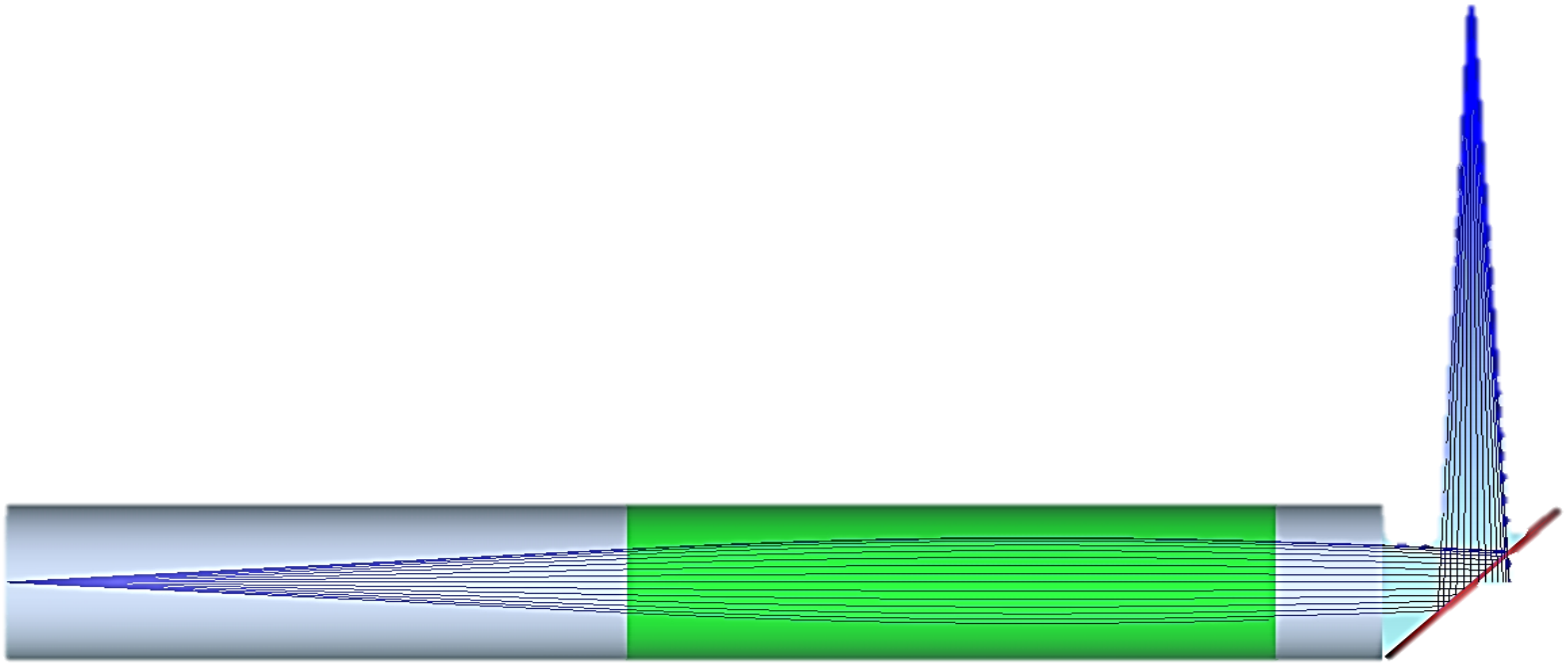
RUSH UNIVERSITY MEDICAL CENTER

C7 Dragonfly™ Imaging Catheter



Imaging Lens

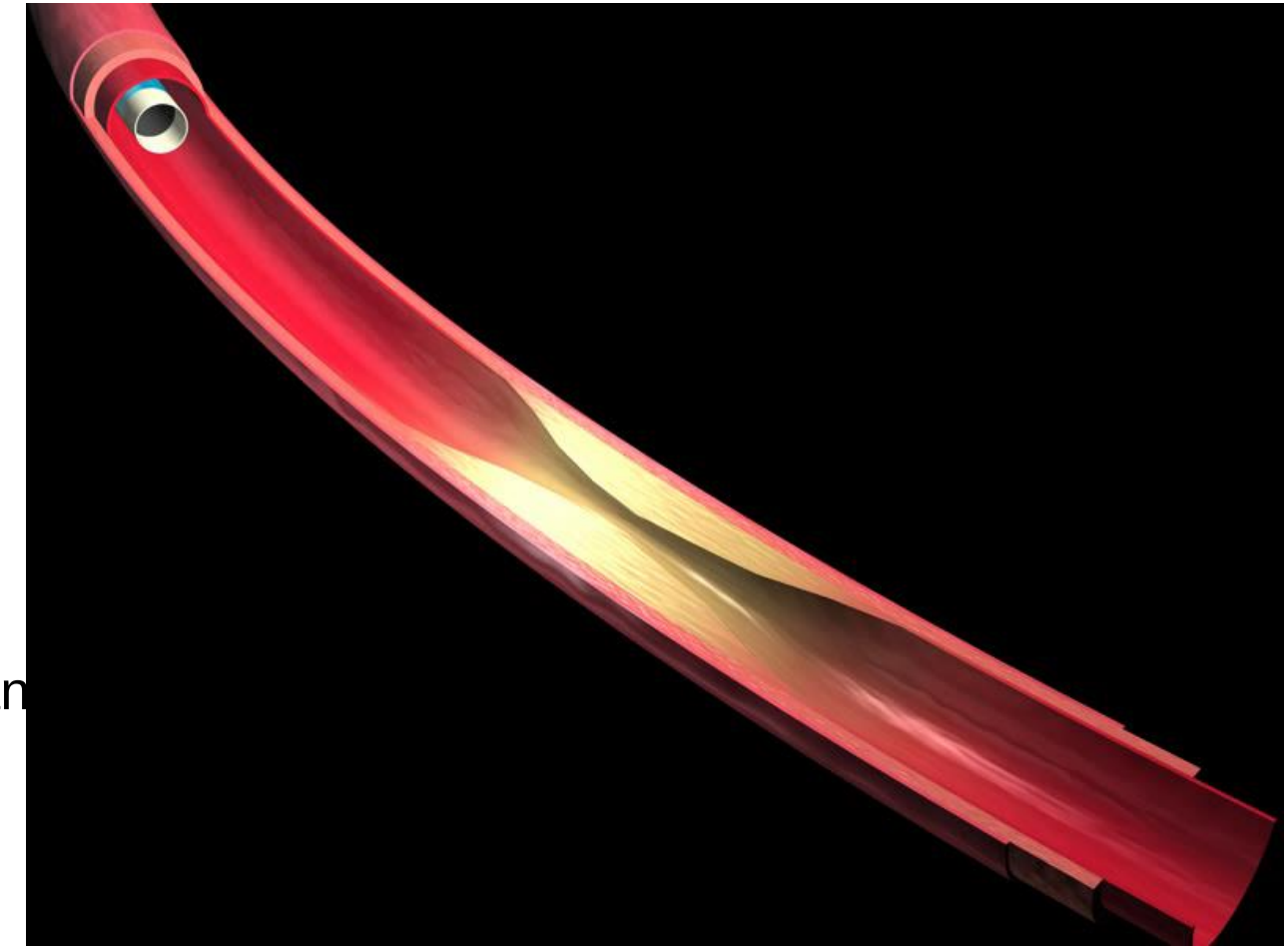
Beam is redirected orthogonal to axis



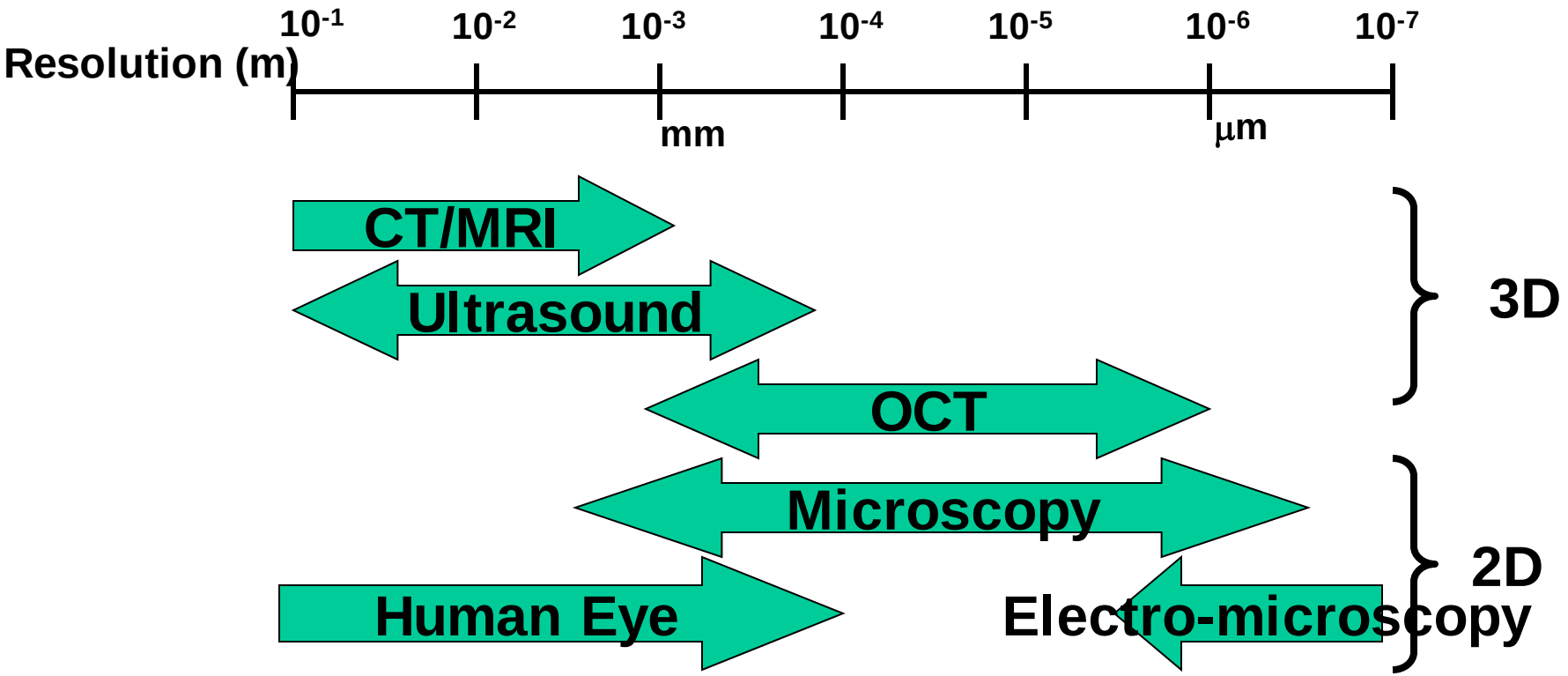
RUSH UNIVERSITY MEDICAL CENTER

A Simple and Fast Procedure

- Cross with C7 Dragonfly™ monorail imaging catheter
- Inject 10-12cc of contrast
- The automatically triggered imaging scan is performed in less than five seconds



