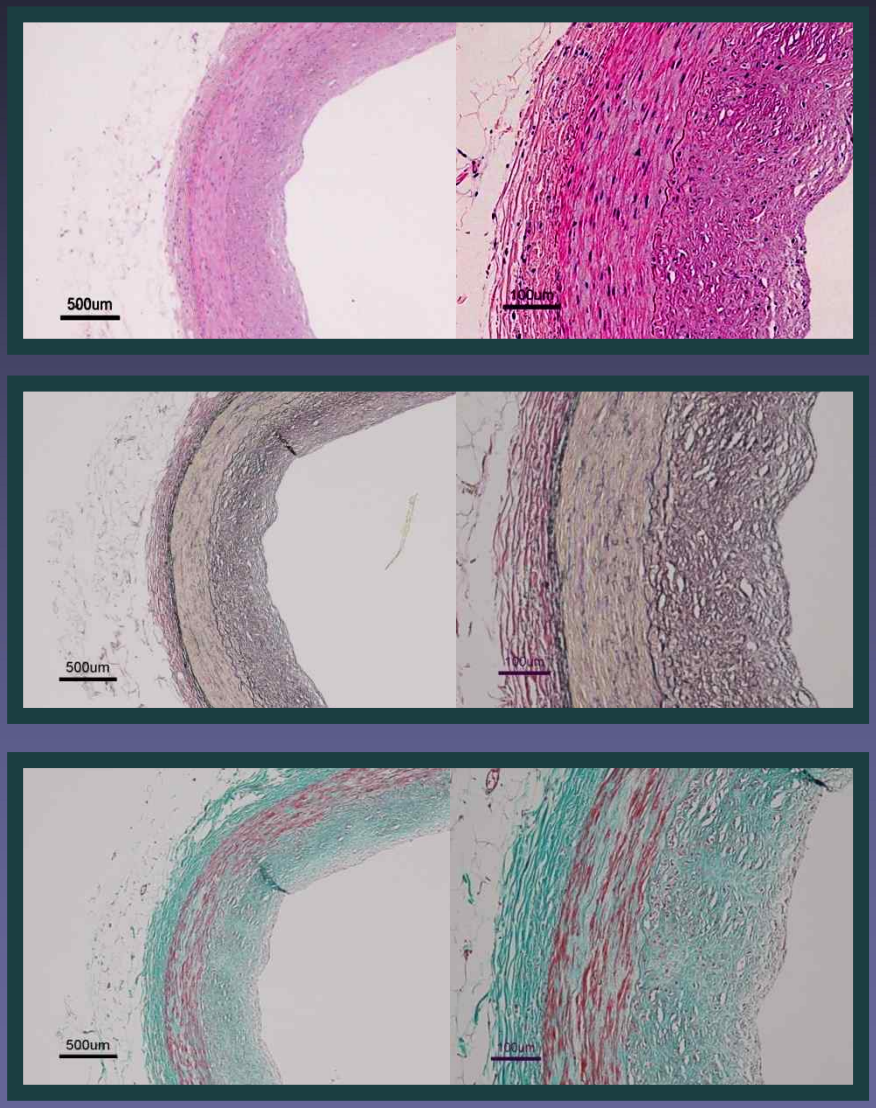

OCT better than IVUS & VH ?
Severance Hospital Cardiac Intervention Room
BAIK, SUNG IL

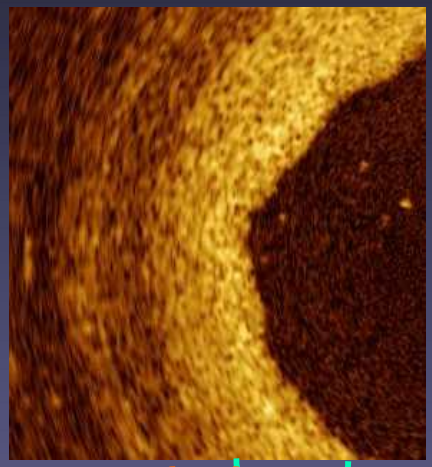
What is Optical Coherence Tomography?

OCT is a high-resolution imaging technology that employs near-infrared light to probe micrometer-scale structures inside biological tissues.

