# Basics of IVUS & OCT

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Sound (IVUS) & Light (OCT)

- Sound and light follow the same physical rules of wave propagation

- Boundary conditions are quite different

- Higher penetration and access to RF signals make IVUS better suited for whole plaque imaging

- Higher resolution and more spectroscopic possibilities make light better for superficial morphological imaging (cap thickness)
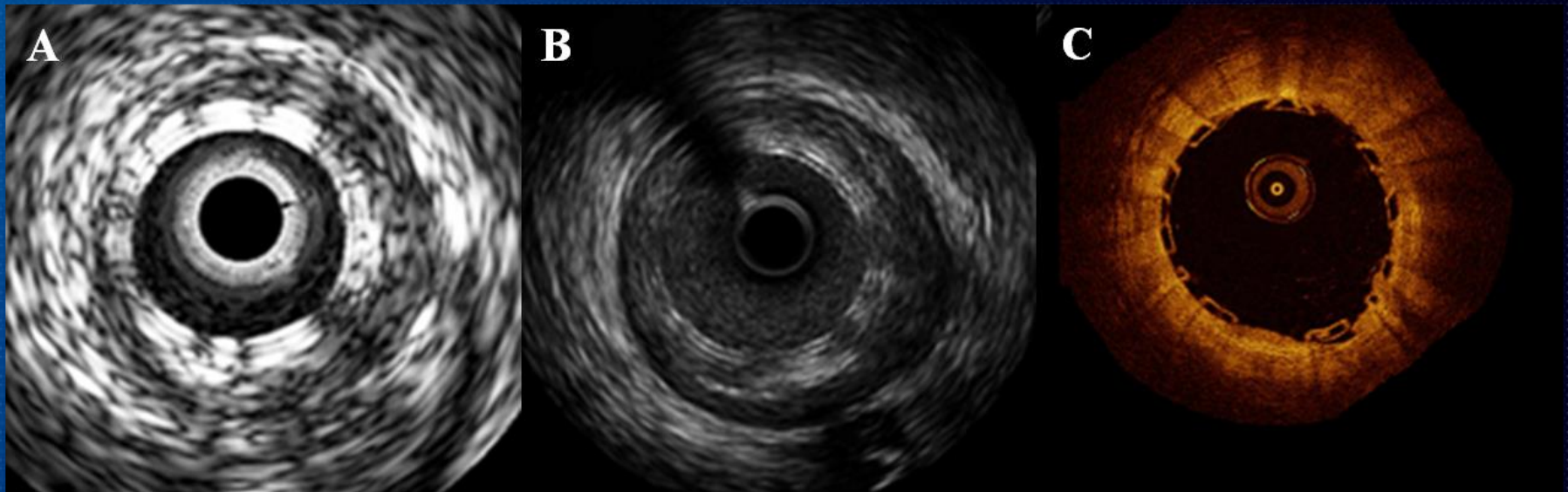
IVUS & OCT
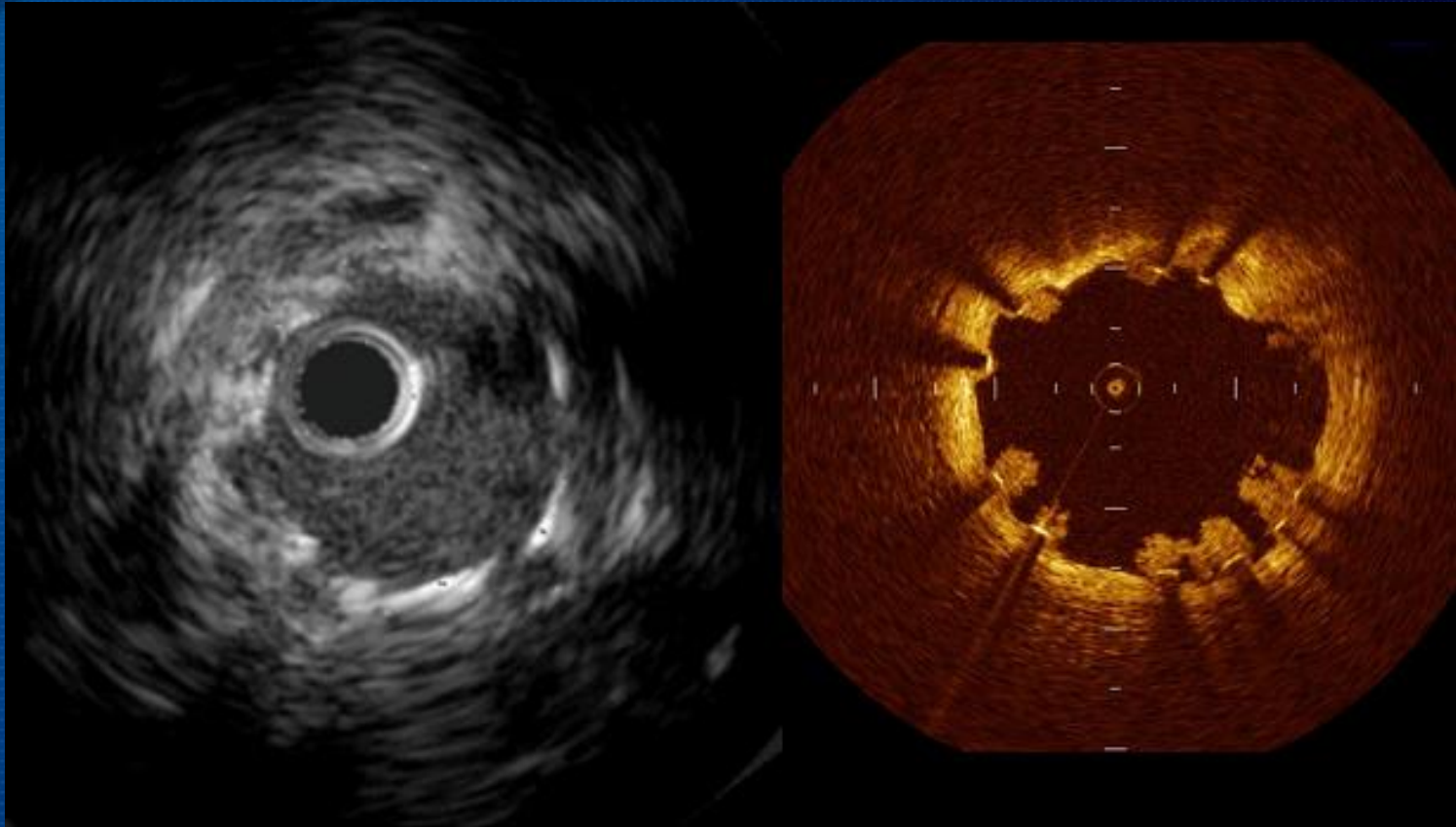
- Vessel & plaque assessment
- Plaque characterization
- Plaque characterization
- Stent assessment

DES

Incomplete apposition

1 mm

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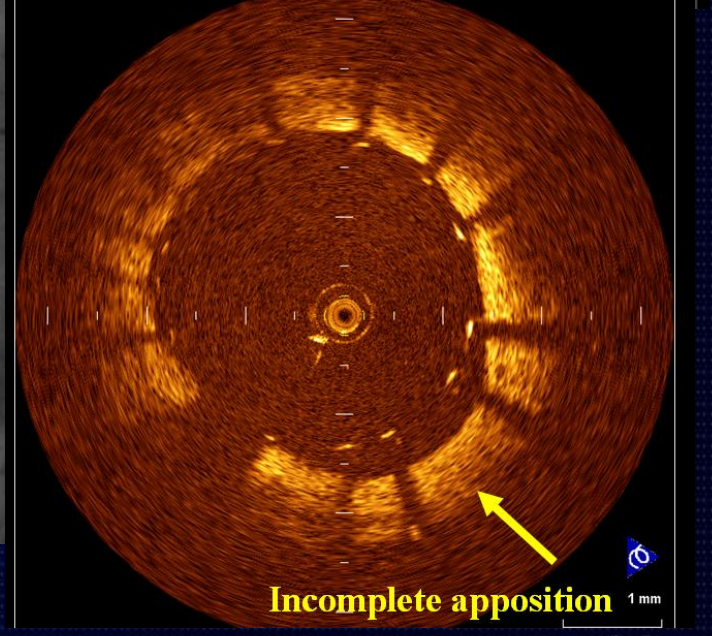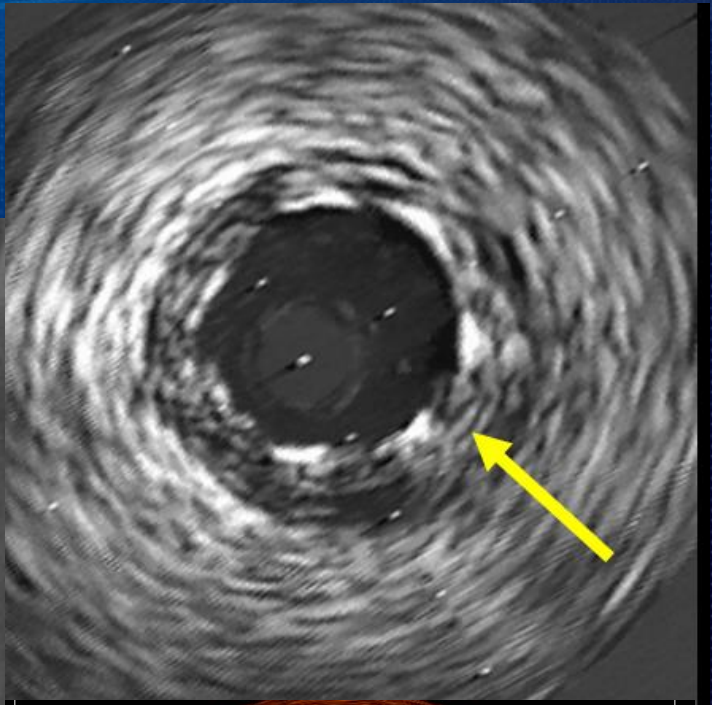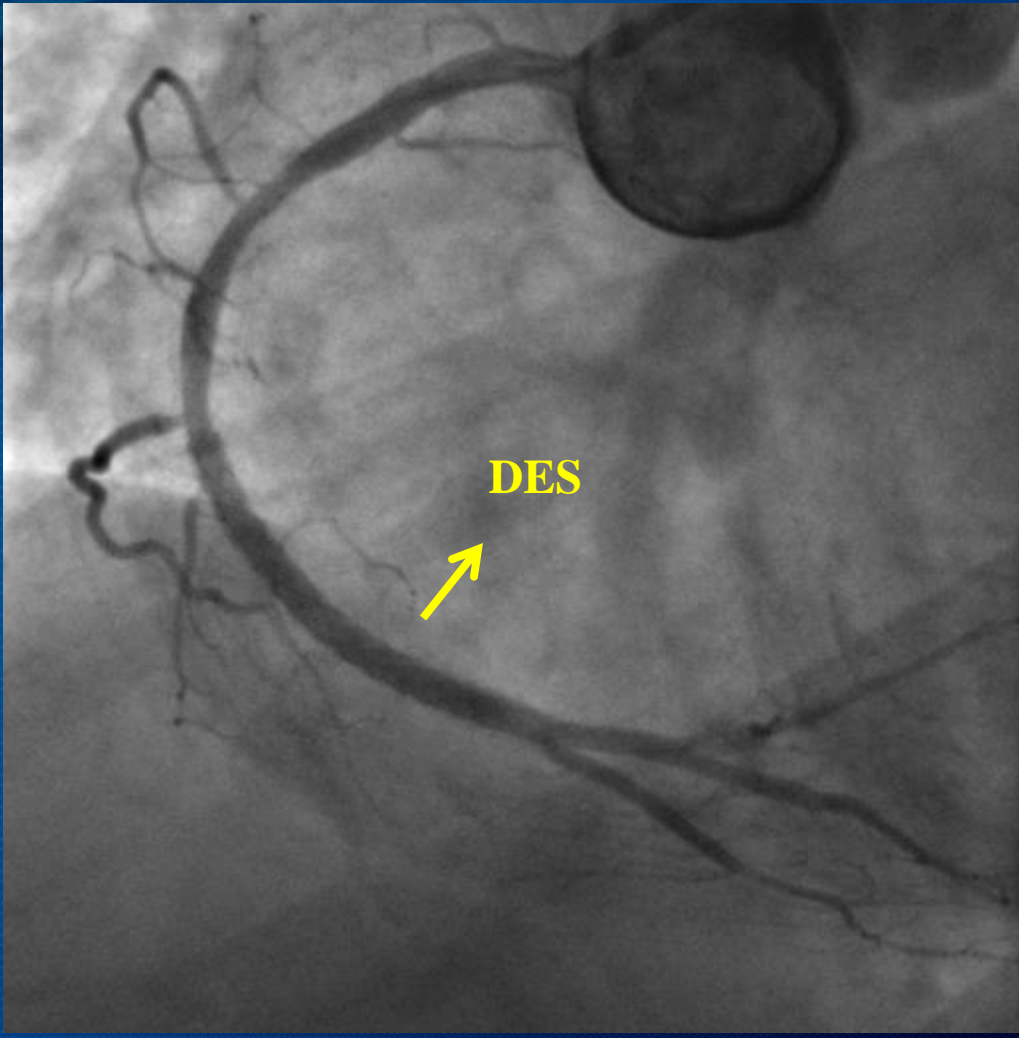
OCT over IVUS