OCT in Medical Imaging



Common Cardiovascular Imaging Modalities

	Mechanism	2D/ 3D	Resolution	Penetration	Usage
Angiography	X-ray attenuation by contrast	2D	~100 um	All body	Blood vessel narrowing
CT	Tissue x-ray attenuation	3D	~ 500 um	All body	Calcification of vessel wall
Intravascular MR	Tissue hydrogen content. Hydrogen atoms' spin	1D	NA	1-5 mm	Lipid content in vessel wall
Intravascular ultrasound	Sound wave reflection/scattering due to mechanical properties	3D	100-200um	5-10mm	Vessel narrowing, plaque formation and composition, stents
Anigrography	Reflection properties of vessel wall surface	2D	~ 10 um	Surface imaging, need blood clearing	Thrombus, epithelial damage
OCT	Optical scattering, absorption and birefringence of vessel wall	3D	10-20 um	1-2 mm Need blood clearing	Vessel narrowing, plaque formation and composition, thrombus, epithelial damage, stents

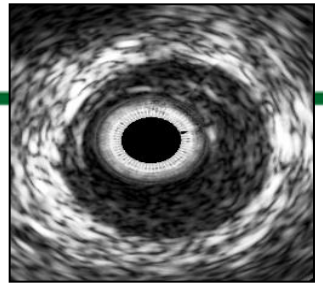
Comparison of Imaging Modalities

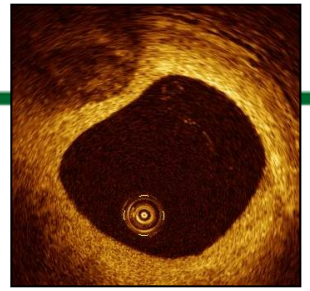
Image Modality	Resolution	Fibrous Cap	Lipid Core	Calcium	Thrombus
IVUS	100μm	+	++	+++	+
Angioscopy	Unknown	+	++	—	+++
OCT	10μm	+++	+++	+++	+
Thermography	.5mm	—	—	—	—
Spectroscopy	not applicable	+	++	++	—
Intravascular MRI	160μm	+	++	++	+

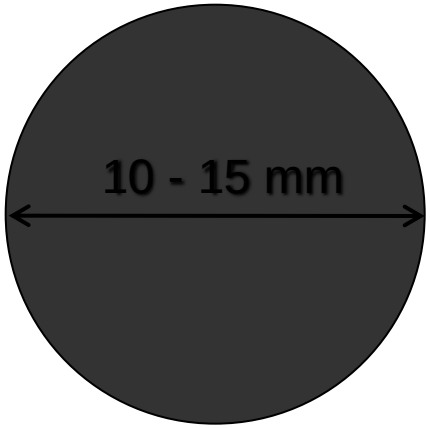
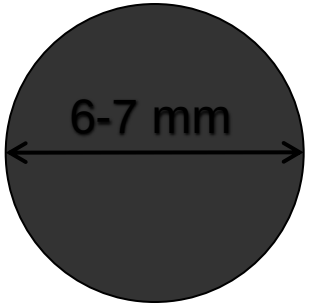
SENSITIVITY KEY

+++ = >90% **++** = 80%~90% **+** = 50%~80% — = <50%

Journal of Atherosclerosis, Thrombosis and Vascular Biology 2003;23:1333-1342

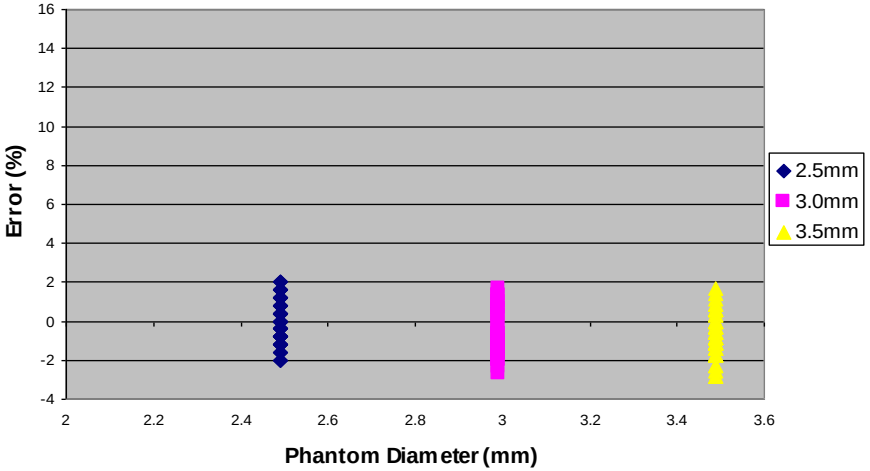




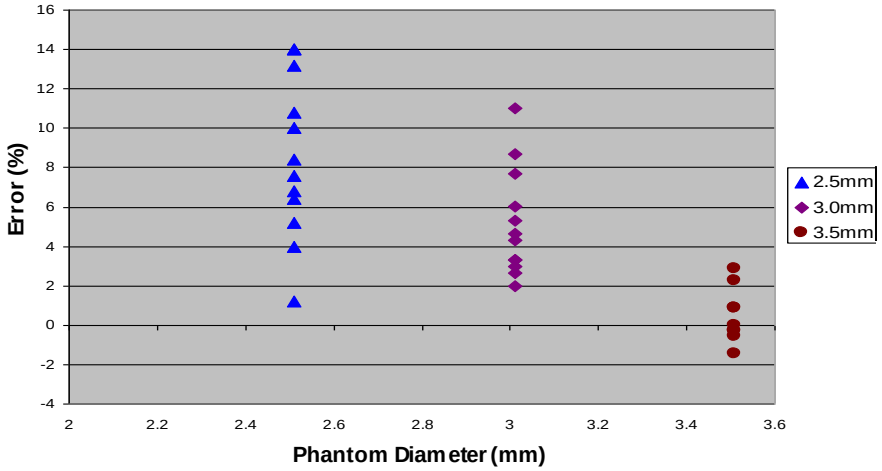
	IVUS	OCT
Resolution (axial)	100 - 150 μm	10 μm
Resolution (lateral)	150 - 300 μm	25 - 40 μm
Scan Area		
Penetration depth	4 - 8 mm	1.5 – 2 mm
Blood removal	Not required	Required

Excellent Measurement Accuracy

OCT



IVUS



In-vitro phantom study

	OCT	IVUS
Mean diameter error	0.98%	4.75%
Max diameter error	2.86%	14.00%

	OCT	IVUS
Mean area error	1.87%	9.53%
Max area error	5.72%	32.18%

Data on file: AQ/LLI/DOCS/14437

FACT™
Focused Acoustic Computed Tomography

New Transducer Technology

Design Goals

- Sub 50 micron axial resolution
- Visualization of entire plaque and vessel wall without needing to flush to clear blood

FACT – Animal Study Image

Why OCT?

Advantages of OCT

- Highest resolution in all in vivo imaging technology (10-20µm)
- Correlation with histology and other intravascular modalities (IVUS, angioscopy)
- Lumen contour detection
  - Easy, very fast, reproducible

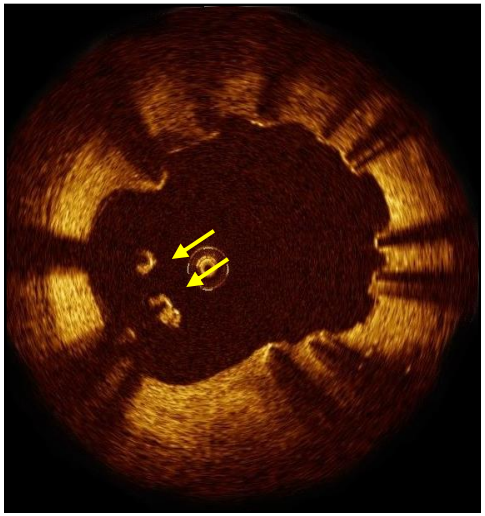
Clinical demands

- Stent evaluations
  - Vessel measurement
  - Post stenting evaluation
  - New stent development
  - Stent "healing"
- Vulnerable plaque
  - Thin cap (<65µm)
  - Macrophages
  - Lipid
  - (Macro) Calcification
- Thrombosis detection