I. Introduction of OCT image

Coronary Artery：three layer

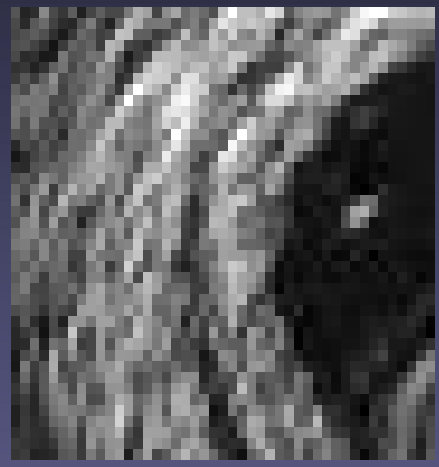




media

intima

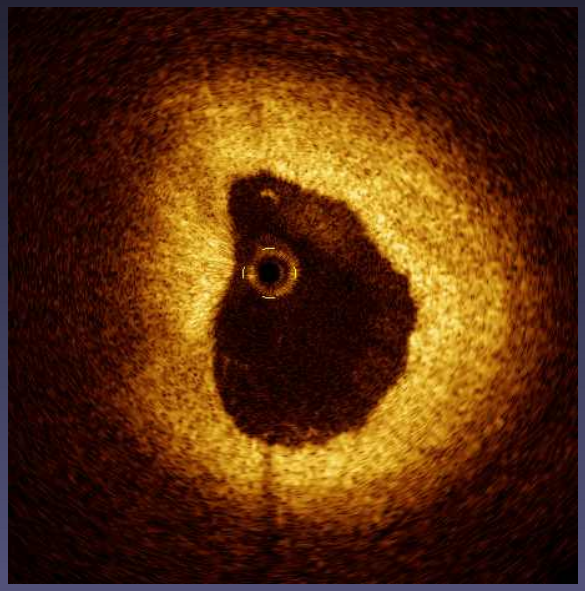
adventitia



adventitia

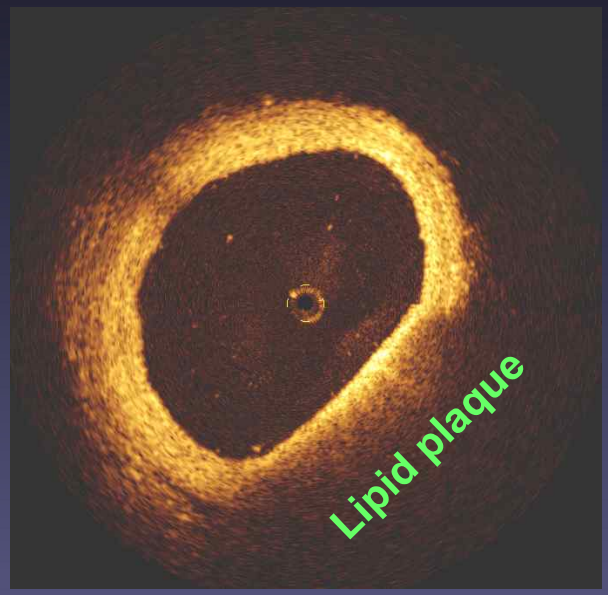
intima-media complex

OCT plaque imaging: Summary