1. 10 times higher resolution than IVUS (spatial resolution 150~200 μm vs. 15~20 μm)

2. Penetration power is lower, 1-3 mm thickness (IVUS: 4-8 mm thickness)
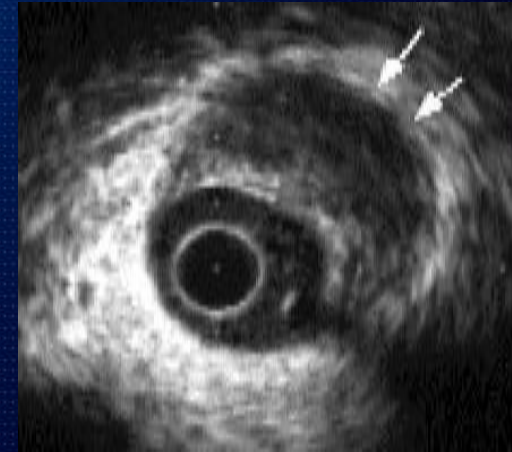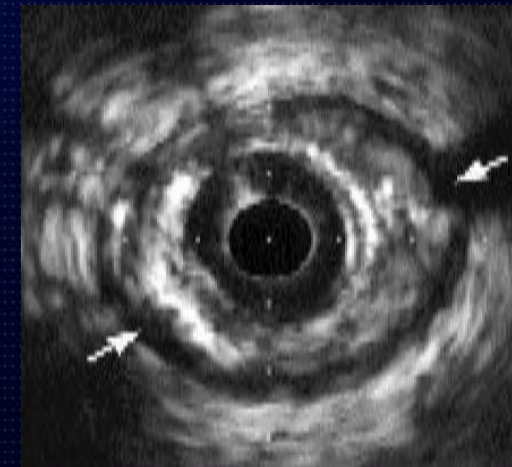

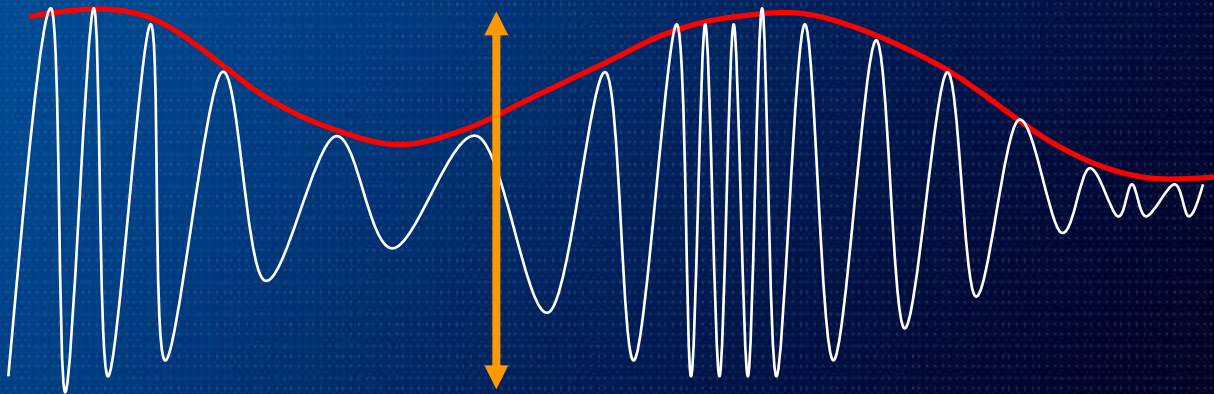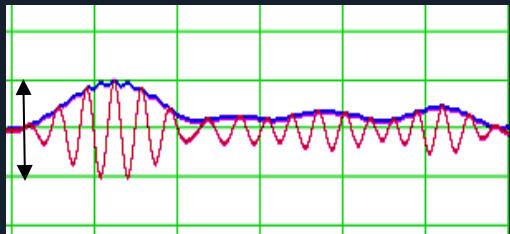20 MHz   40 MHz   OCT

Gray Scale Image

Echolucent

- Discrimination of lipid is inconsistent using grayscale images alone
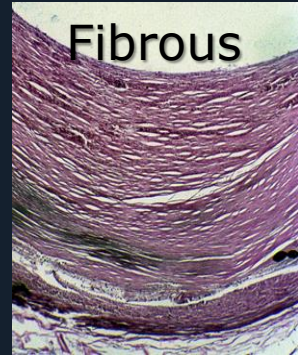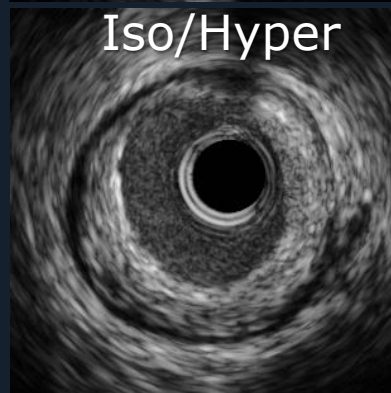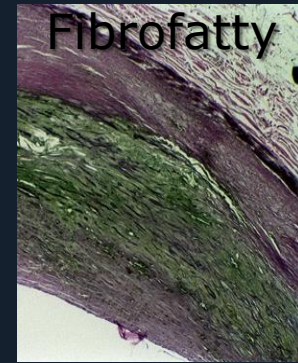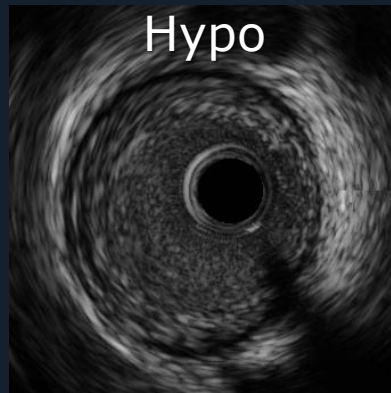- Only the envelope amplitude is used to form the gray-scale IVUS
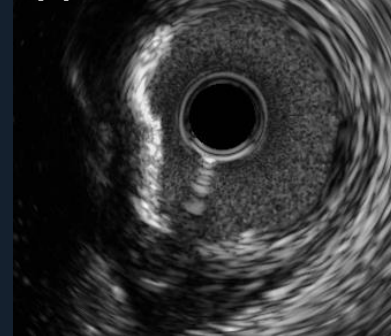
Echogenic

Grey Scale IVUS Tissue Characterization
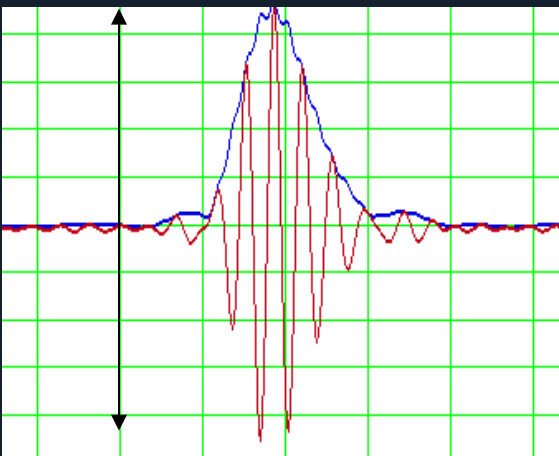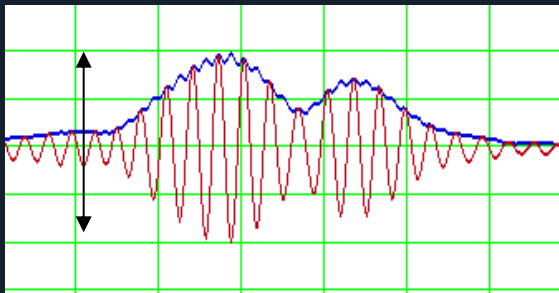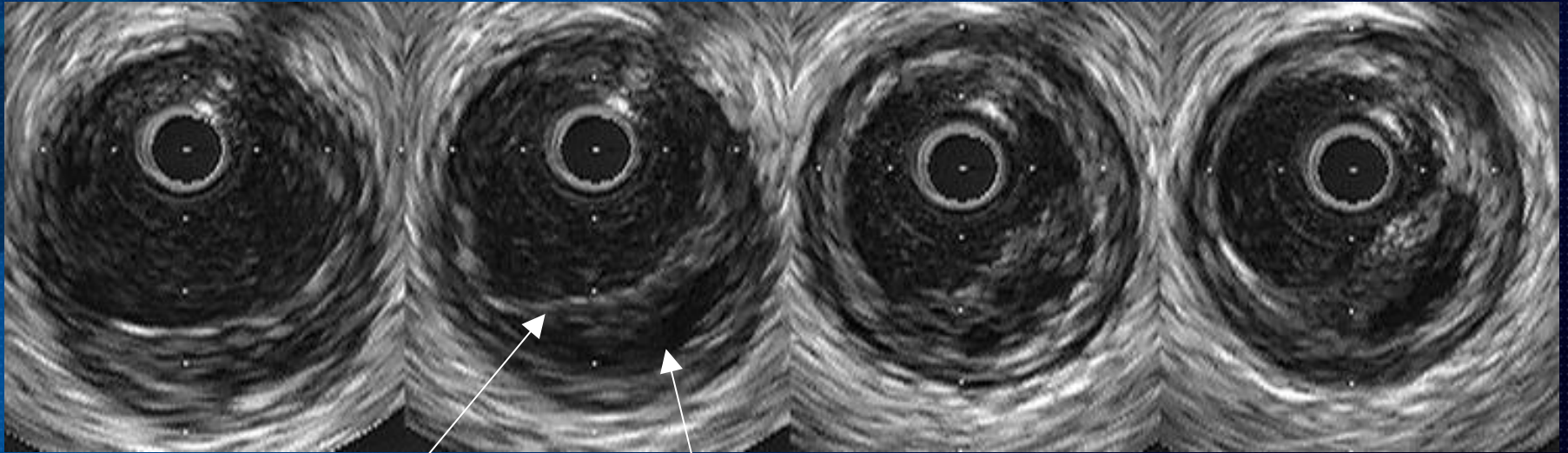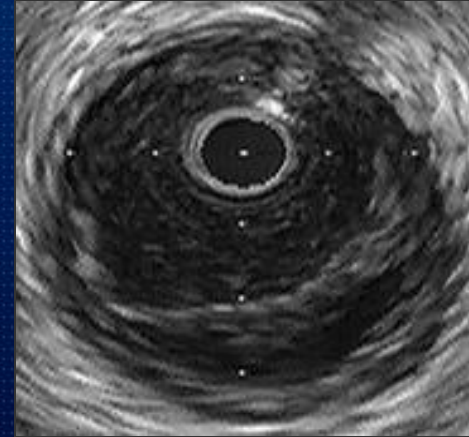
Fibrous Cap   Necrotic Core