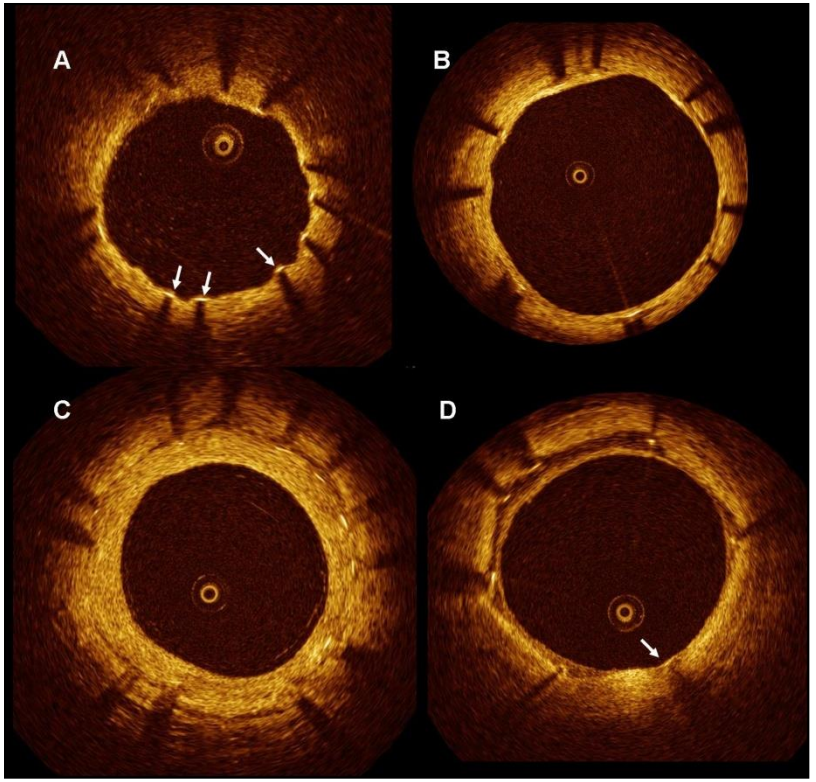
OCT for stent evaluation

Follow up

Strut apposition

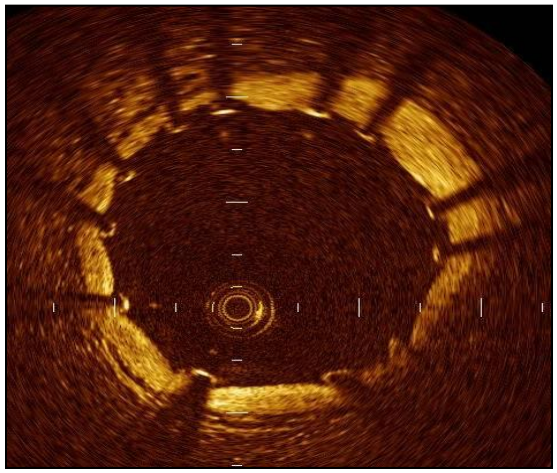


Strut coverage

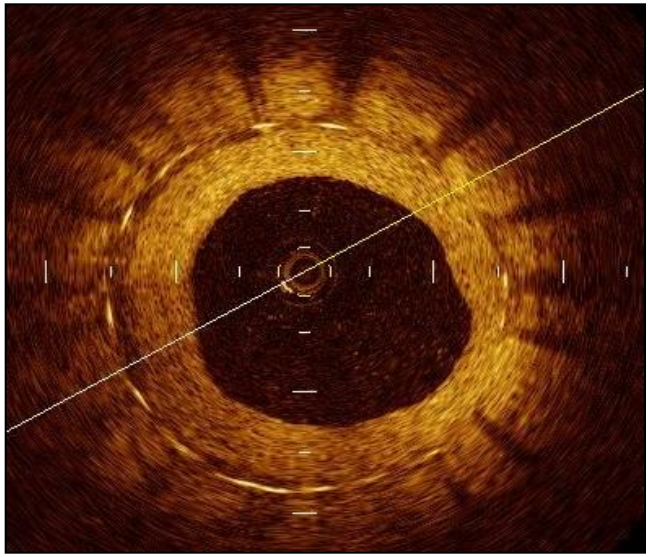


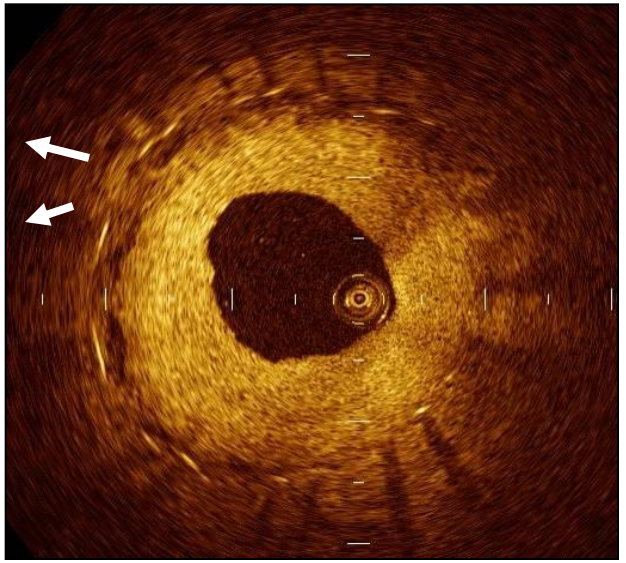
OCT and Stents

New implanted stents

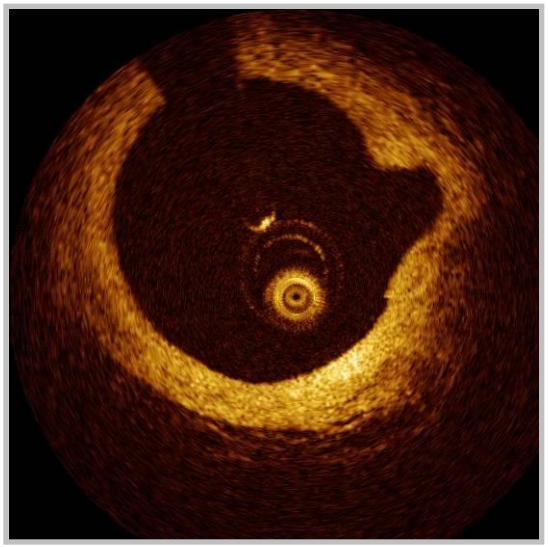


Stent follow-up (neointima growth)





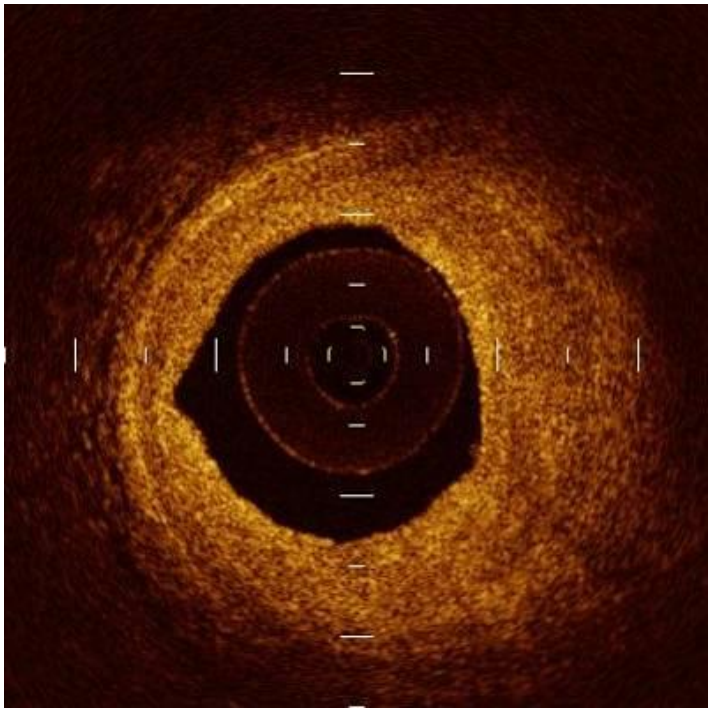
Side branch detection



False lumen

Intima tear

OCT Tissue Characterization Preliminary Results



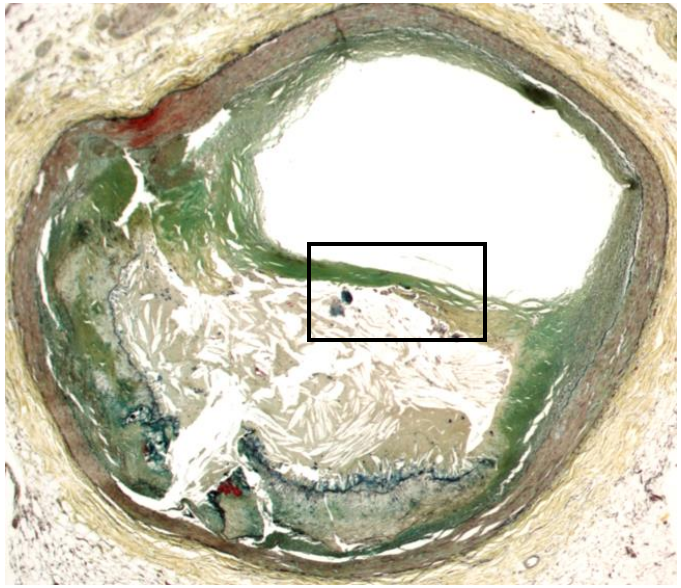
OCT image features:

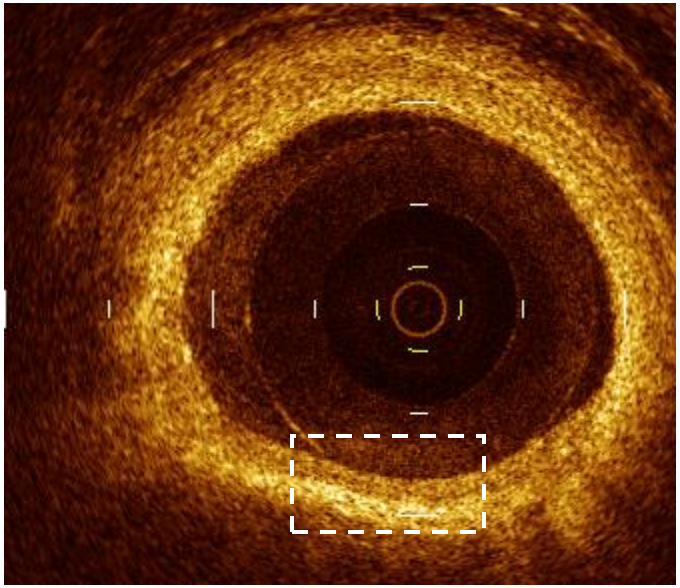
1. Signal intensity
2. Attenuation
3. Edge sharpness
4. Texture

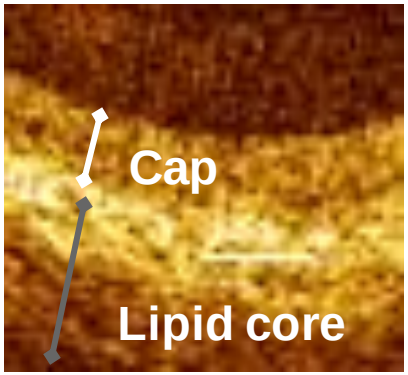
Histology features:

1. Staining colors
2. Cellular morphology

Thin-cap Necrotic Core





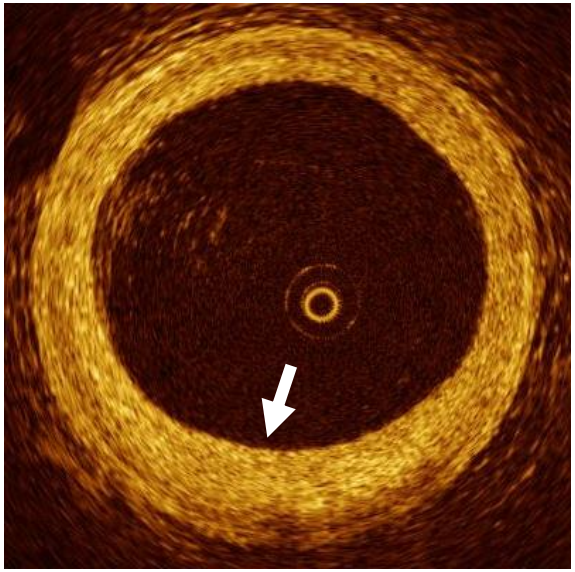


TCFA without macrophage infiltration: Two-layer structure.
Diffuse boundary formed by the cap and the underlying core