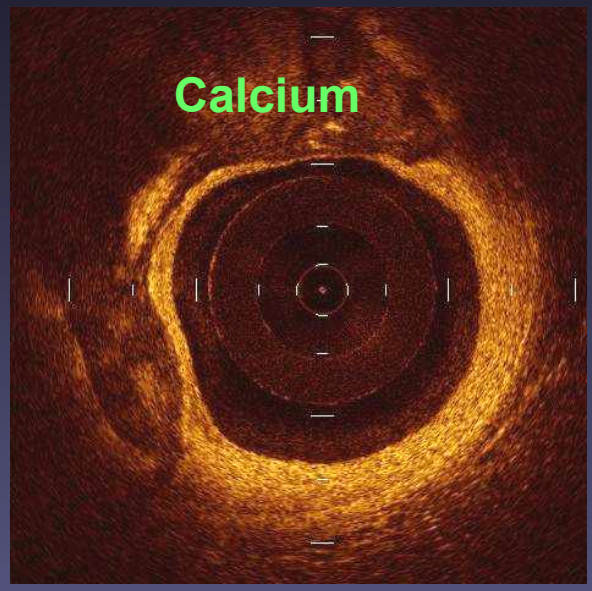
Fibrous

- High reflectivity
- Homogenous
- Finely textured



Lipid

- Low reflectivity
- Homogenous
- Diffuse margins

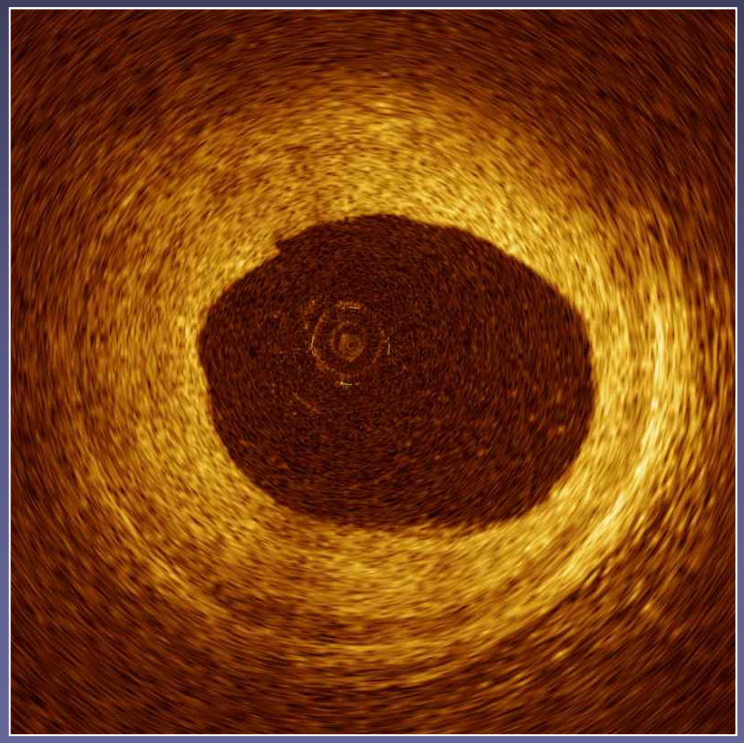


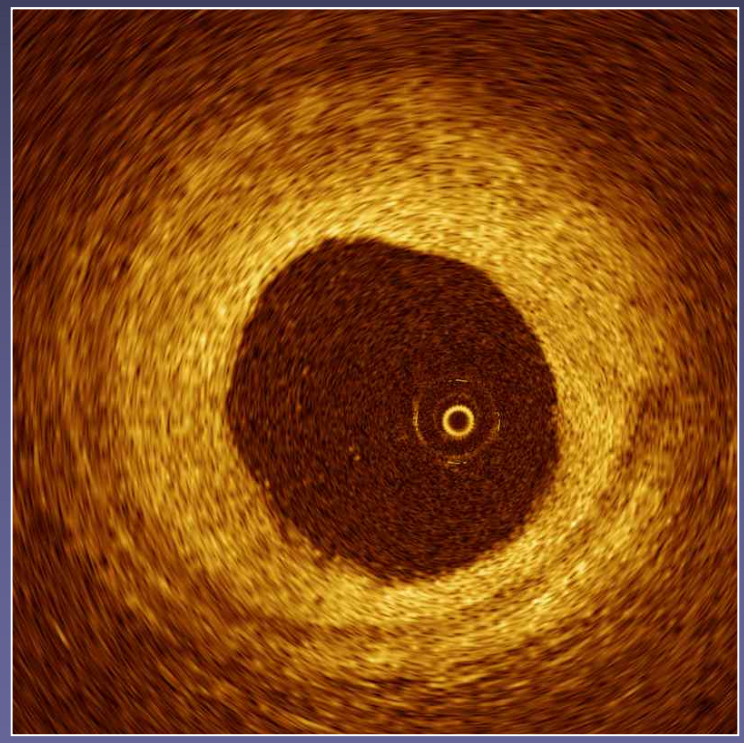
Calcium

Low reflectivity

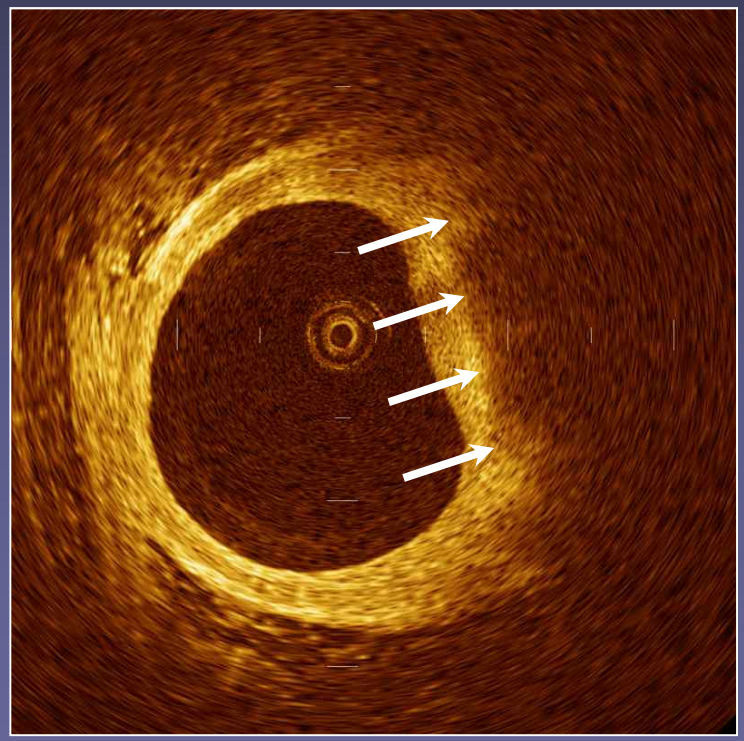