Detection of Necrotic Core

- Lipid necrotic area

- 40MHz IVUS

- Human 10 coronary & 2 carotid arteries, in vitro

  30 /122 (25%): histological lipid pool
  19/122 (16%): IVUS lipid pool

  Sensitivity: 67%
  Specificity: 94%

Prati F, et al Z Kardiol 2000
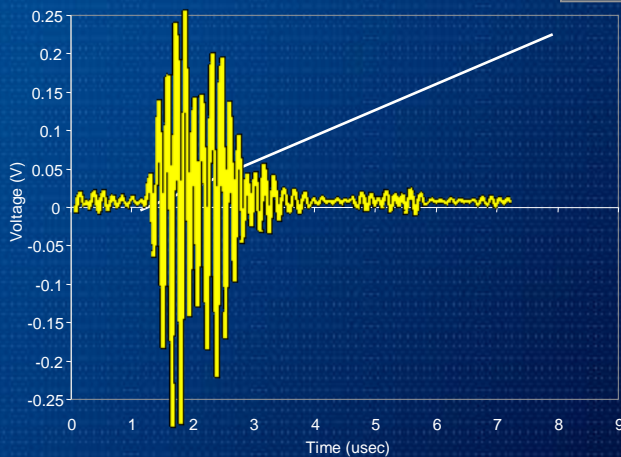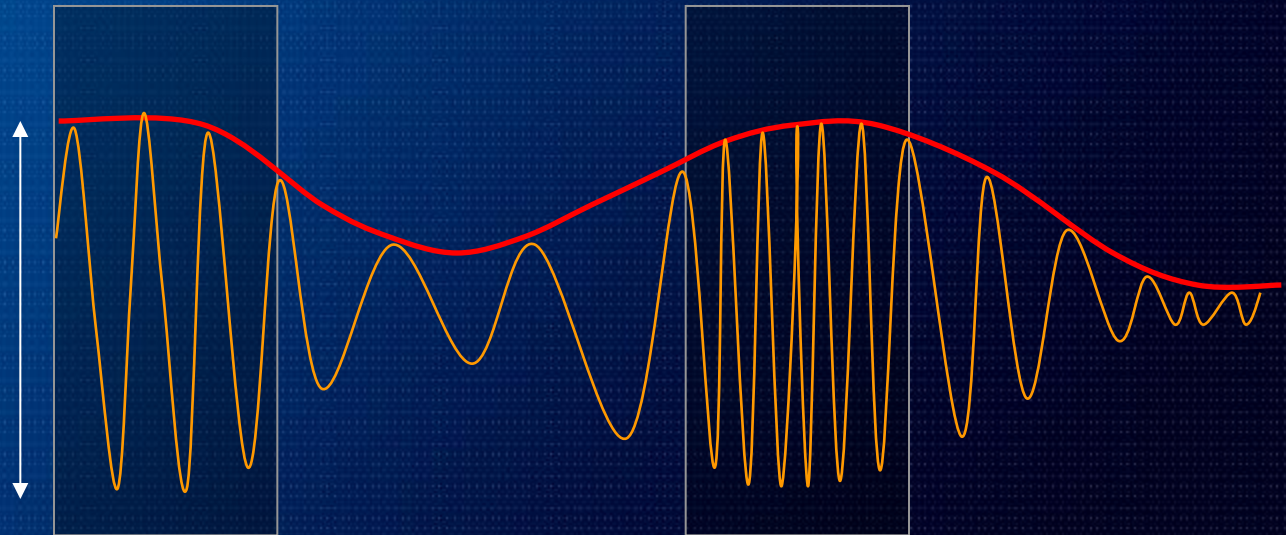
Plaque Characterization

- Integrated Backscatter (IB) IVUS

- Virtual Histology (VH) IVUS
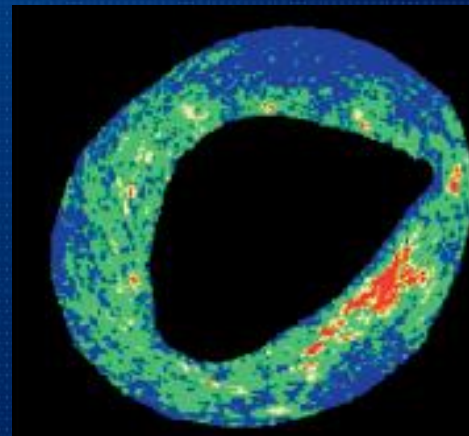
- i-Map

Radiofrequency Data

VH-IVUS
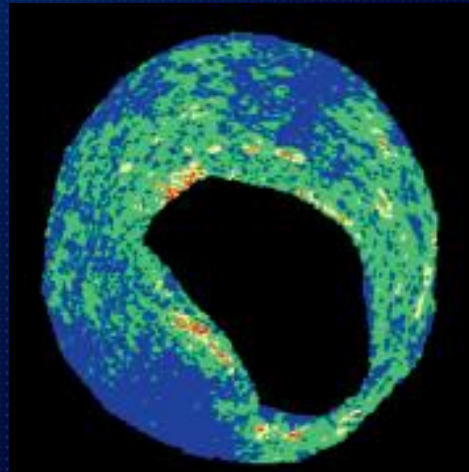# Use Power and Frequency

Amplitude

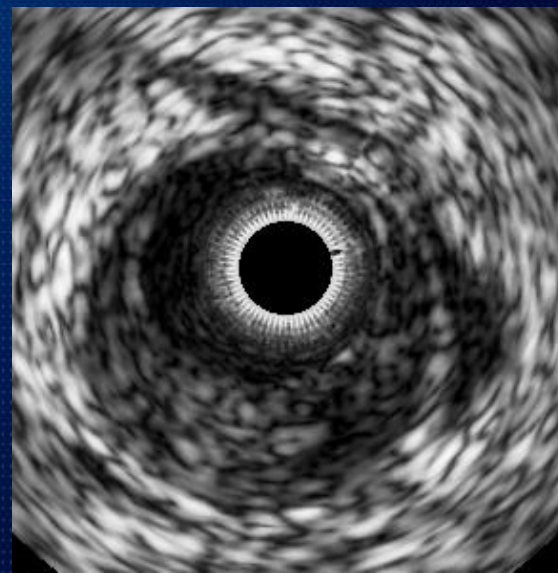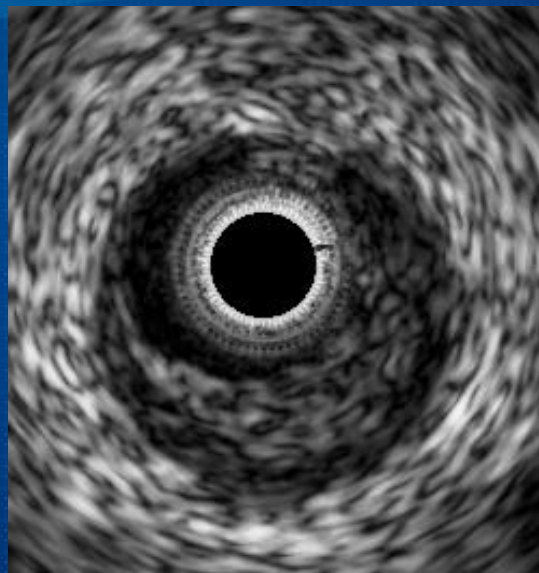Same amplitude, different frequency

Integrated Backscatter (IB)-IVUS

■ Calcification

■ Dense Fibrous

■ Fibrosis

■ Lipid Pool

Okubo, Kawasaki, et al Ultrasound Med Biol 2008, 34:655-63.
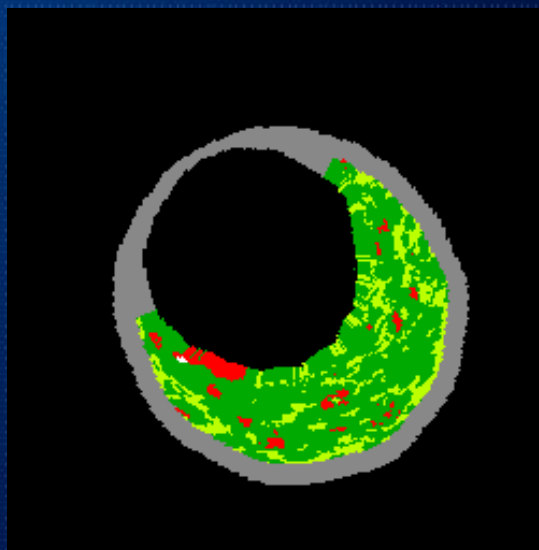
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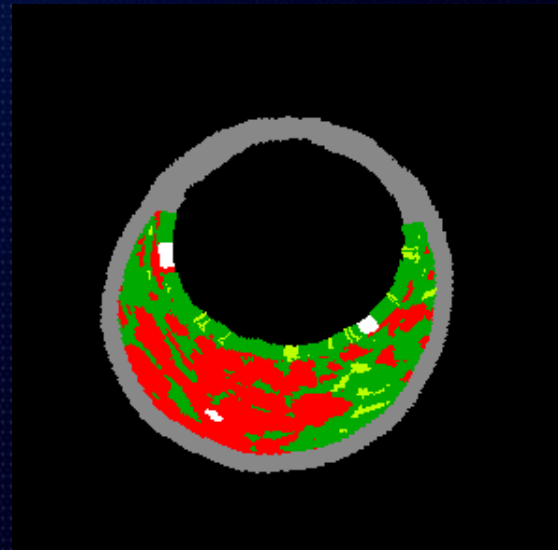
Grey Scale IVUS

VH-IVUS

In vitro Diagnostic Accuracy

- **Necrotic Core (96%)**
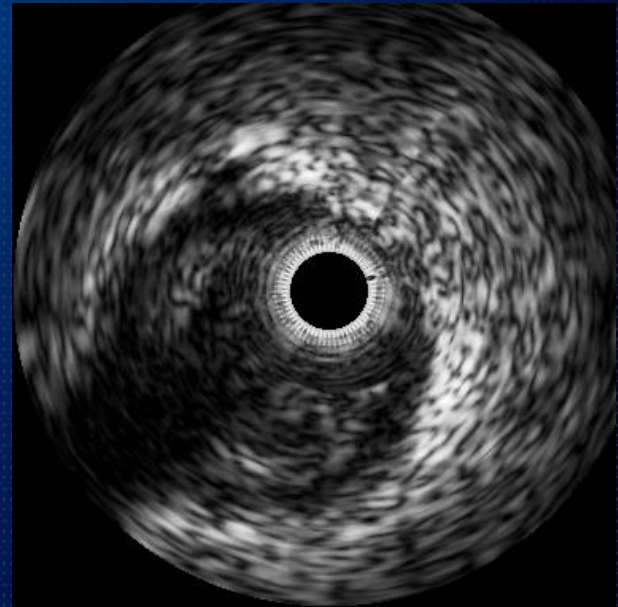- **Dense Calcium (97%)**
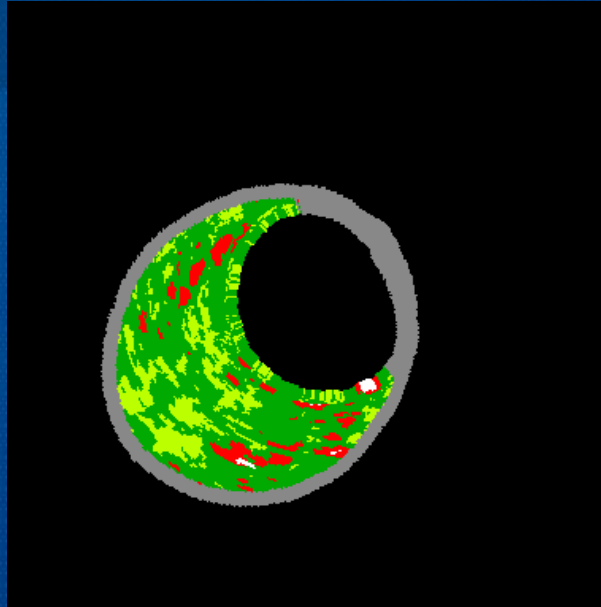- **Fibrous (94%)**
- **Fibrofatty (94%)**
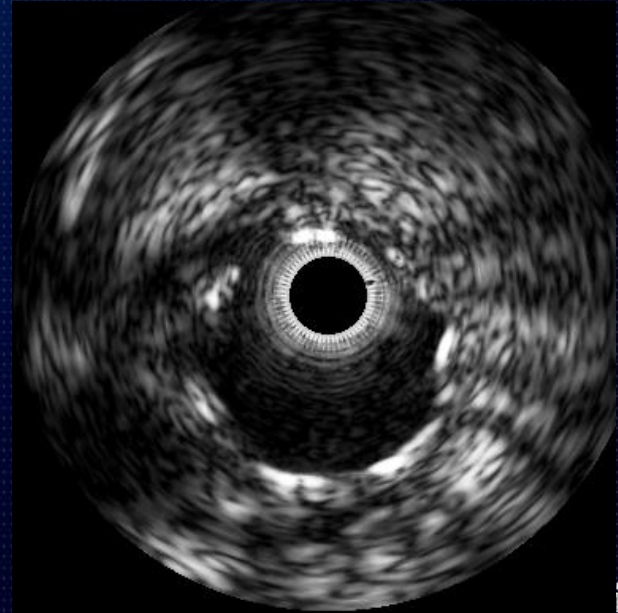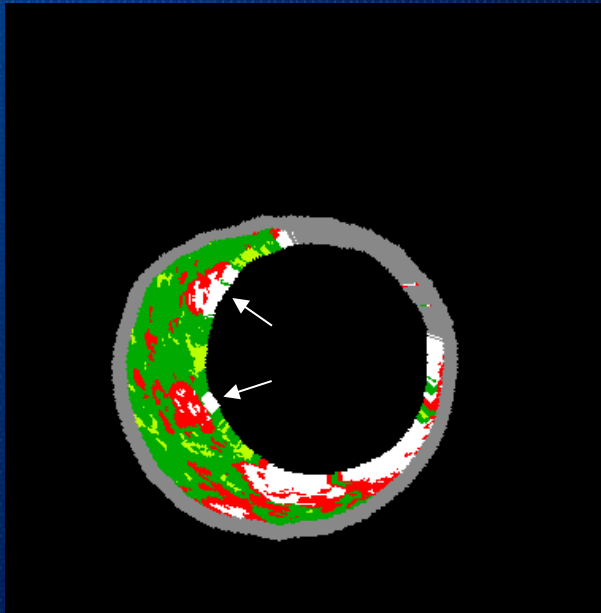
Pathological Intimal Thickening (PIT)

Thick Cap Fibroatheroma

Nair, et al Eurointerv 2007, 3:113-120.