Atherosclerotic plaque composition

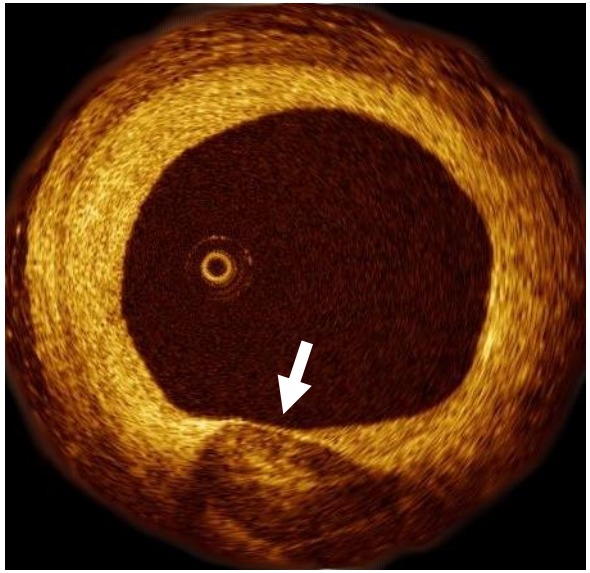
Fibrous

Homogeneous signal-rich region



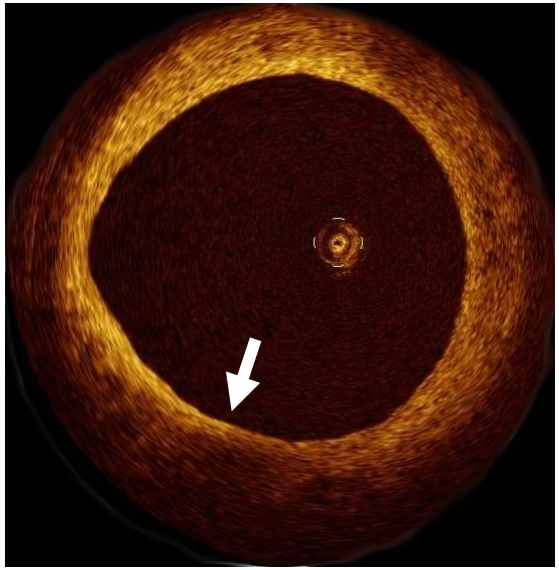
Fibrocalcific

Well-delineated, signal-poor region with sharp borders



Lipid-rich

Signal-poor region with diffuse borders

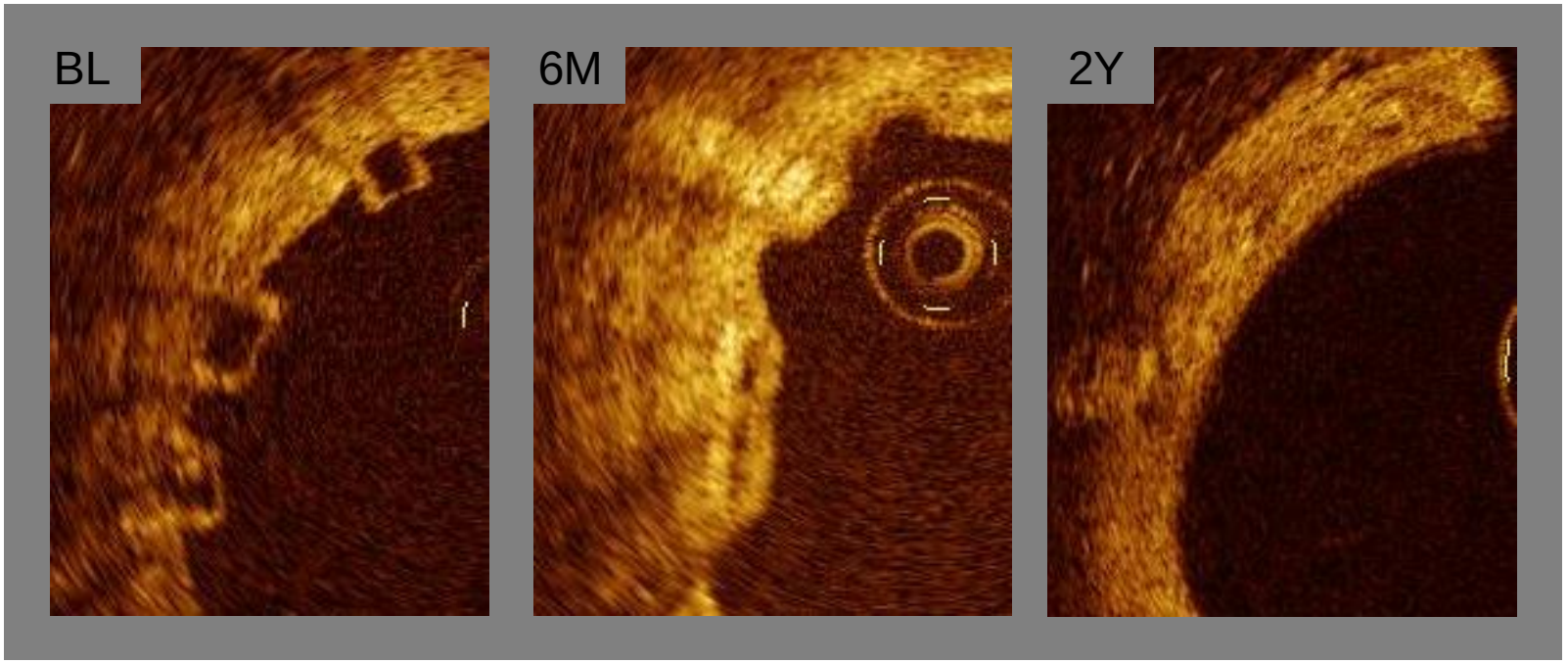


Sensitivity and specificity: 71-79% and 97-98% for fibrous, 95-96% and 97% for fibrocalcific and 90-94% y 90-92% for lipid-rich plaques.

Yabushita et al. Circulation 2002;106(13):1640-5.

OCT for the evaluation of new generation stents Bioabsorbable stents.

- The prospective, multicenter, ABSORB study evaluated the safety and efficacy of a fully absorbable everolimus eluting stent (BVS*) for the treatment of de novo single coronary stenosis.
- OCT substudy in Rotterdam after implantation, at 6 months and 2 years.

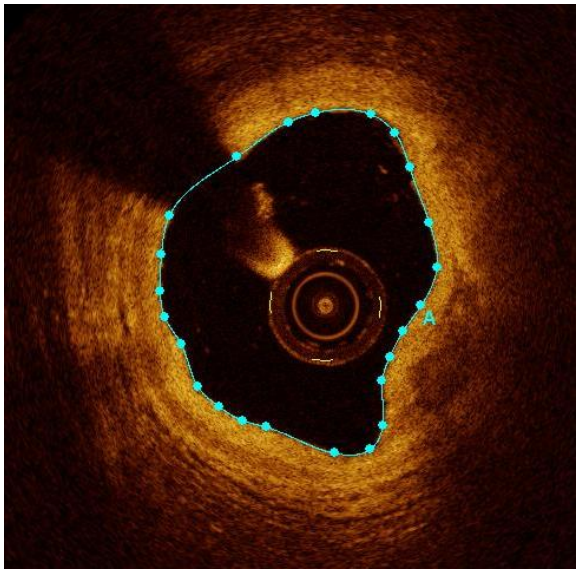


*Bioabsorbable Vascular Solutions, Inc, an affiliate of Abbott Laboratories, located in Mountain View, CA

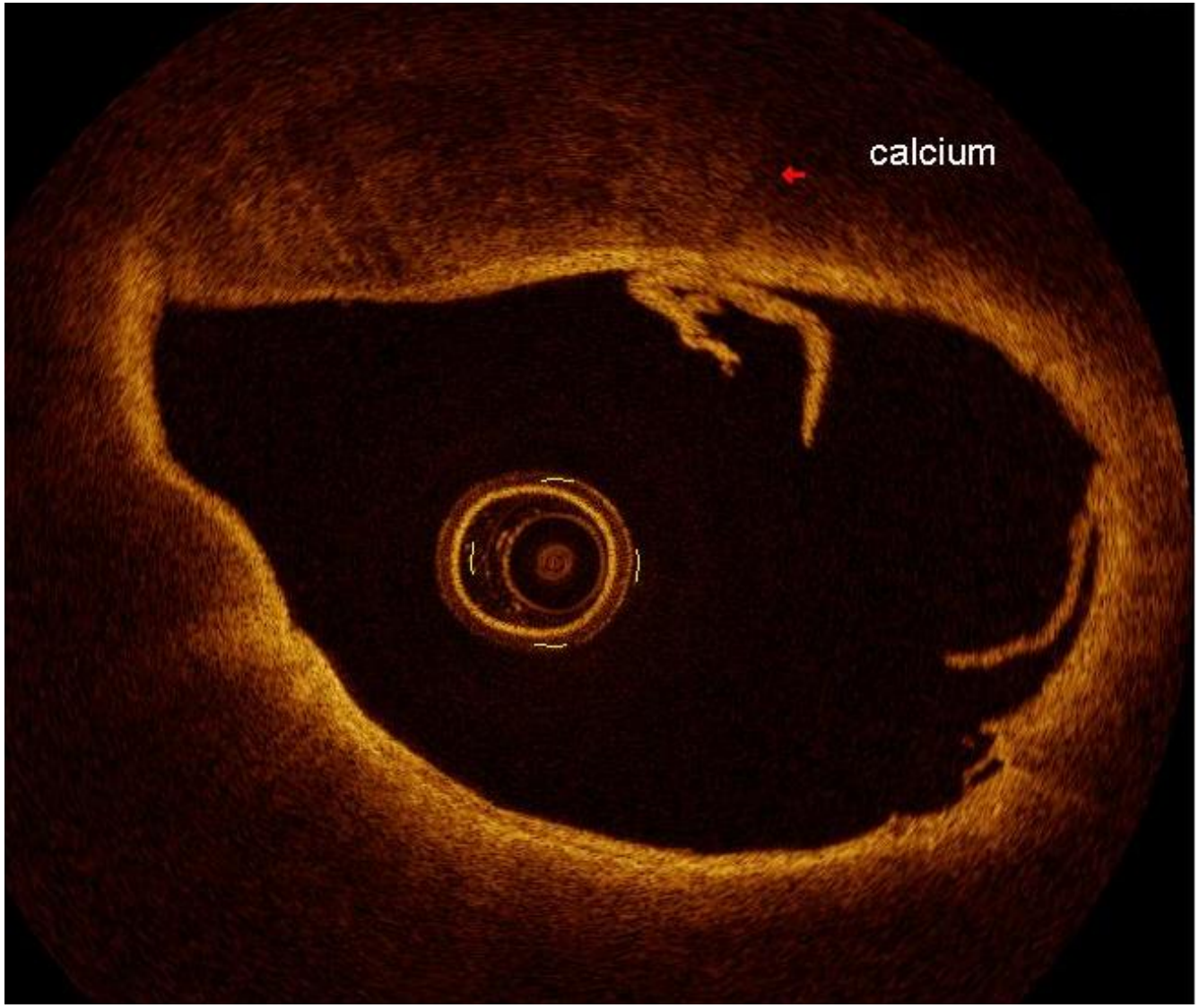
Serruys et al. Lancet 2009; 373: 897–910