- Inhomogenous
- Sharp margins

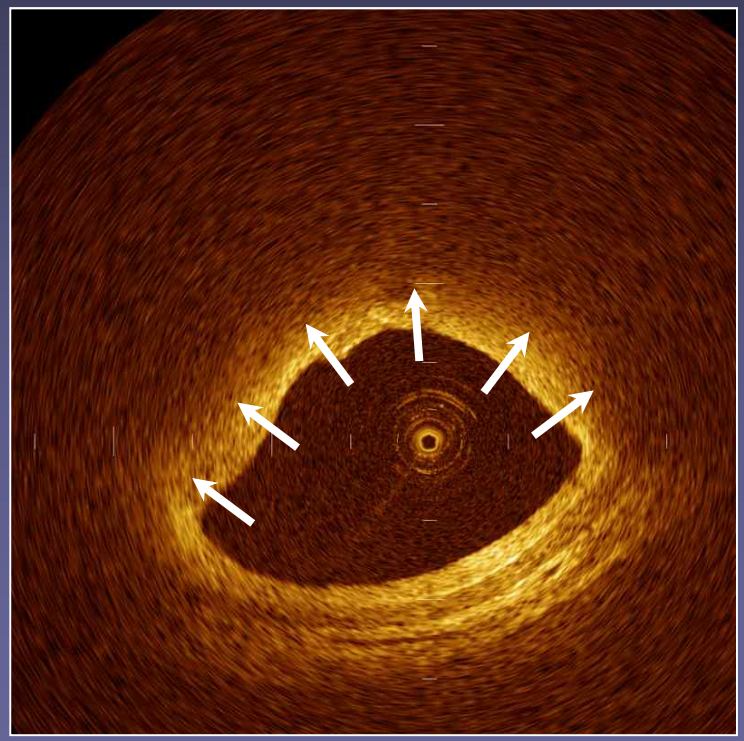
Fibrous plaque



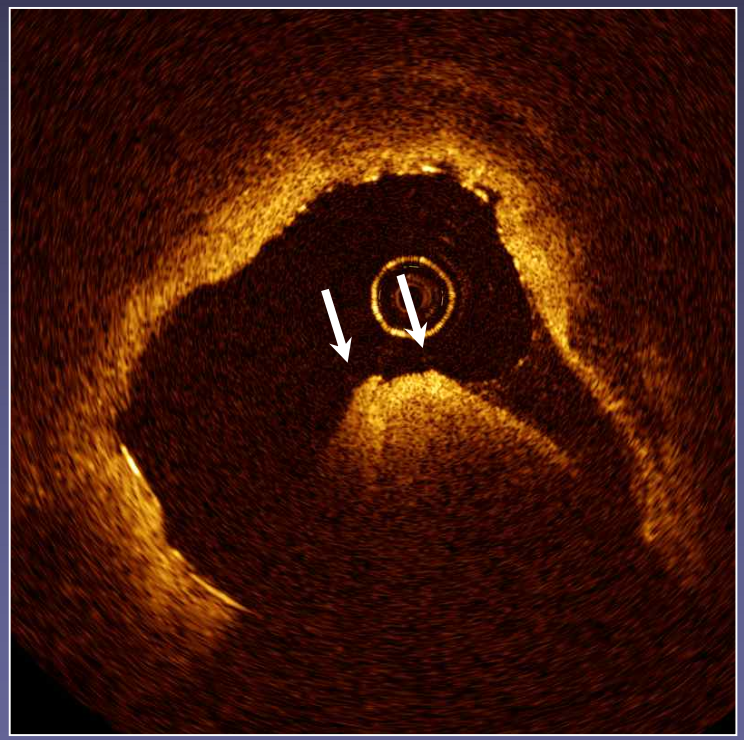


Lipid rich plaque

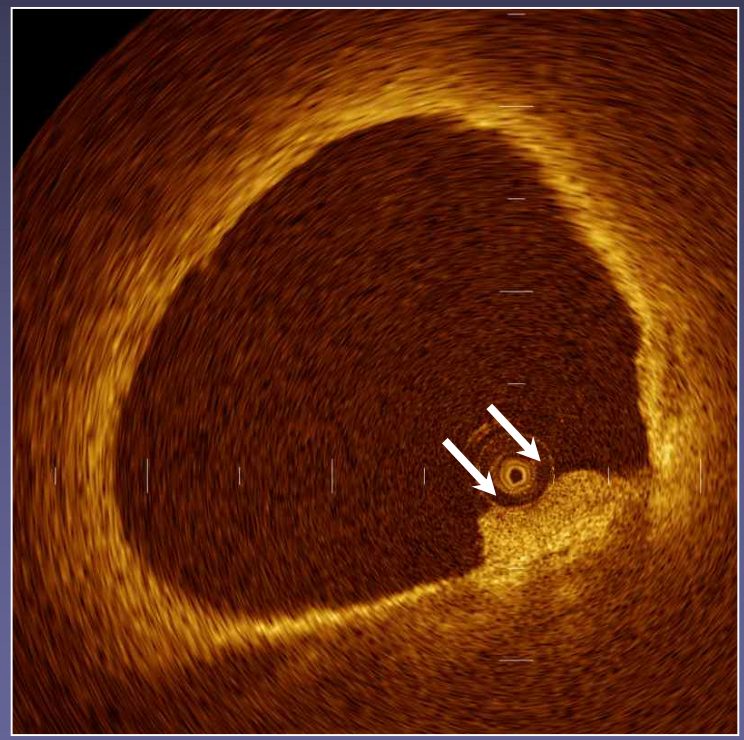




White and Red Thrombus

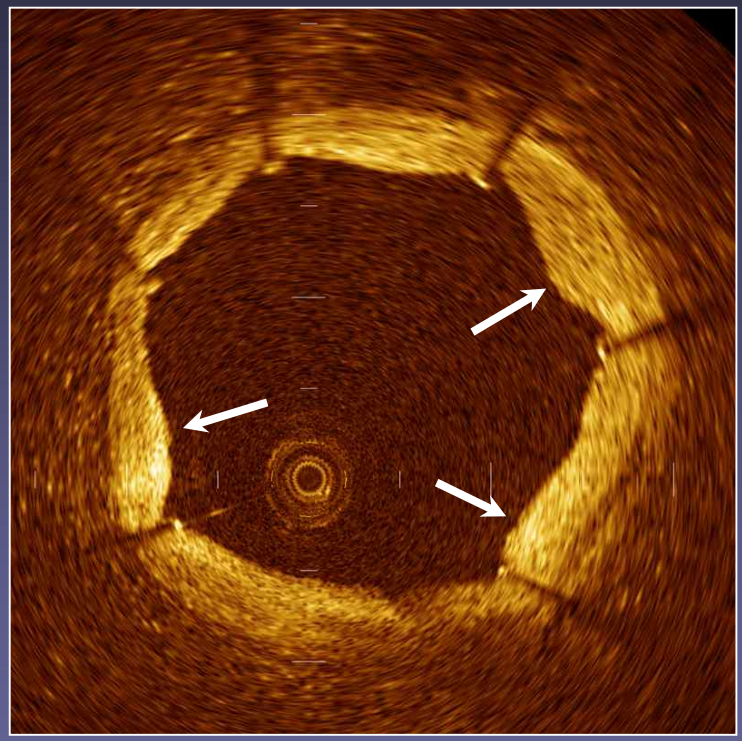


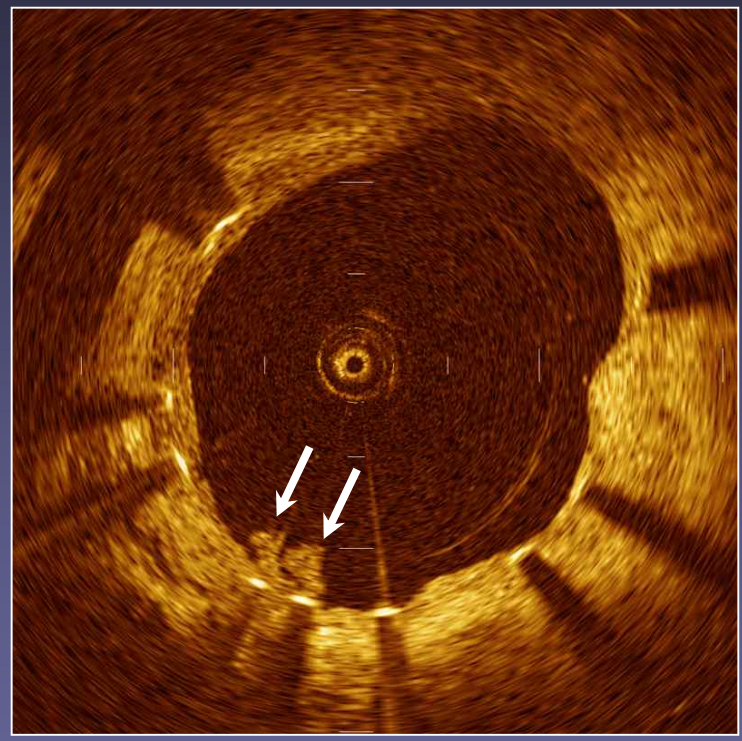