Stent Struts

Before-Stent

Post-Stent

Tissue Characterization IVUS: VH, iMAP
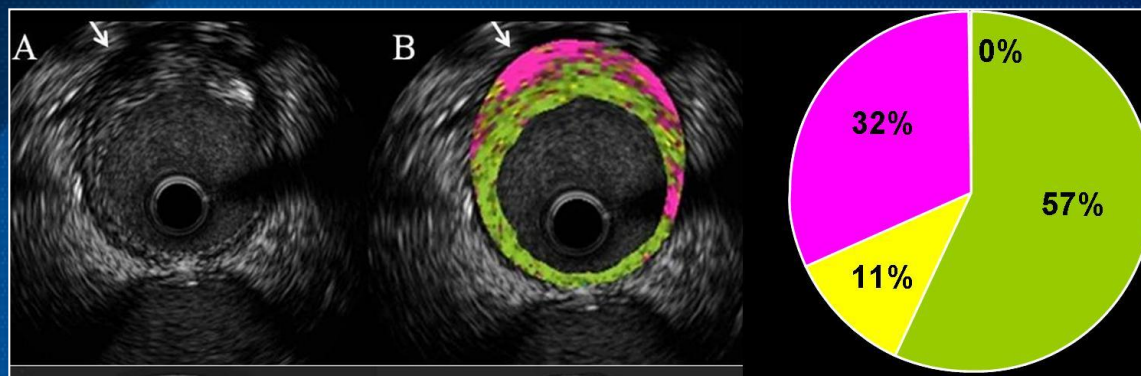
iMap	Color	Accuracy
Fibrotic		95 %
Lipidic		98 %
Necrotic		97 %
Calcified		98 %
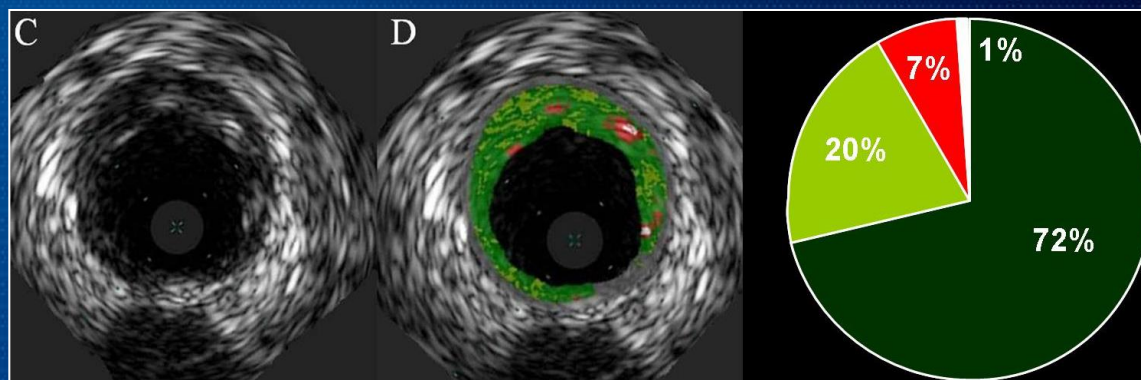
VH	Color	Accuracy
Fibrous		87 %
Fibro-fatty		87 %
Necrotic core		88 %
Dense calcium		97 %

Intracoronary OCT Principle
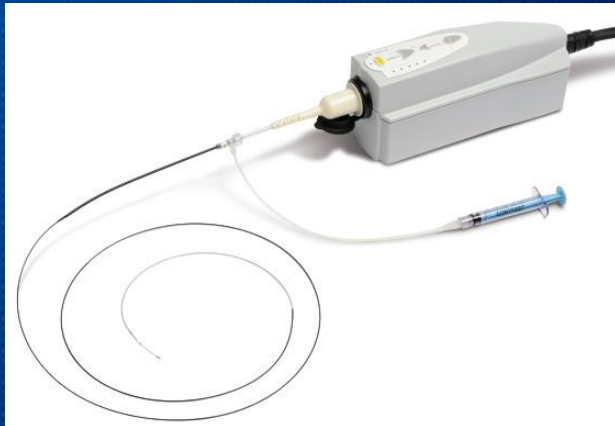
OCT,
analogous to sonar and radar,
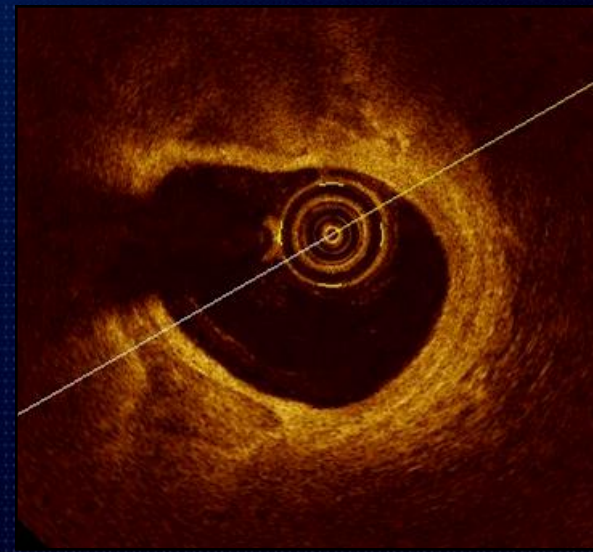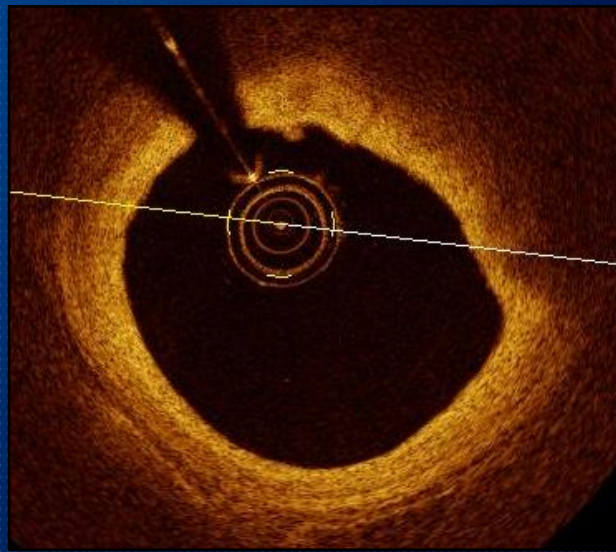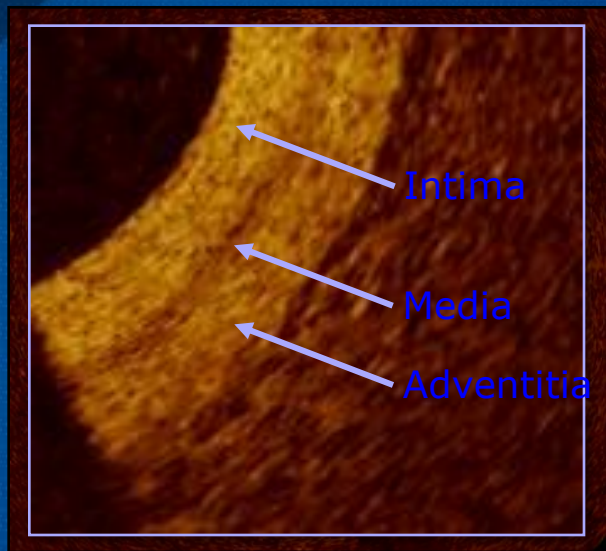measures <u>optical echoes</u>,
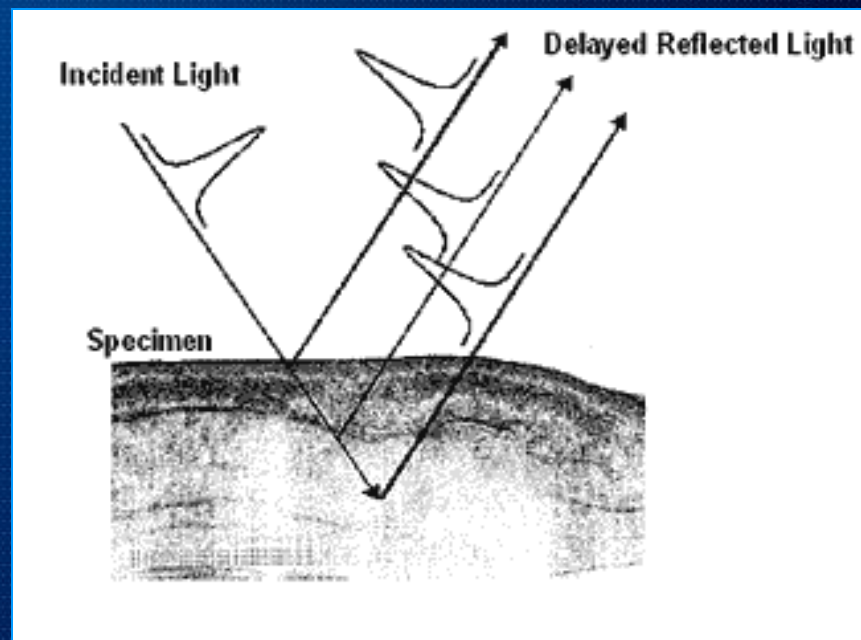
C7XR System

- Balloon occlusion not required
- Fast flush, spiral pullback acquisition
- 5 cm arterial segment in 2.5 sec
- Rapid exchange (Rx) imaging catheter

Plaque Characterization

Normal artery wall with mild intimal thickening
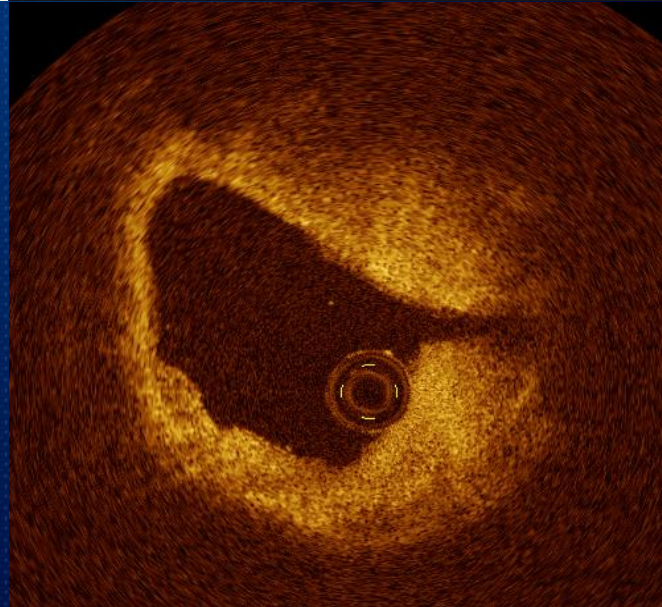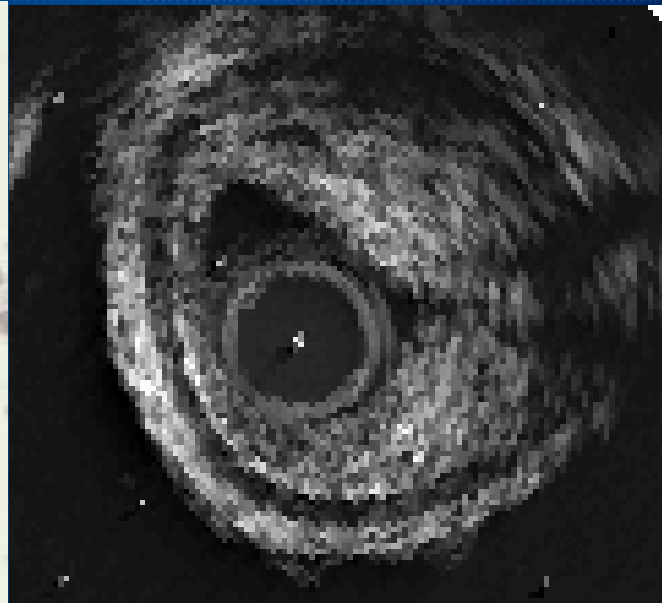
Fibrofatty plaque