RUSH UNIVERSITY MEDICAL CENTER

Precise Vessel Measurement

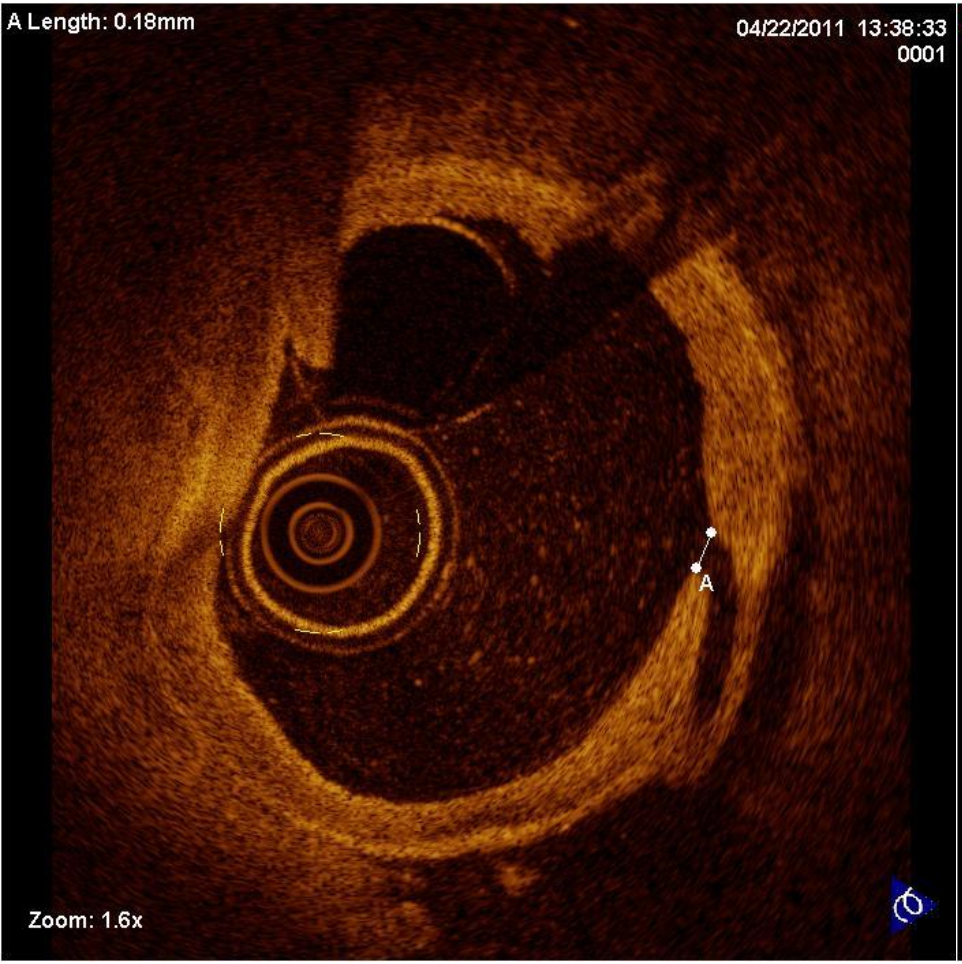


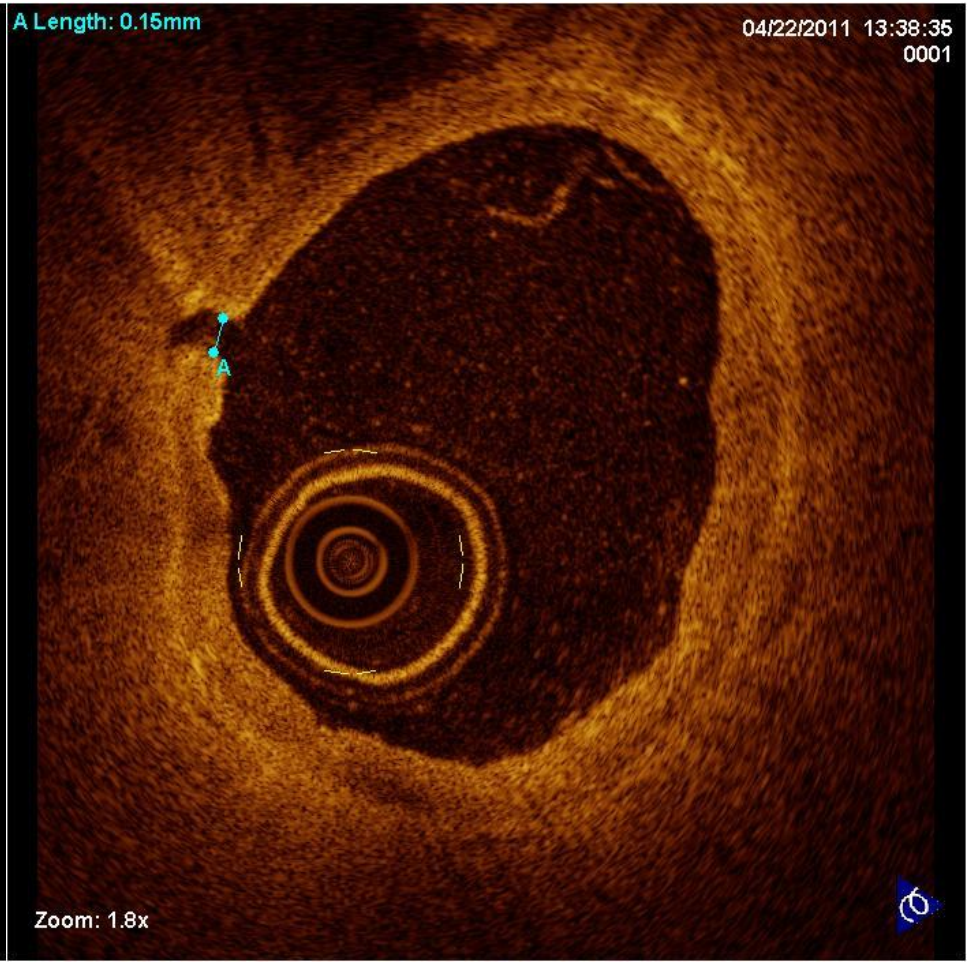
Neuro Plaque



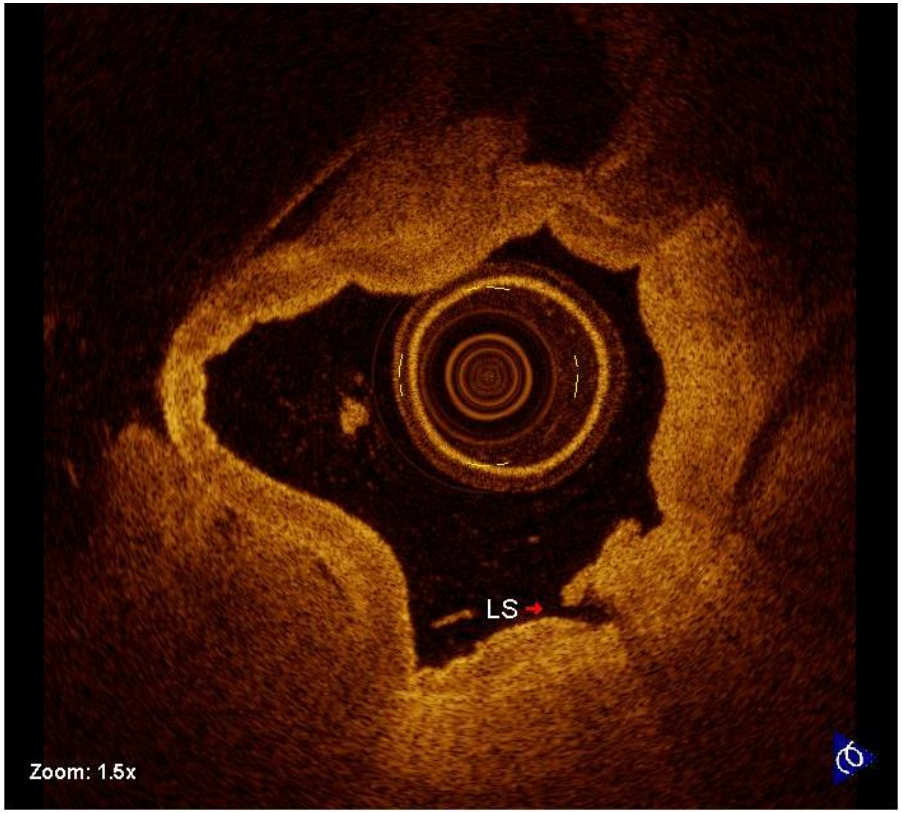
RUSH UNIVERSITY MEDICAL CENTER

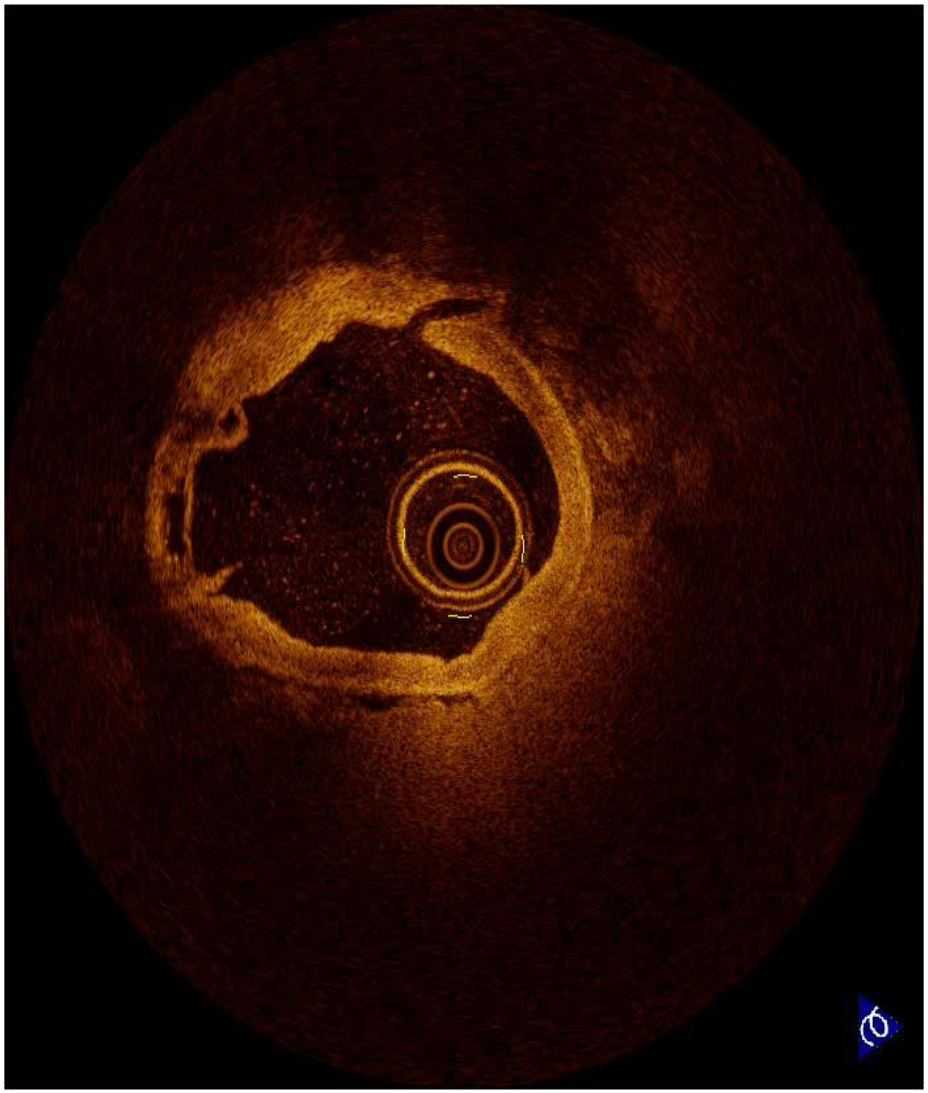