Red Thrombus



White Thrombus

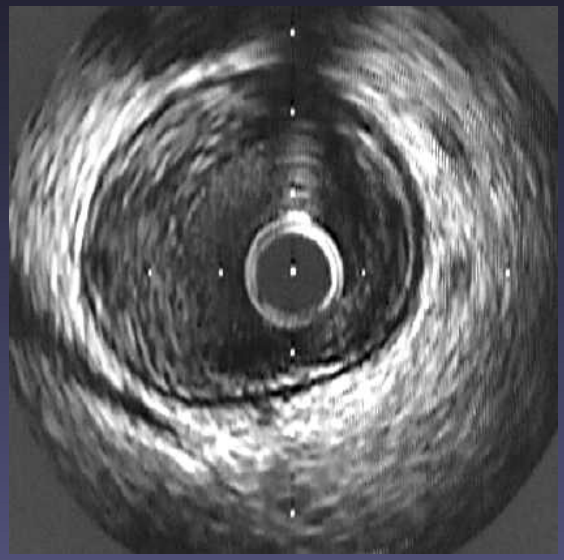
Thrombus In Stent



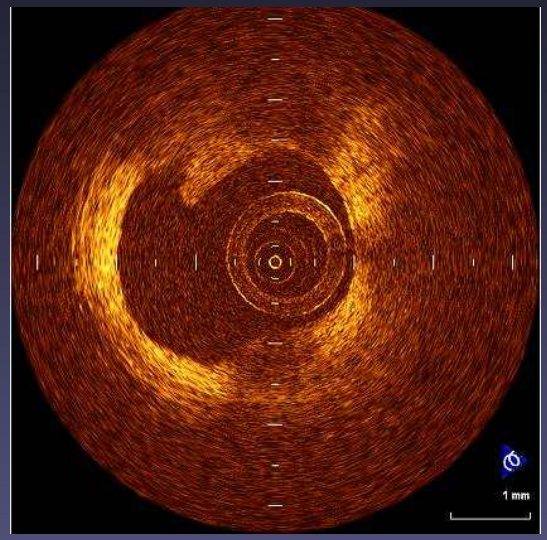


White thrombus in stent

Ruptured plaque 1

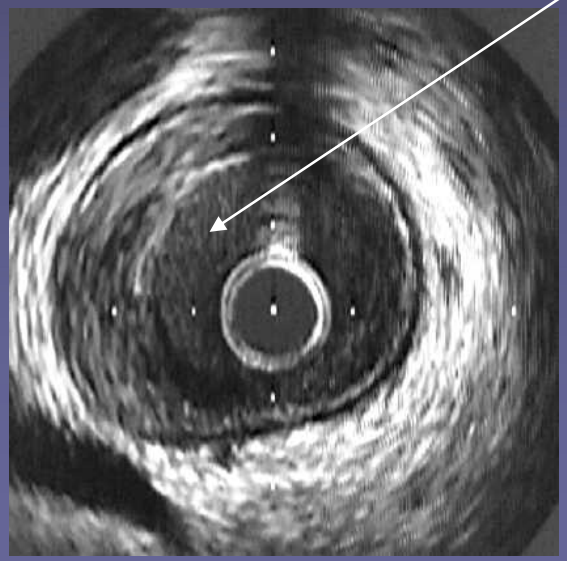


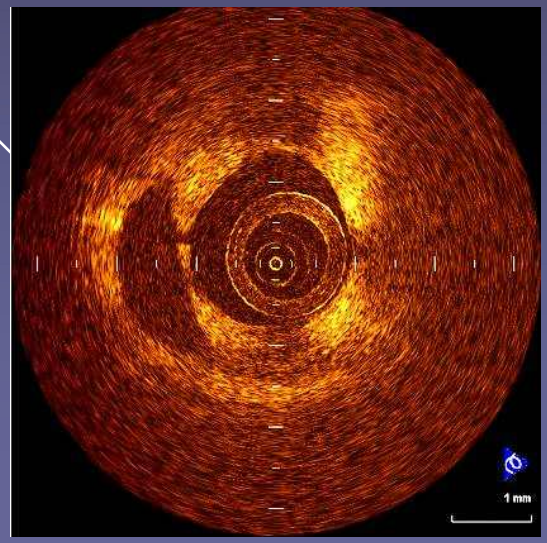
Proximal



Fibrous cap ???