Calcified Plaque

Ex Vivo Study Results

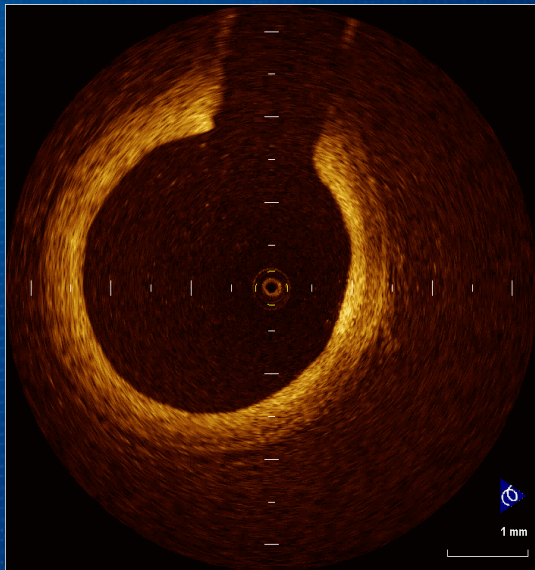|				
Fibrous	SENS	.87	PPV	.88
	SPEC	.97	NPV	.96
Calcific	SENS	.95	PPV	1.0
	SPEC	1.0	NPV	.95
Lipid pool	SENS	.92	PPV	.81
	SPEC	.94	NPV	.97

Intracoronary Imaging
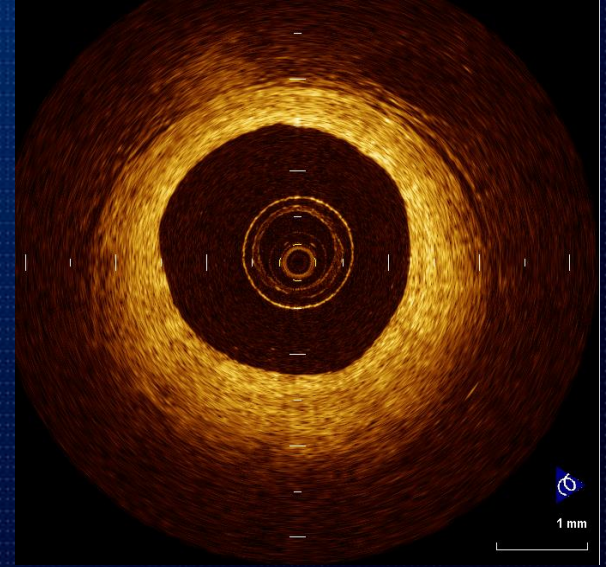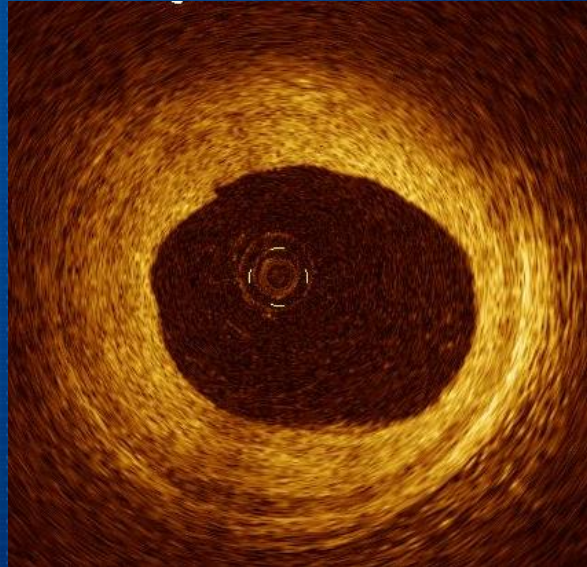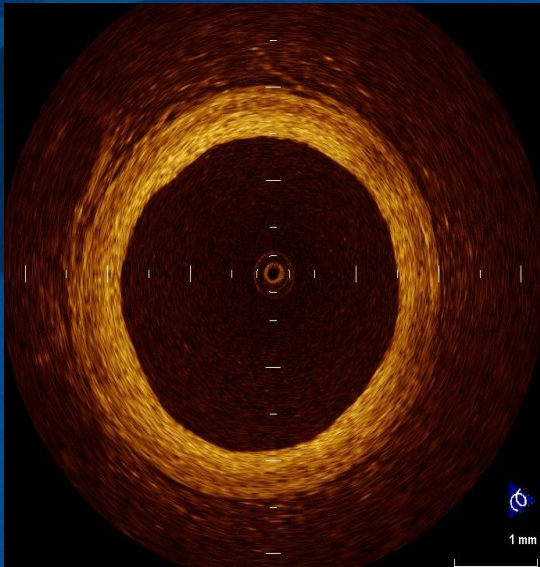# Comparison among OCT & IVUS

- Tissue Characterization: comparison with histology

- Vulnerable plaque identification

- Stent Follow-up

Fibrous plaque

1mm

Signal rich
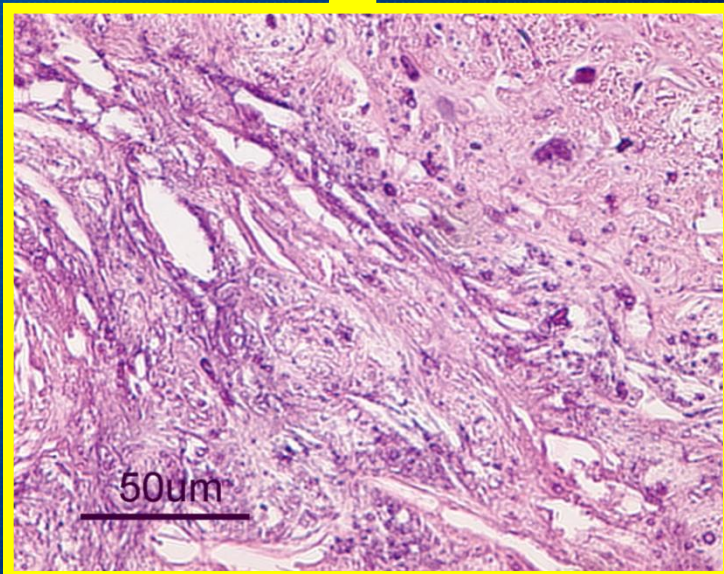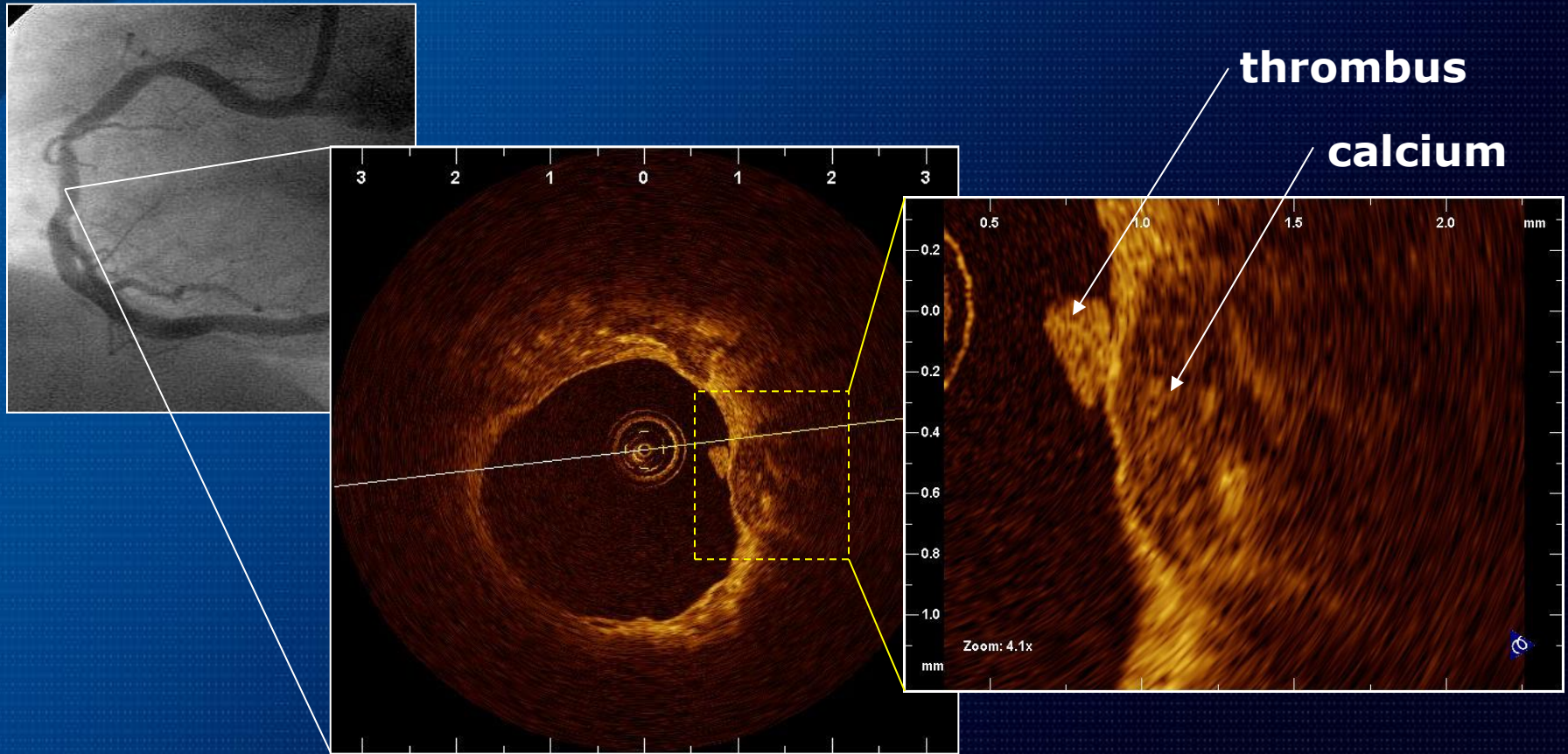Diffuse border

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Fibrous Plaque

Fibrocalcific plaque

1mm

50um

Signal poor
Sharp border
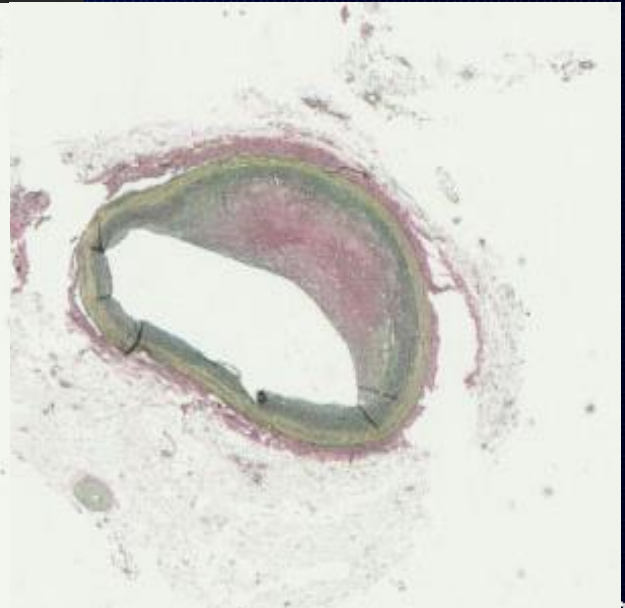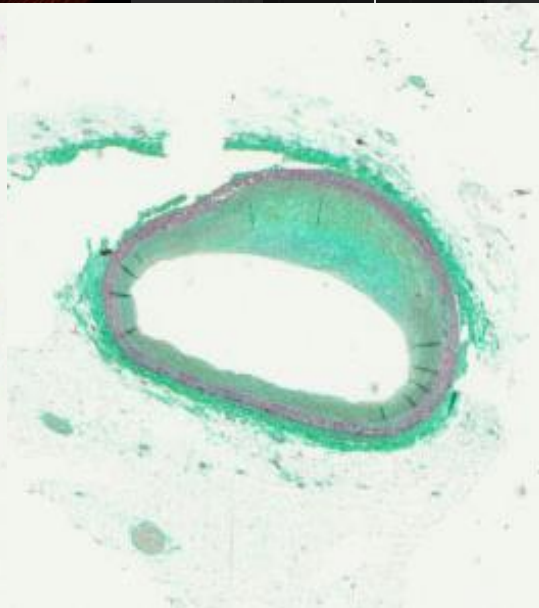
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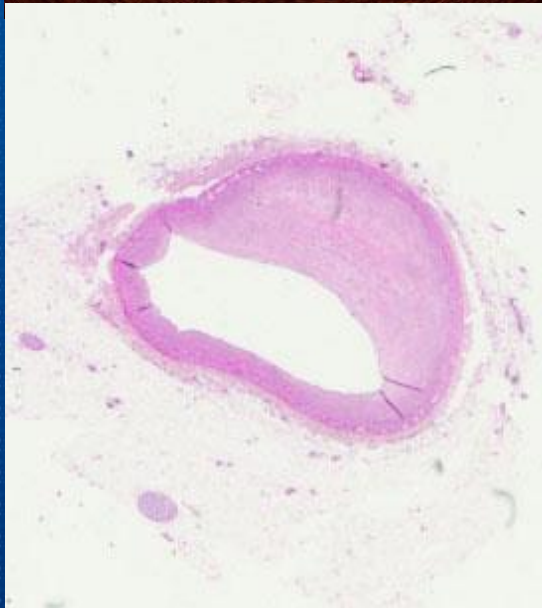# Calcified Plaque