MCA – Lenticulostriate perforators





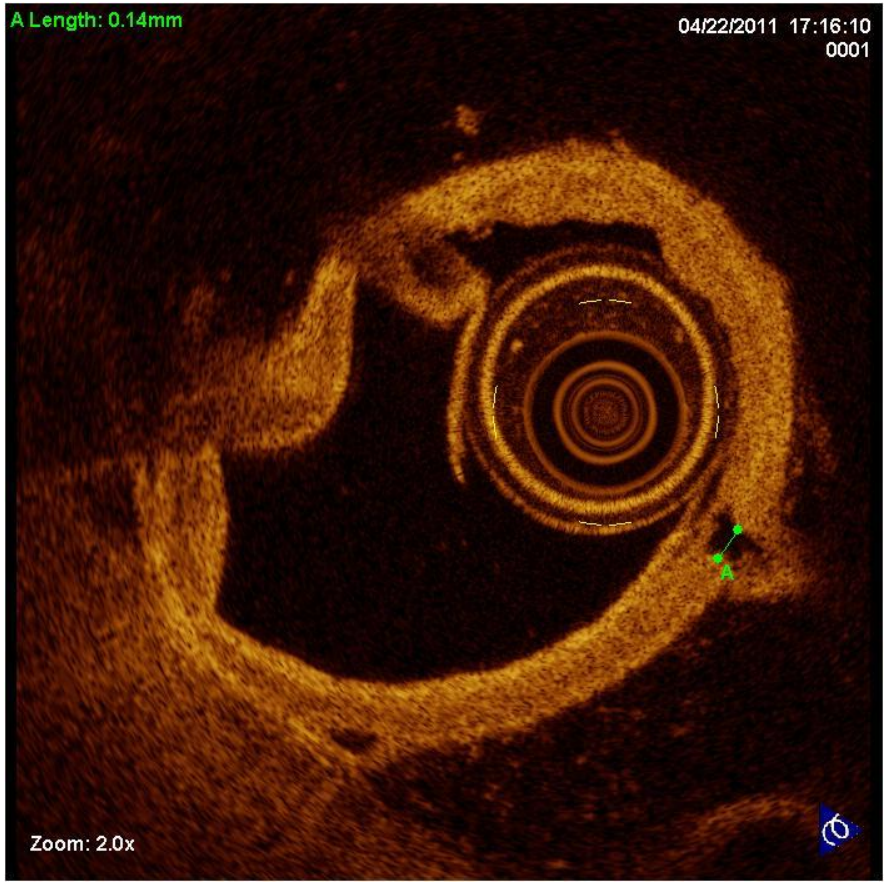
MCA – Lenticulostriate perforators

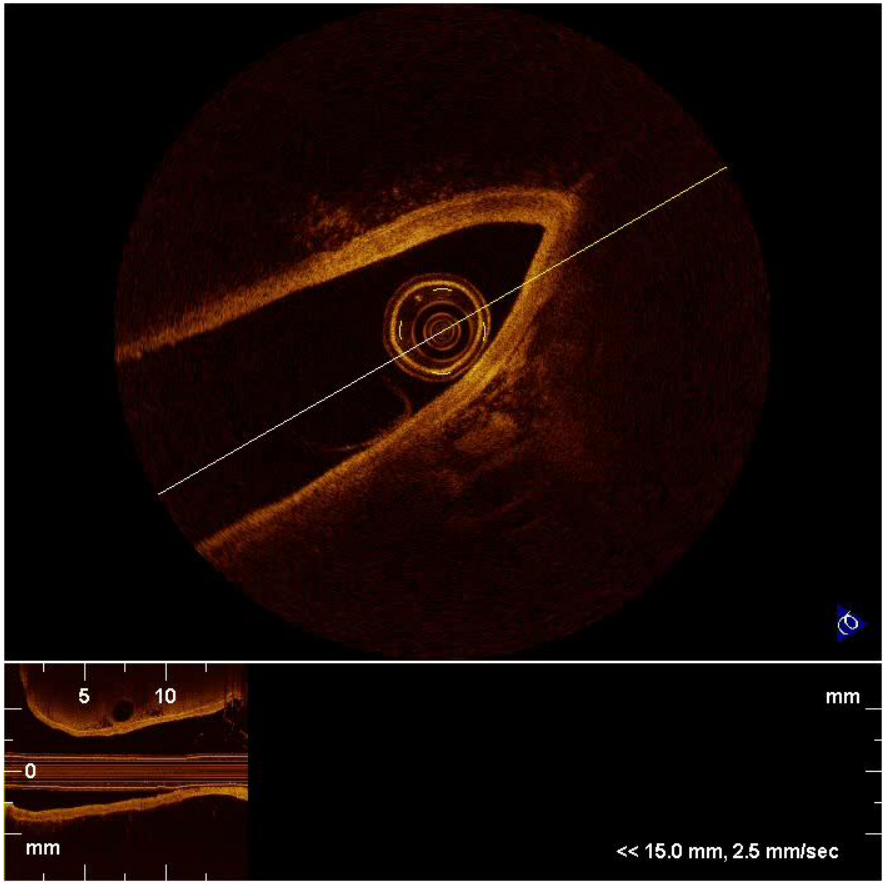




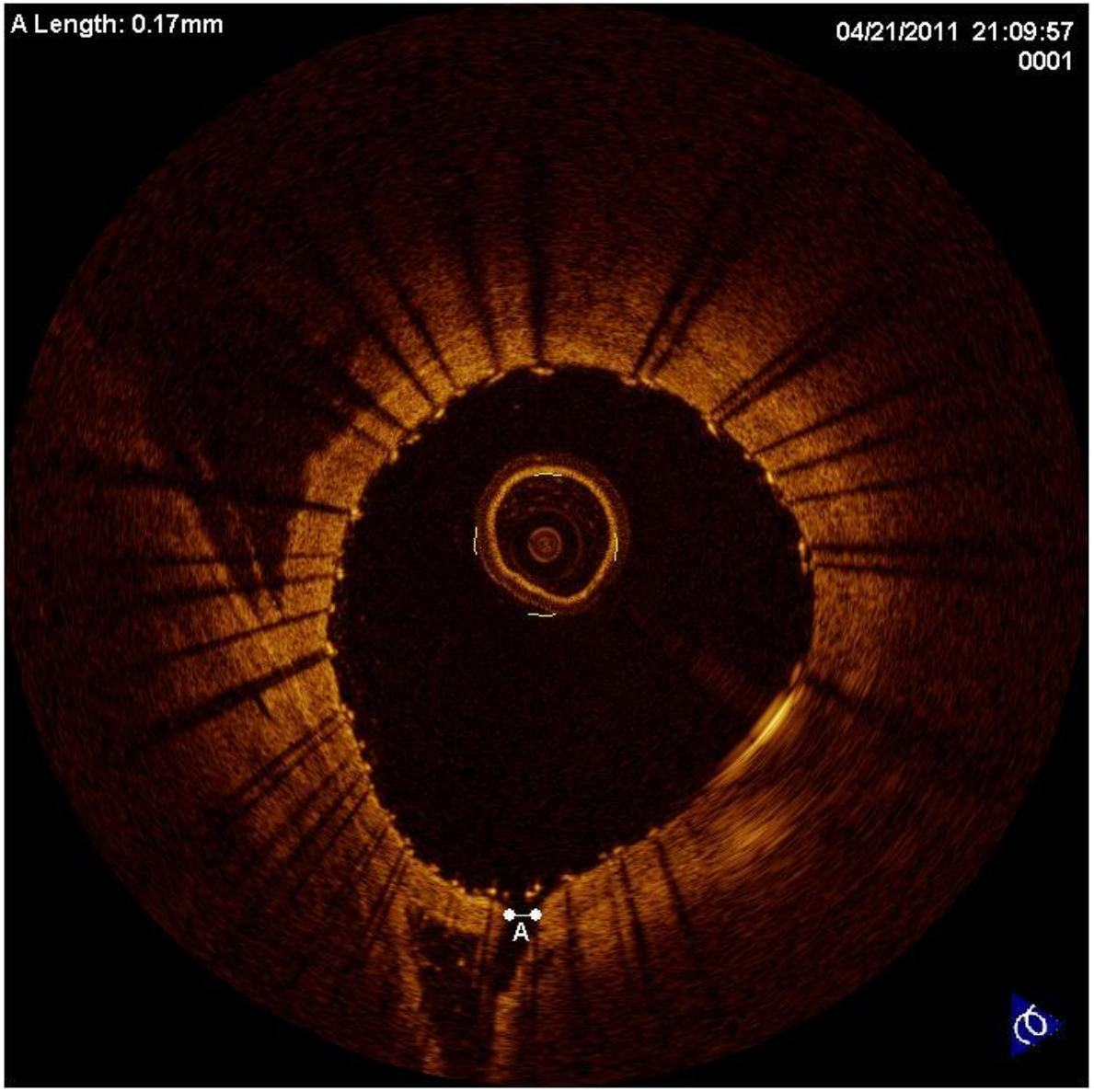
RUSH UNIVERSITY MEDICAL CENTER

Anterior Cerebral Artery

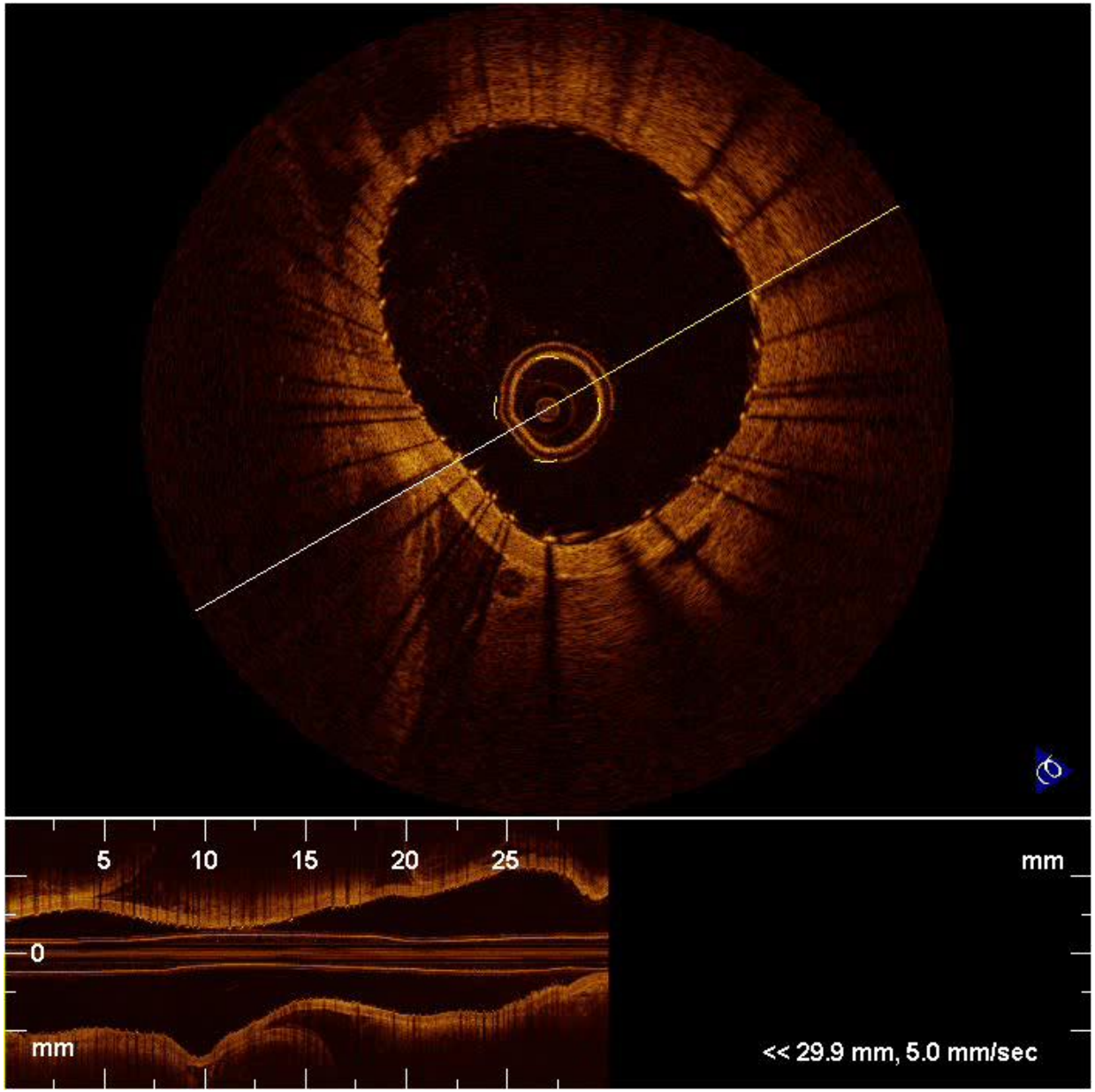