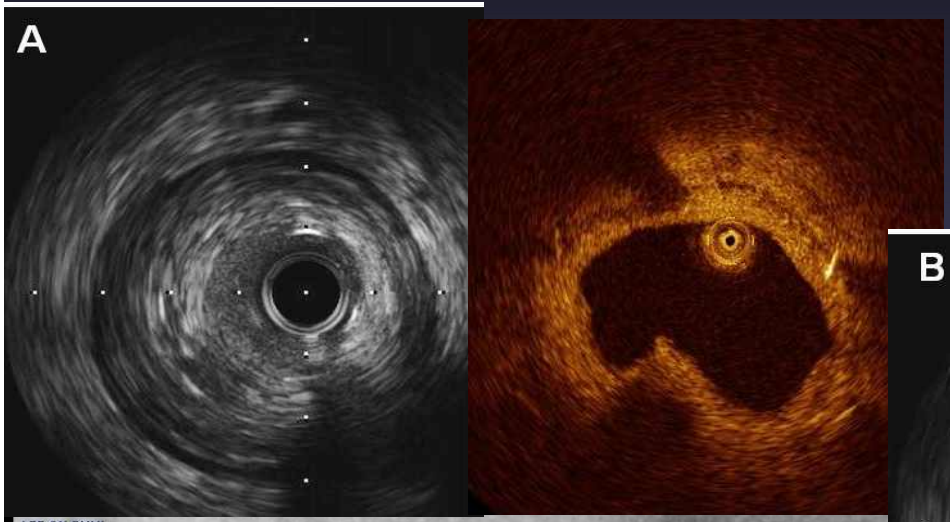
Fibrous cap !!!!