thrombus
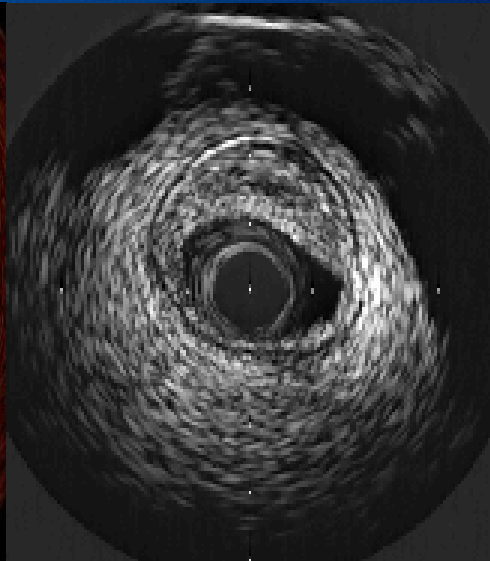
calcium

Calcified plaque

Superficial calcified nodule
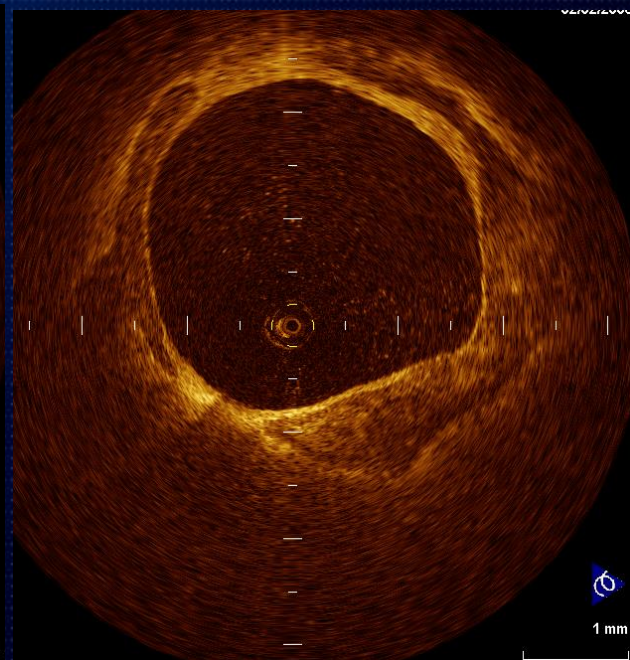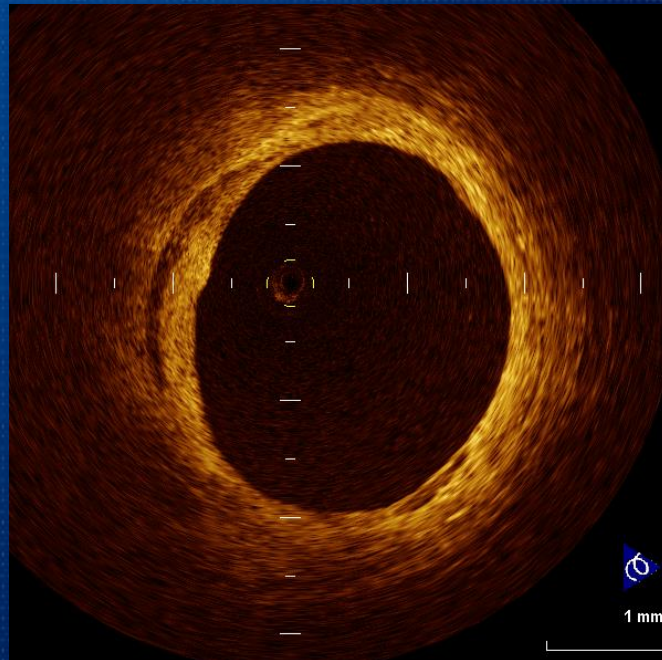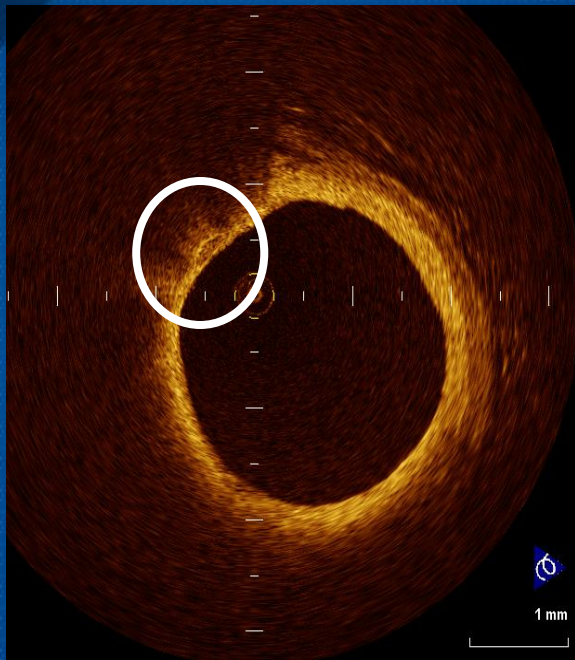
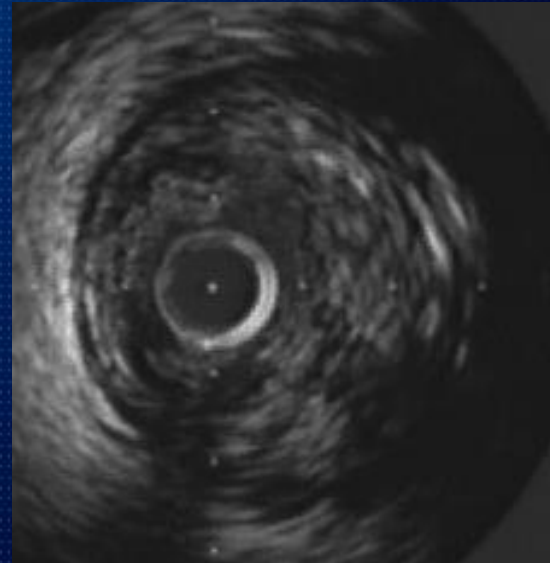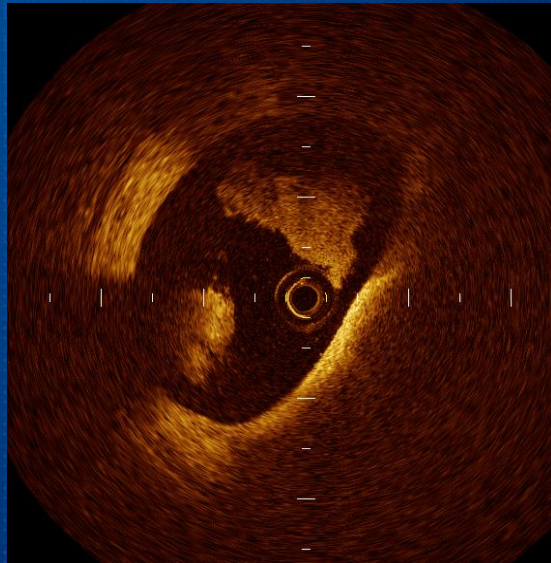# Fibrofatty plaque

Signal poor
Diffuse border

Thrombus

Red & white thrombus

Red thrombus

White thrombus

Protrusion mass
with shadow

Protrusion mass
with shadow

Kubo T, Akasaka T, et al.(J Am Coll Cardiol 50:933-939,2007)
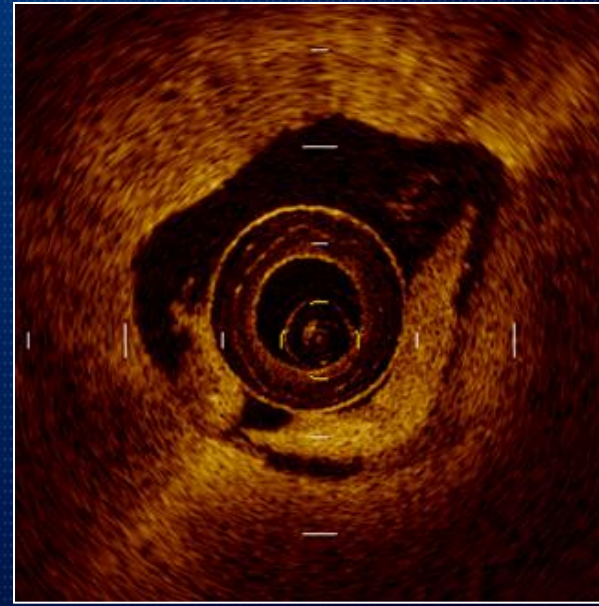
Instent thrombus
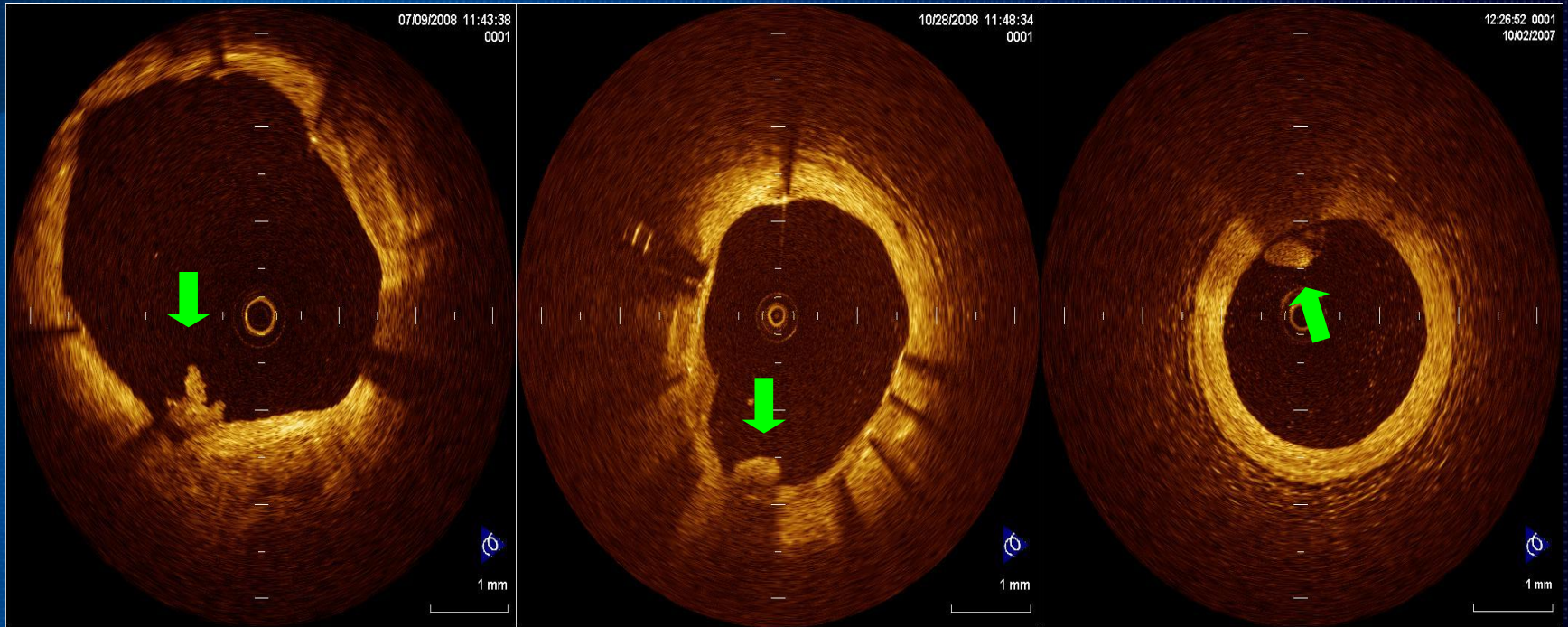
DES   BMS   Distal to DES