Relationship pipeline - perforator

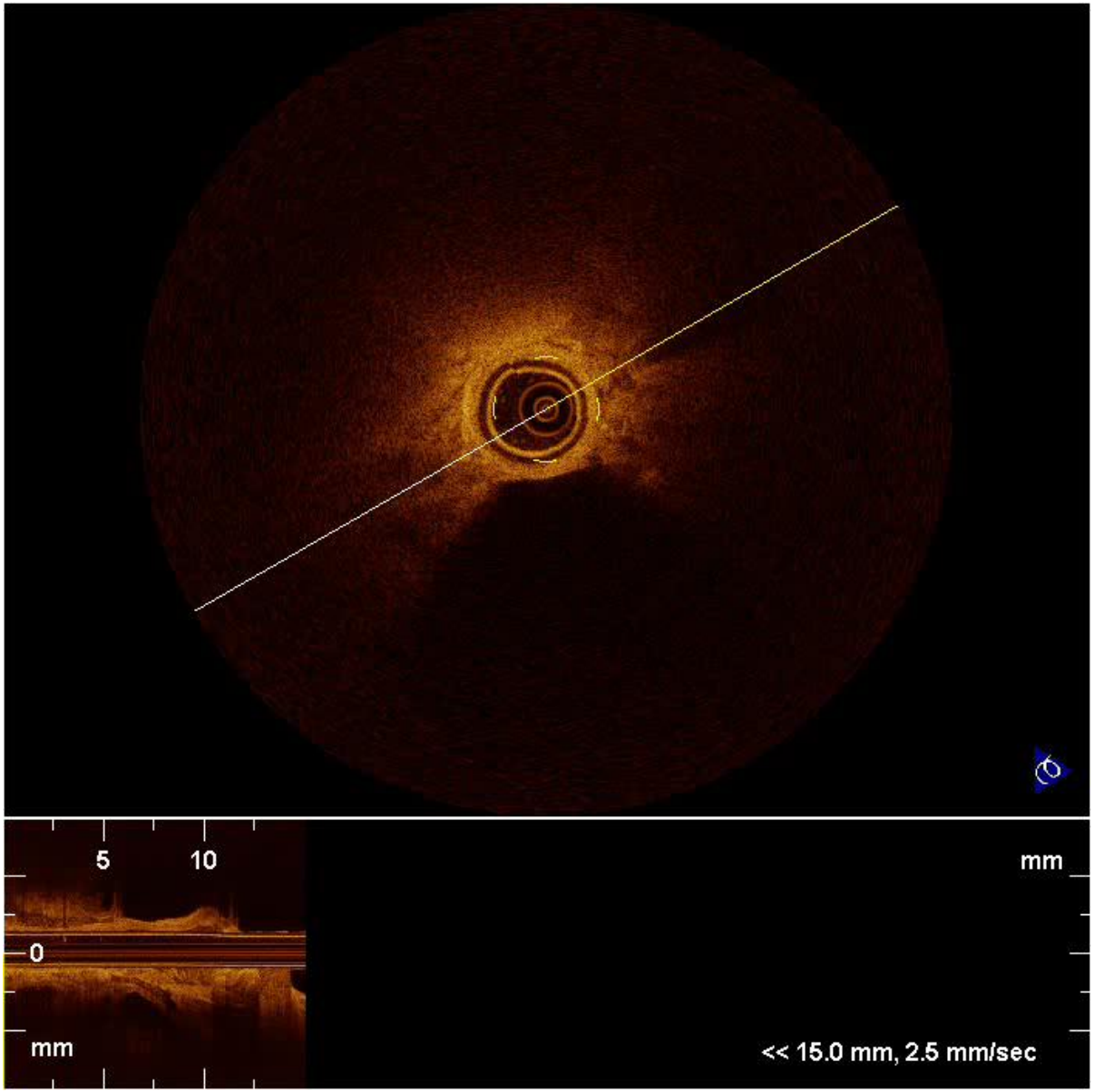


Basilar post Pipeline

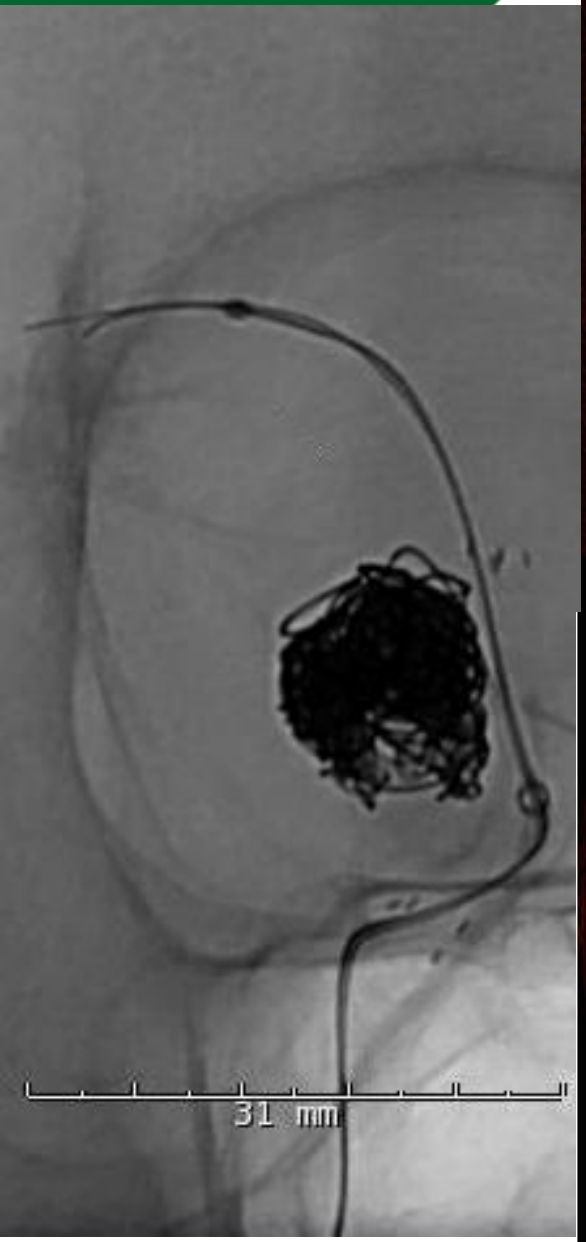


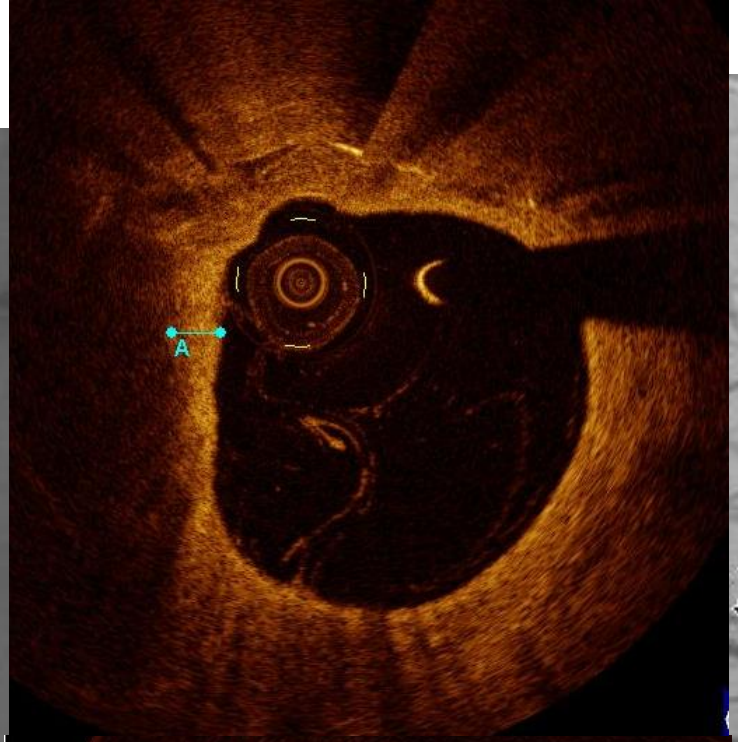
RUSH UNIVERSITY MEDICAL CENTER

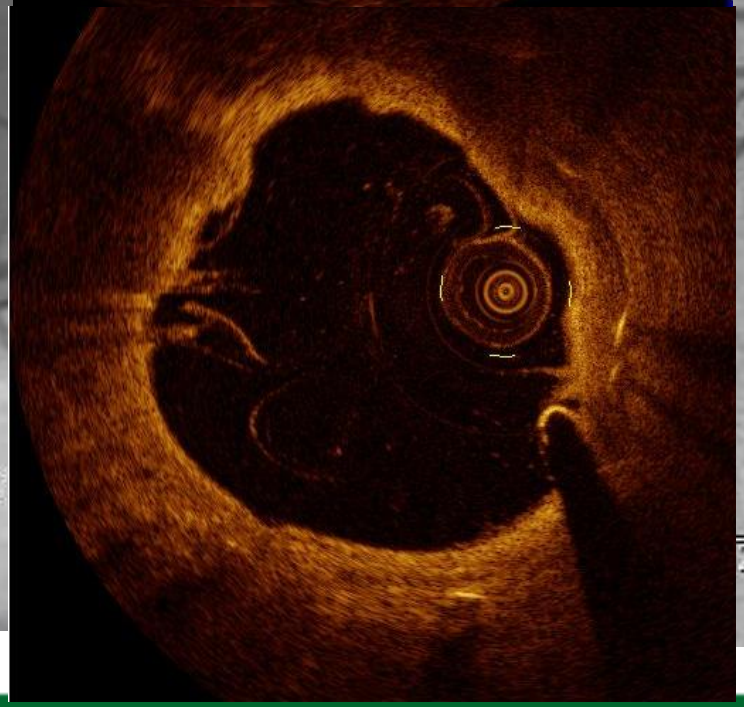
P-com artery (smallest)