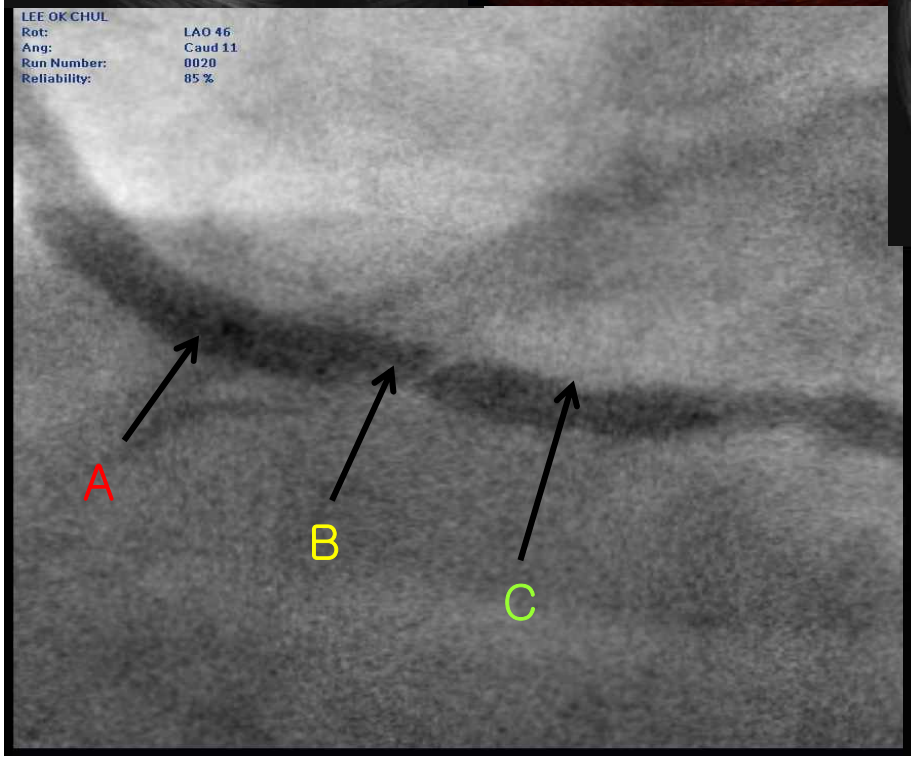


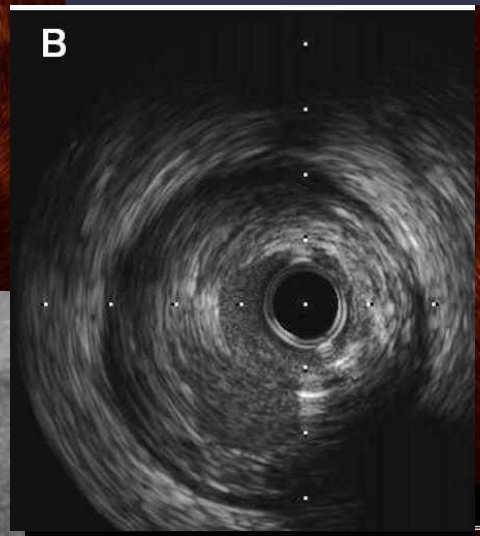


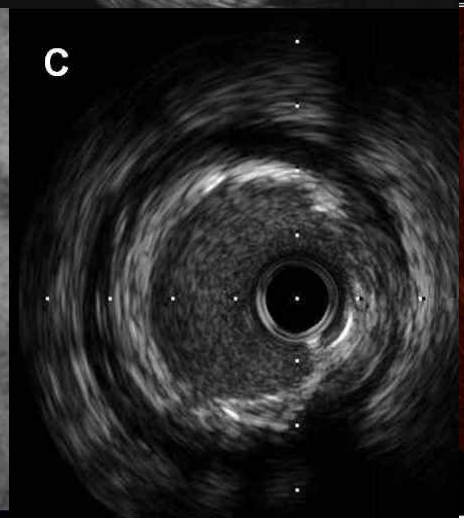
Distal

Ruptured plaque in stent 2

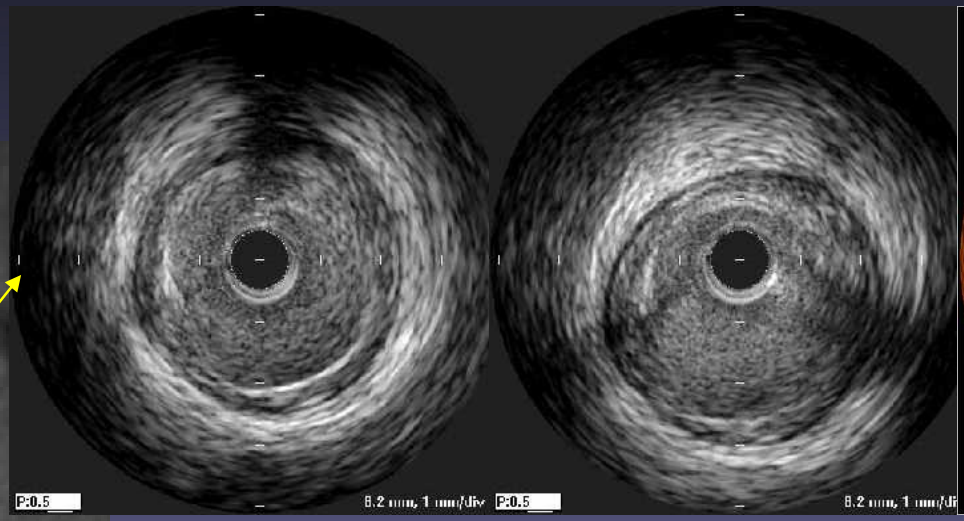


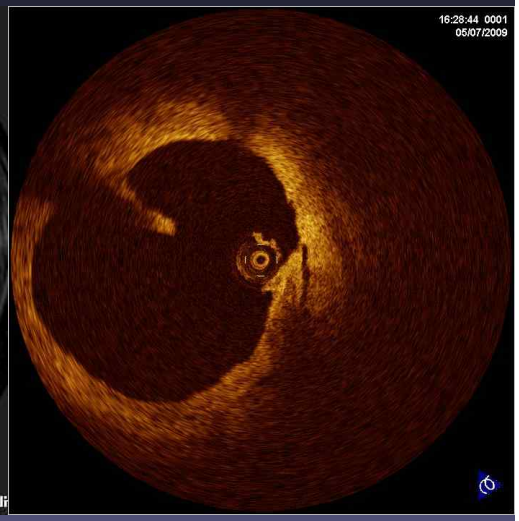