Neointimal Coverage
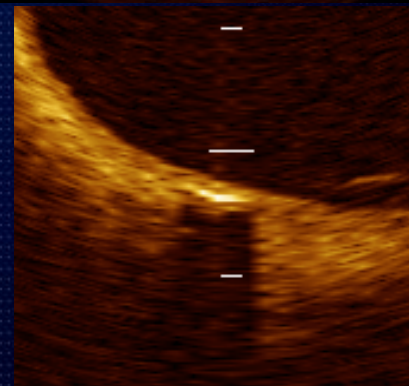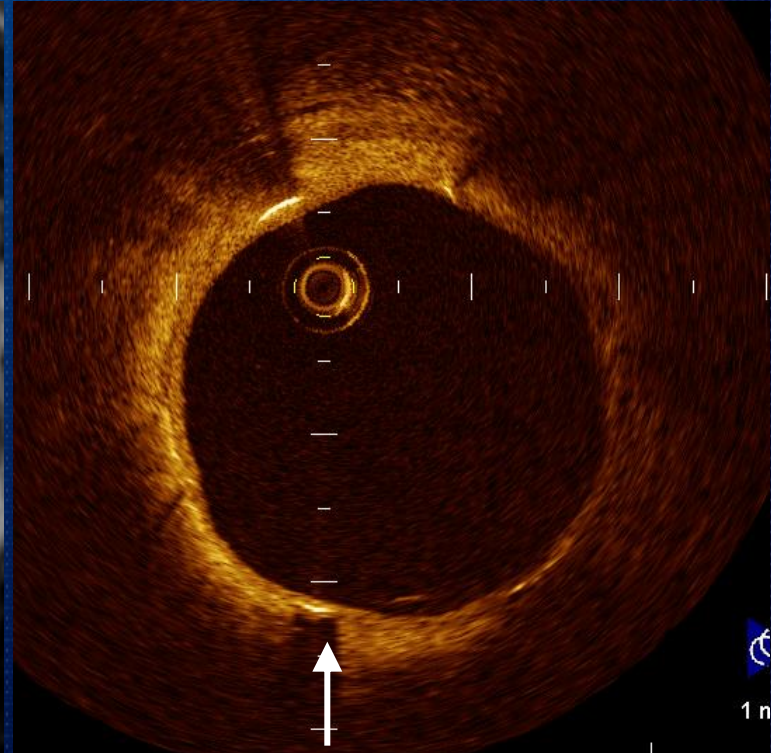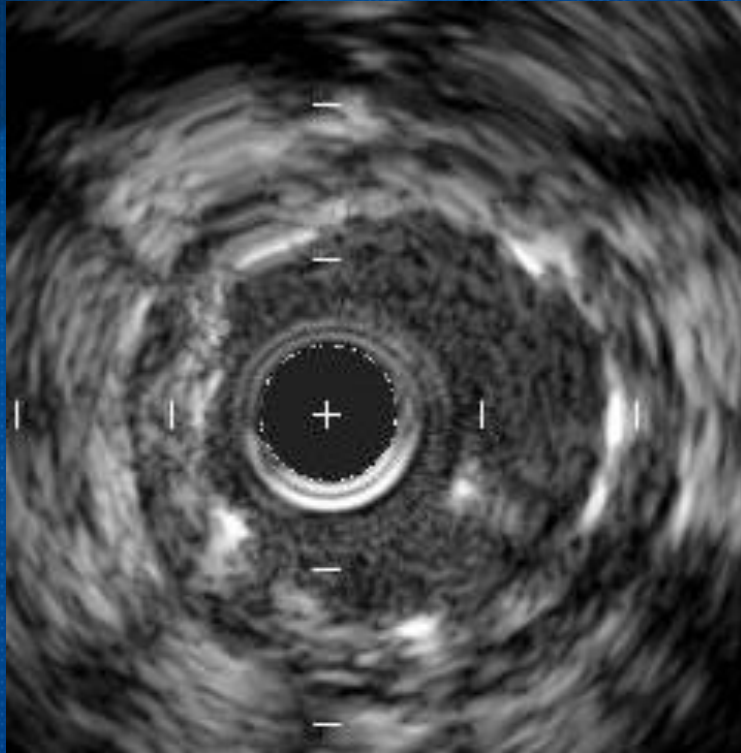
Post-stent follow up
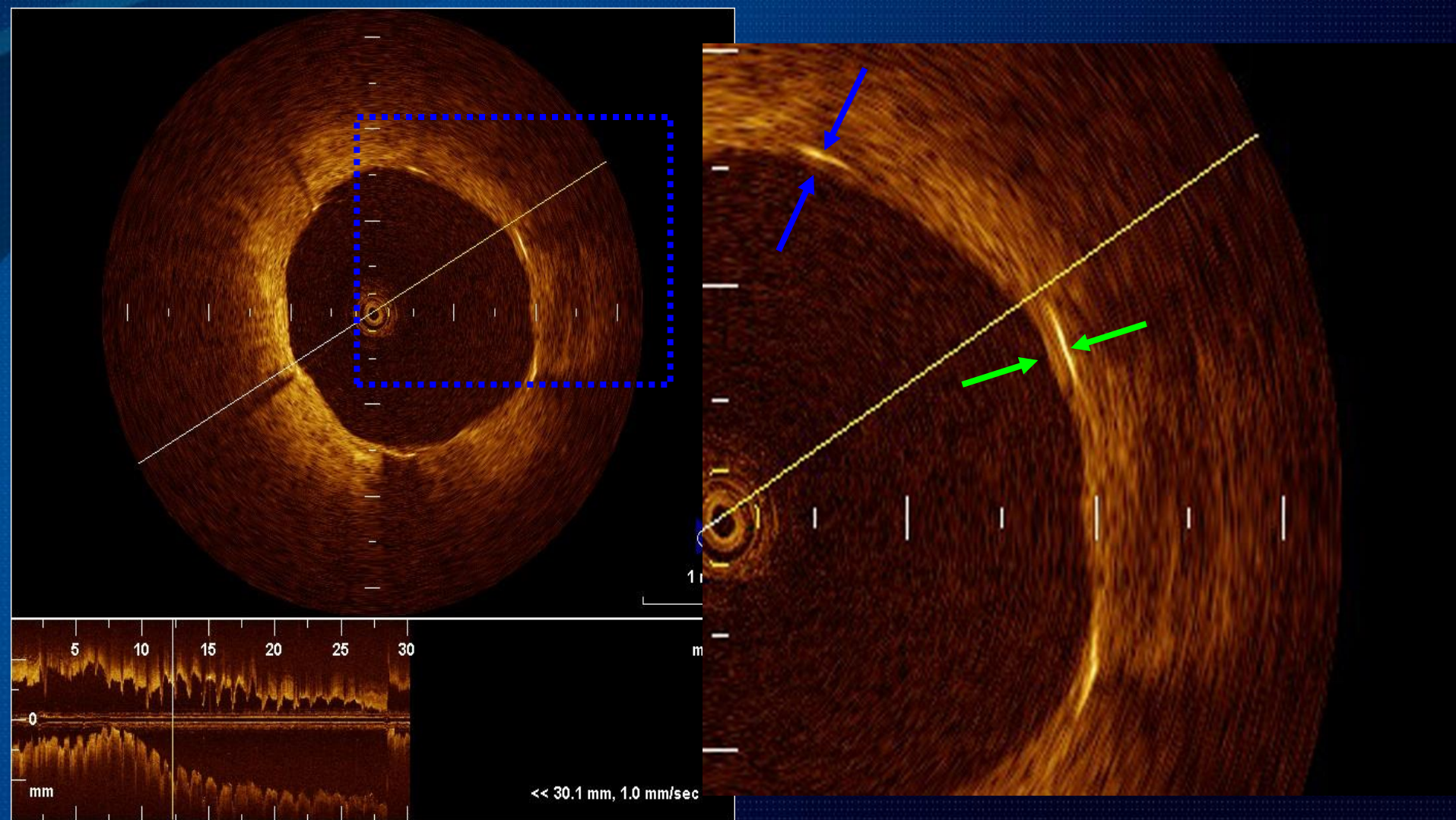
Various OCT images of acute impacts after stent implantation
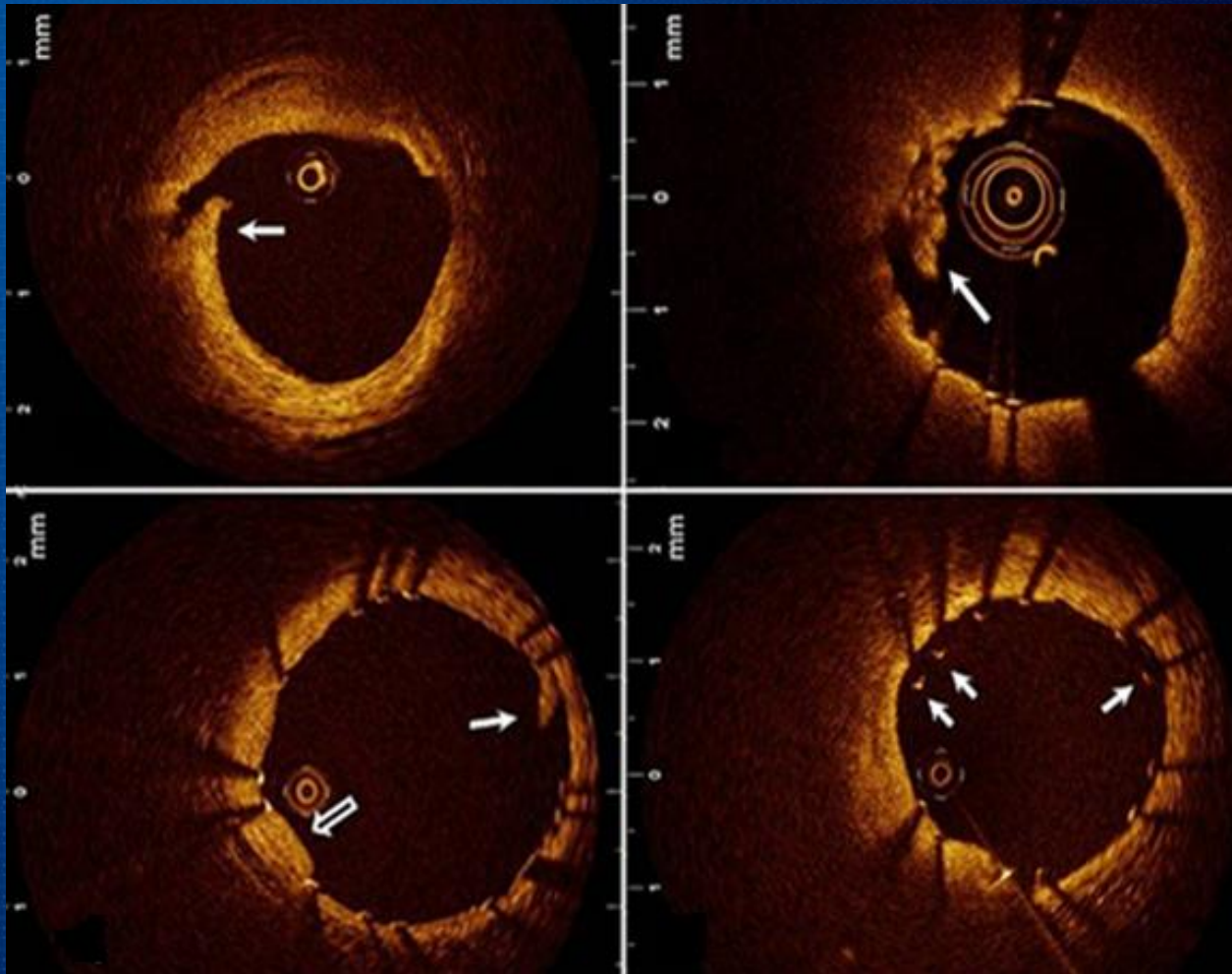
OCT Findings Post Stenting
Incidence of periprocedural vessel trauma
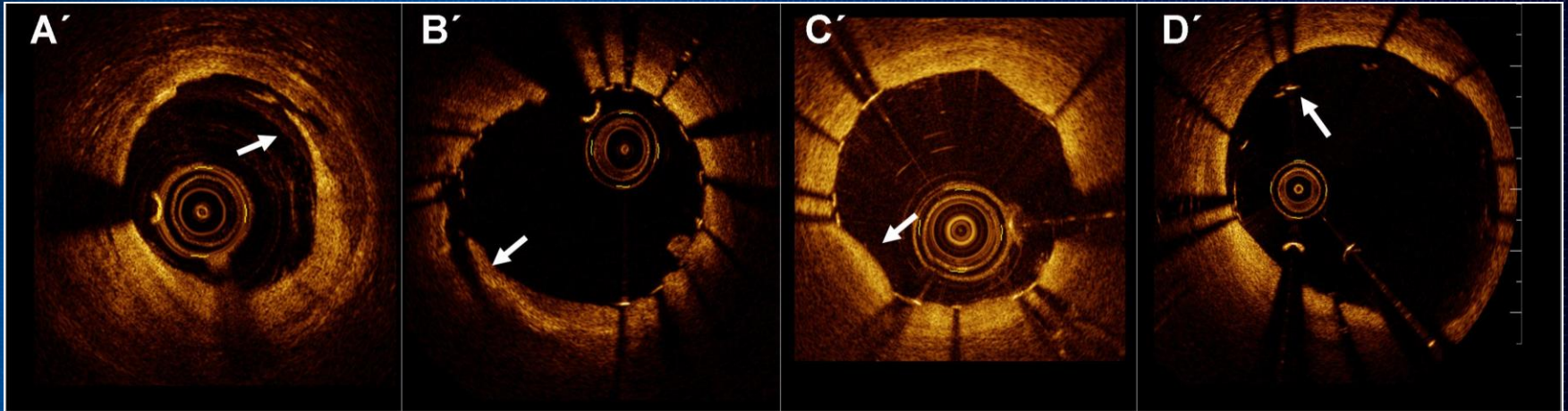
Edge dissection	Intra-stent dissection	Tissue prolapse	Strut malapposition
26.0%	**87.5%**	**97.5%**	**65.5%**