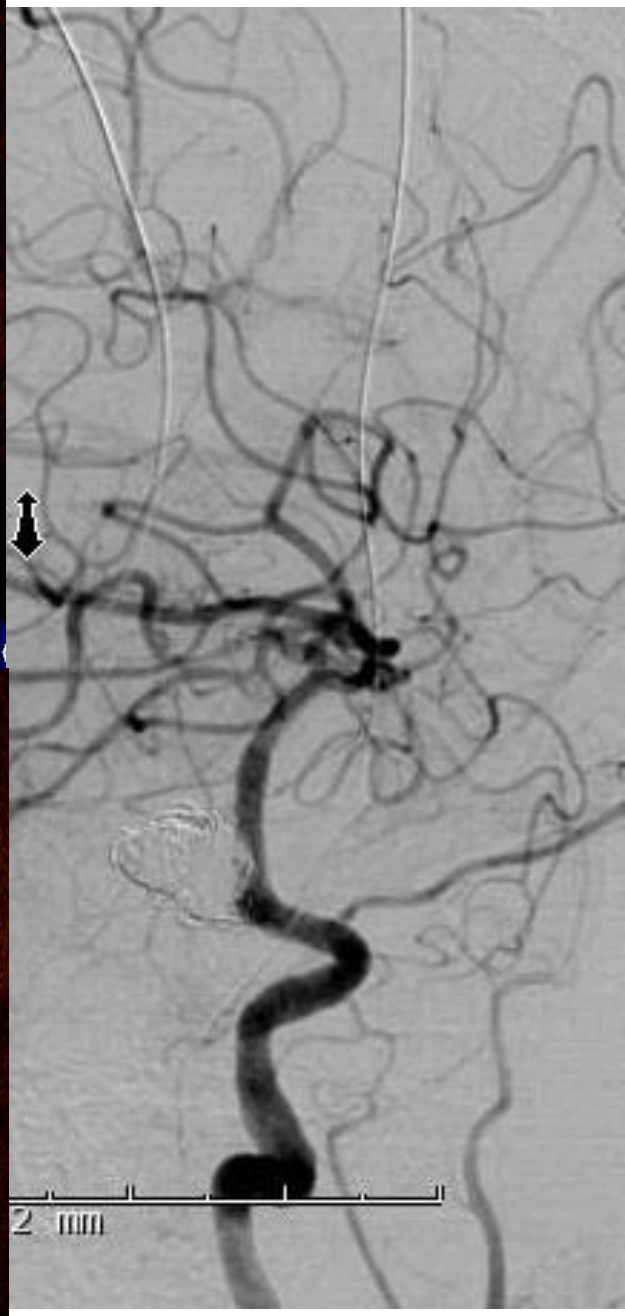


RUSH UNIVERSITY MEDICAL CENTER



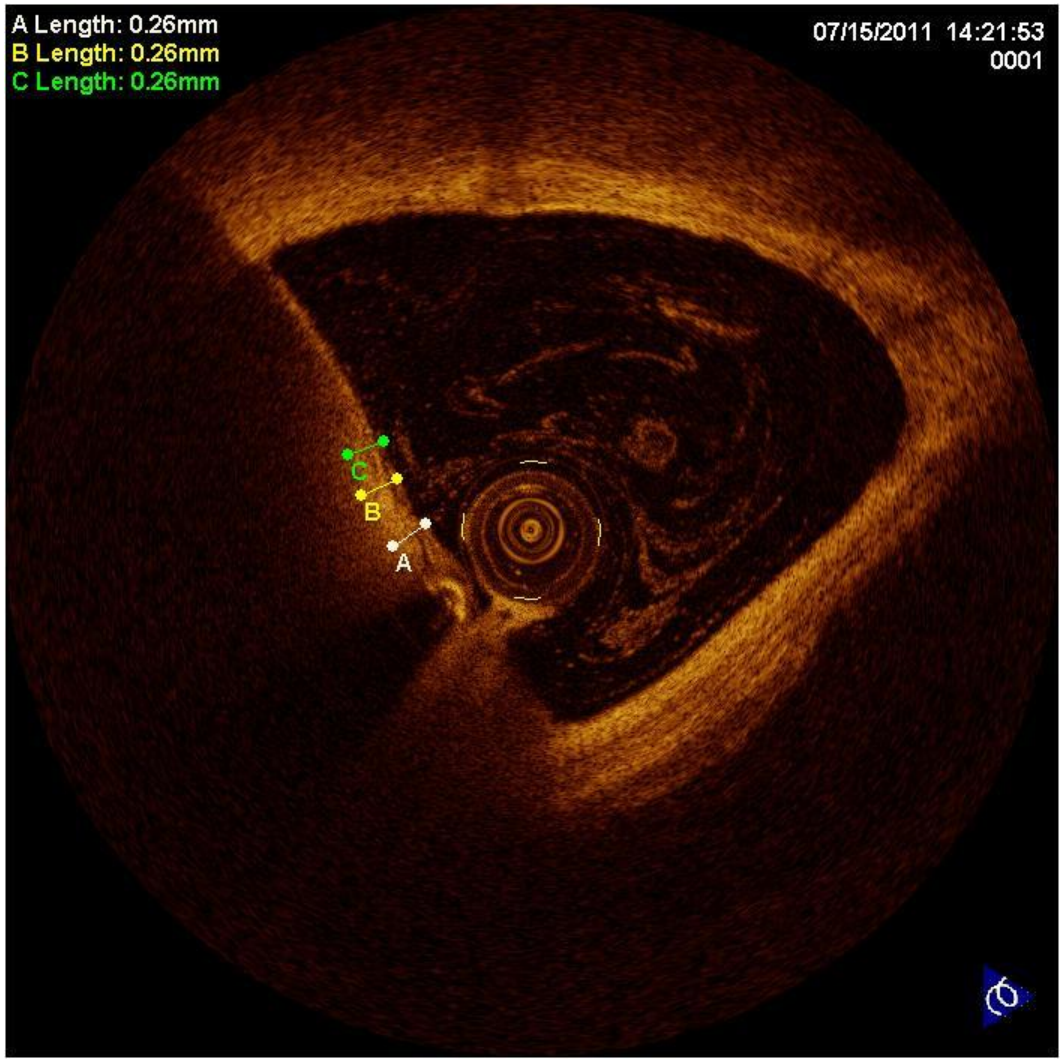






RUSH UNIVERSITY MEDICAL CENTER

Transverse sinus imaging



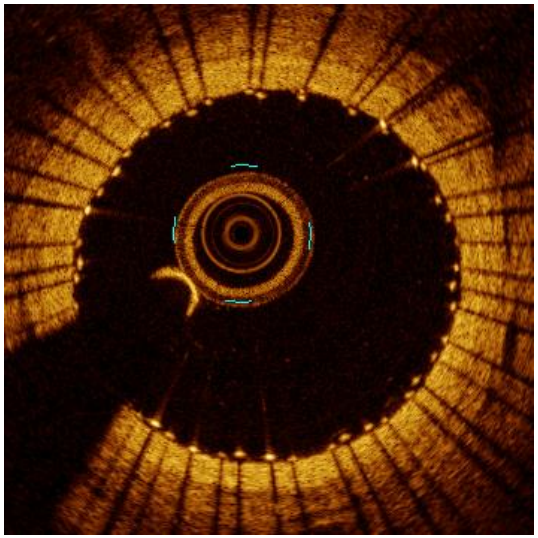
Stent endothelialization monitored with intravascular imaging and histology in porcine

RUSH UNIVERSITY MEDICAL CENTER

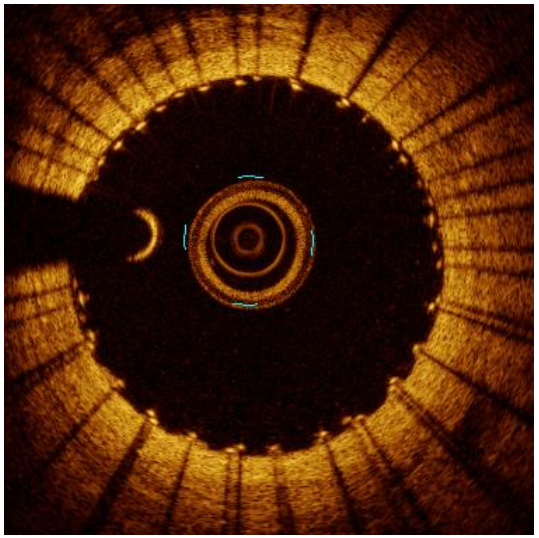
Results - 4 days

- Endothelialization : FLEX (5 × 12mm) vs. FLEX with Shield (5 × 12mm) vs. Solitare (5 × 20mm) (1Fr.=0.1mm)

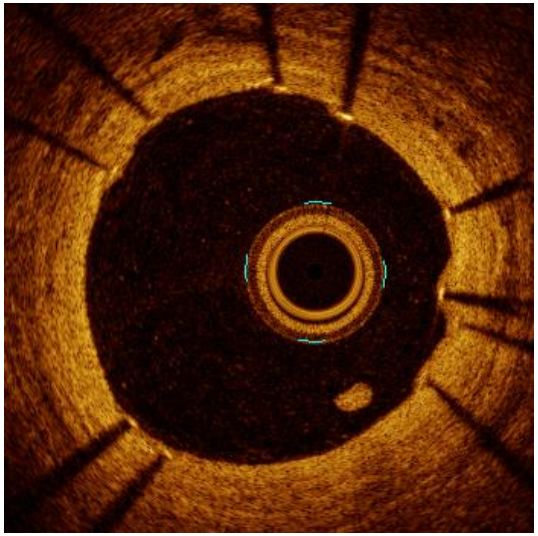
FLEX 1



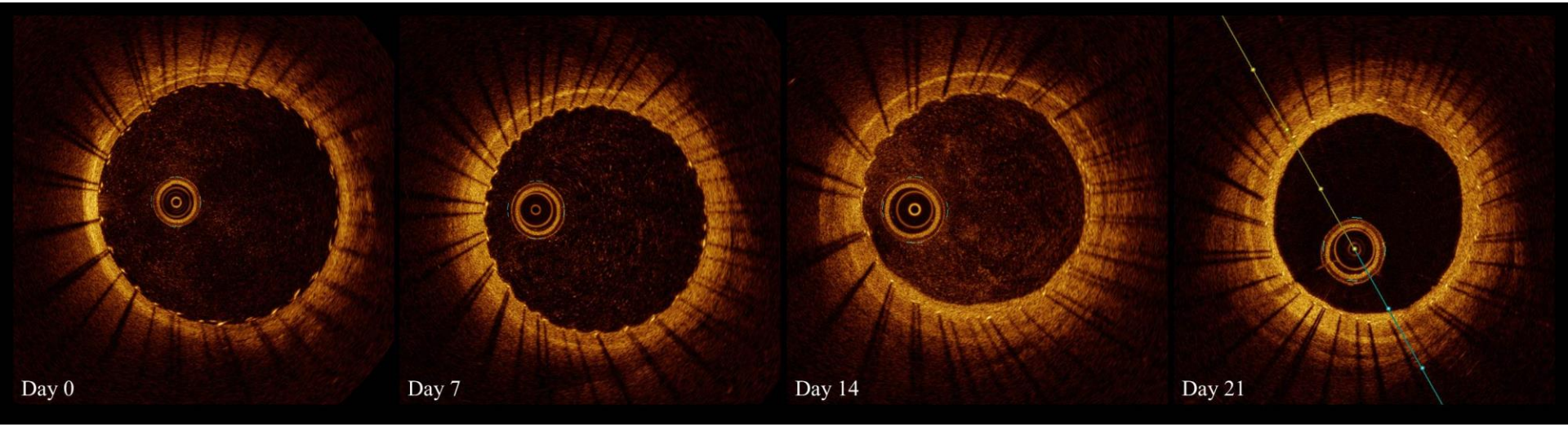
Shield 1



Solitare 1



Endothelialization of device over time in a porcine model



RUSH UNIVERSITY MEDICAL CENTER

Rush Center for Neuroendovascular surgery

Thank you