Gonzalo N et al., Heart 2009

Comparison of OCT and IVUS Findings Post Stenting

Bouma, Jang, Heart 2003
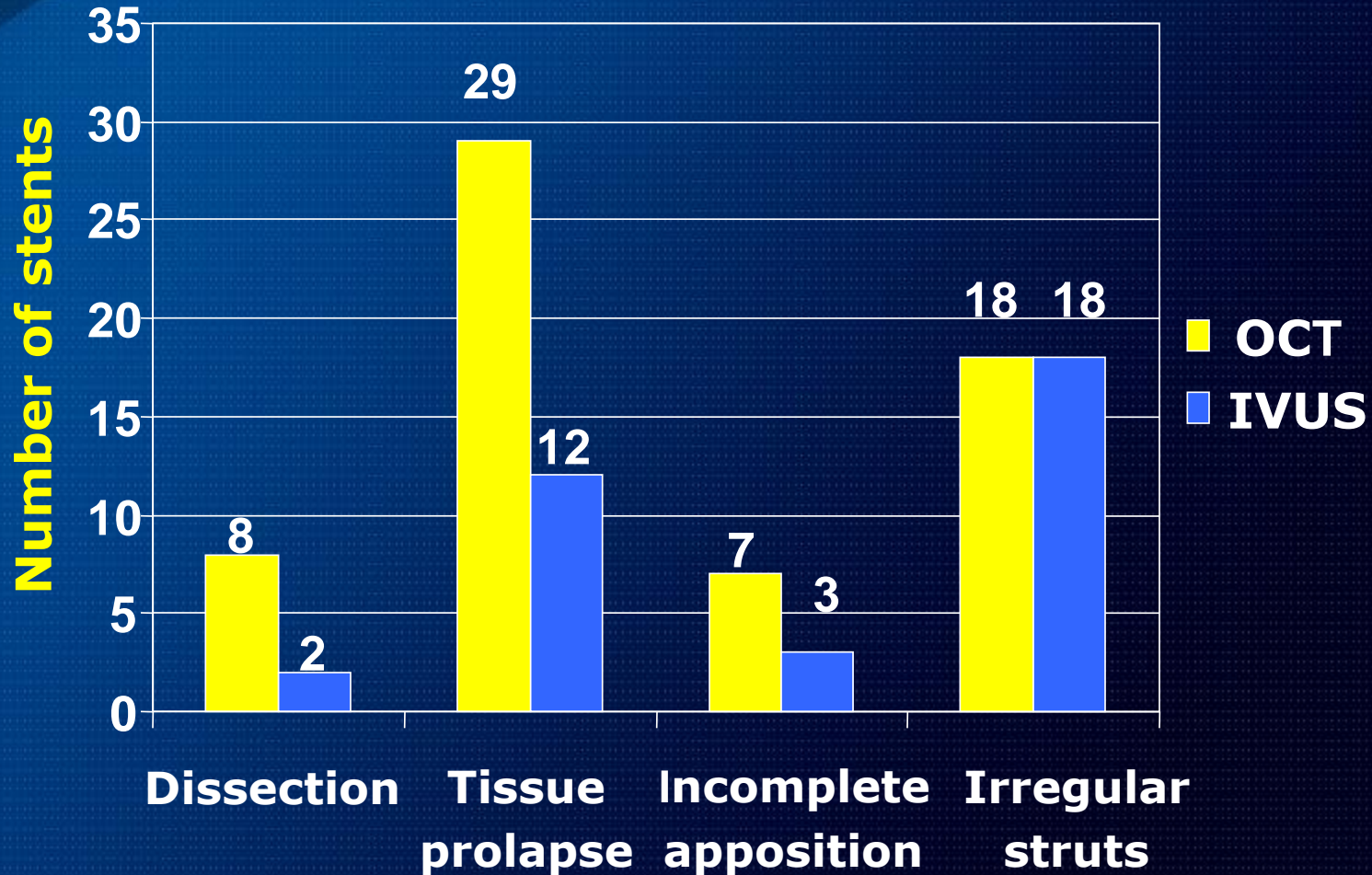
Thin-cap fibroatheroma (TCFA)
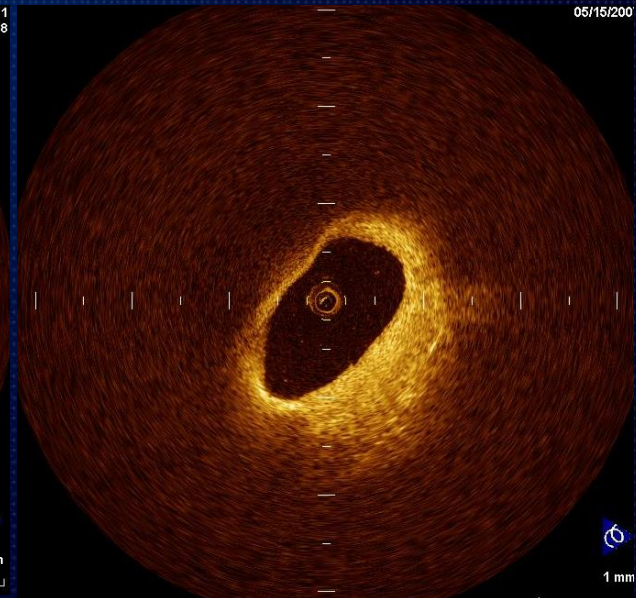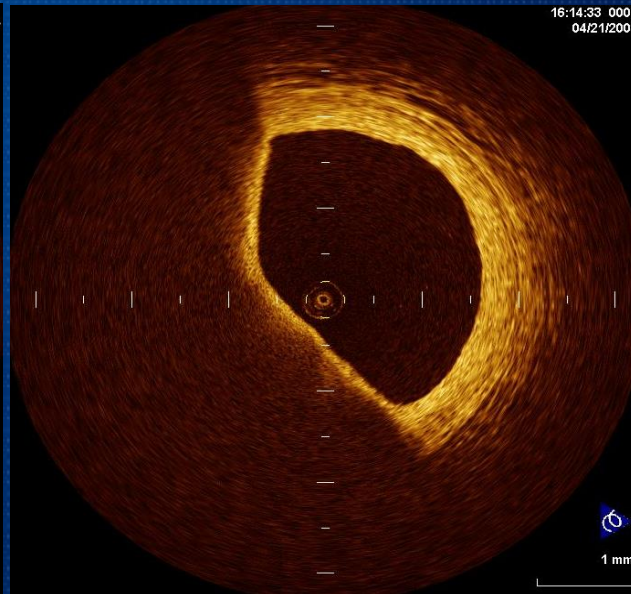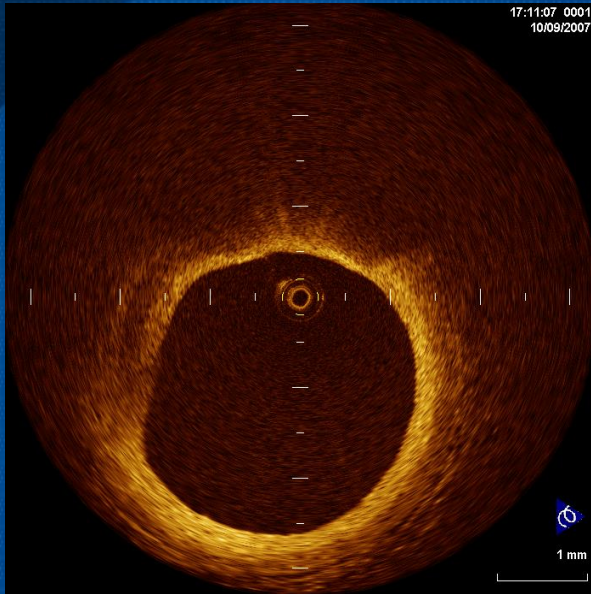
IVUS Advantages and Disadvantages

– Assessment of lumen, vessel wall and adventitial border

– Well validated

– Golden standard

– High amount of well documented clinical data showing impact on clinical outcome

– Established indications

Mintz GS et al. J Am Coll Cardiol. 2001 Apr;37(5):1478-92

OCT Advantages and Disadvantages

- There is a large body of data demonstrating OCT sensitivity, specificity and reproducibility
  - To differentiate plaque type
  - To identify thin cap fibroatheroma
  - To assess stent strut apposition
 - To assess vascular response after PCI

OCT Advantages and Disadvantages

- In vivo image interpretation is easy, but might be hampered
  - Artifacts
  - Limited penetration depth and resolution
 - Morphology does not always allow direct conclusions on function

OCT Advantages and Disadvantages

• The clinical importance and the prognostic value of OCT findings need further evaluation.

• Need for standardization
  • Image display
  • Imaging protocol
  • Image interpretation
  • Terminology
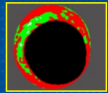 • Qualitative & quantitative analysis
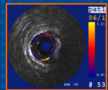
Intravascular Diagnostic Tools
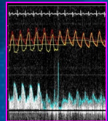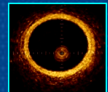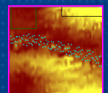

CFR / FFR
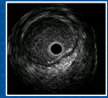
IVUS

IVUS Echogenicity

IVUS Tissue Characterisation (VH; I – Lab)

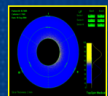IVUS Palpography

Optical Coherence Tomography

NIR Spectroscopy

Intravascular MRI

Function

Gross morphology

Microstructure

Chemical composition
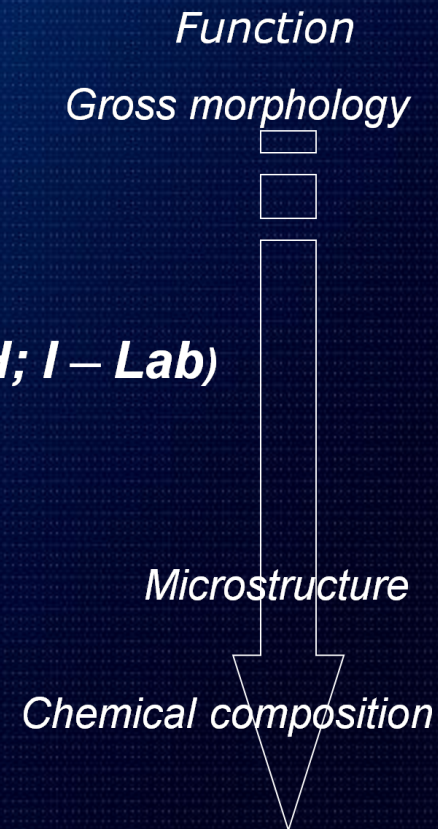
No single modality can identify all of the relevant characteristics of coronary plaques.

Thank you for your attention !