Dissection

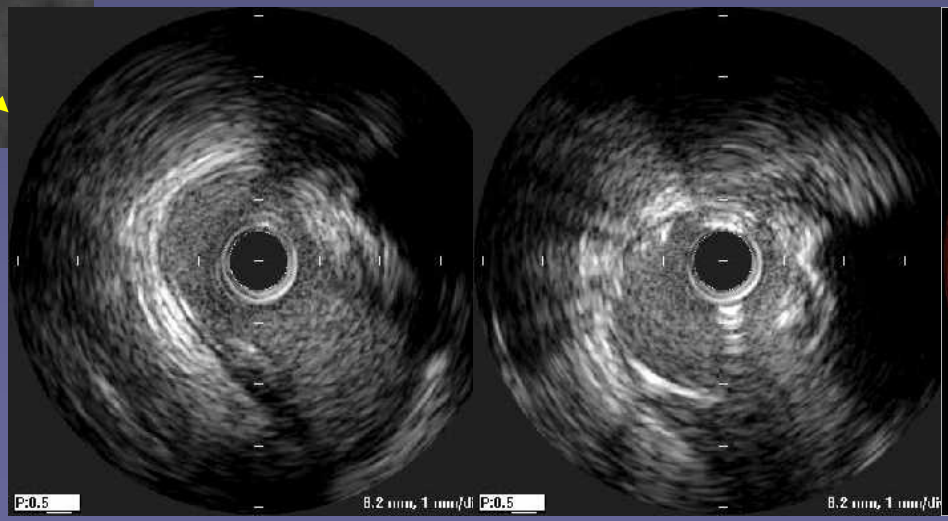


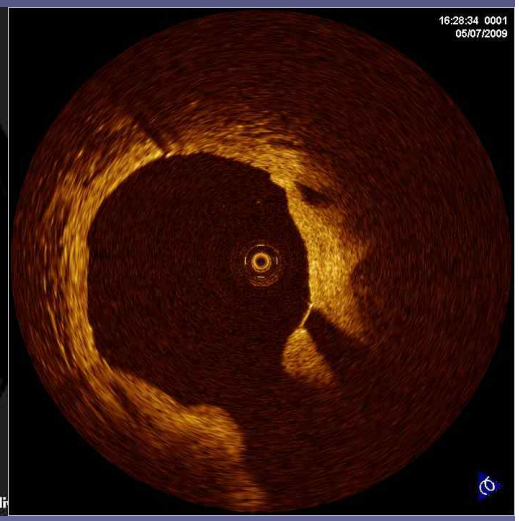


Pre STENT-IVUS

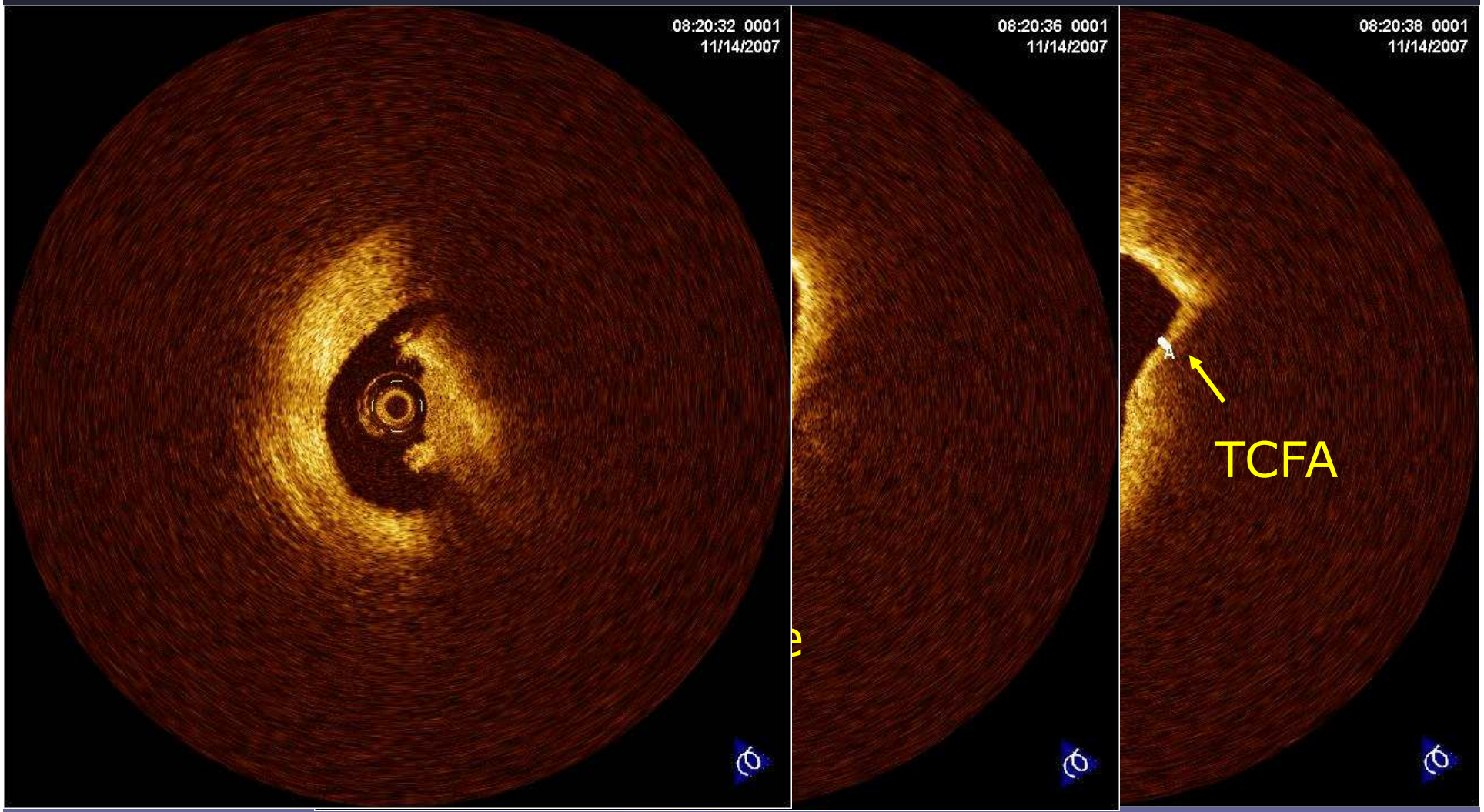
Post STENT-IVUS

Post STENT-OCT

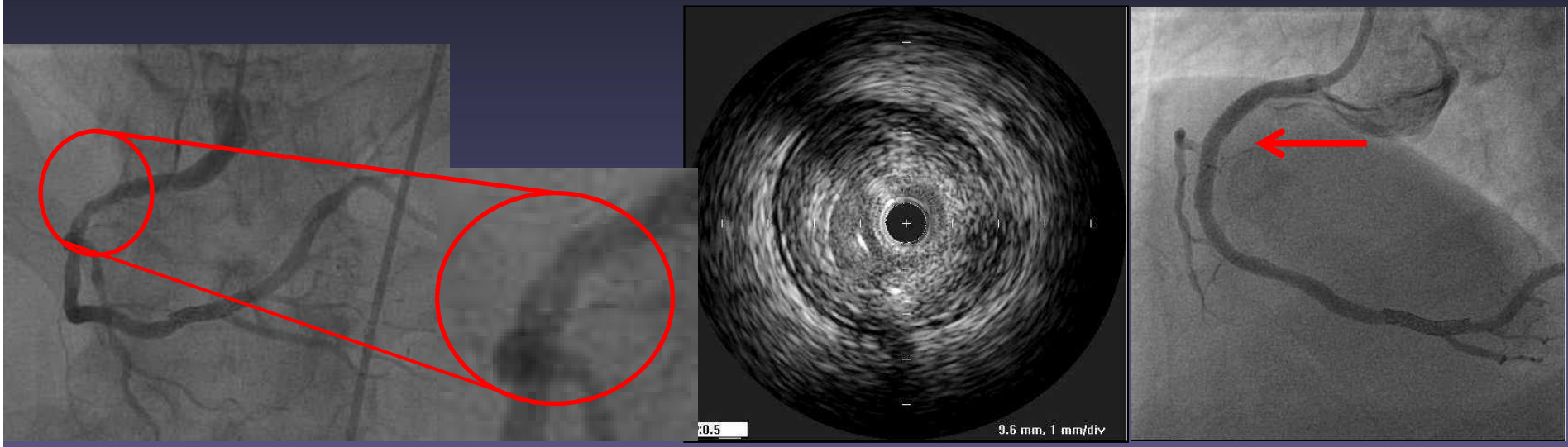




Pre-procedural OCT



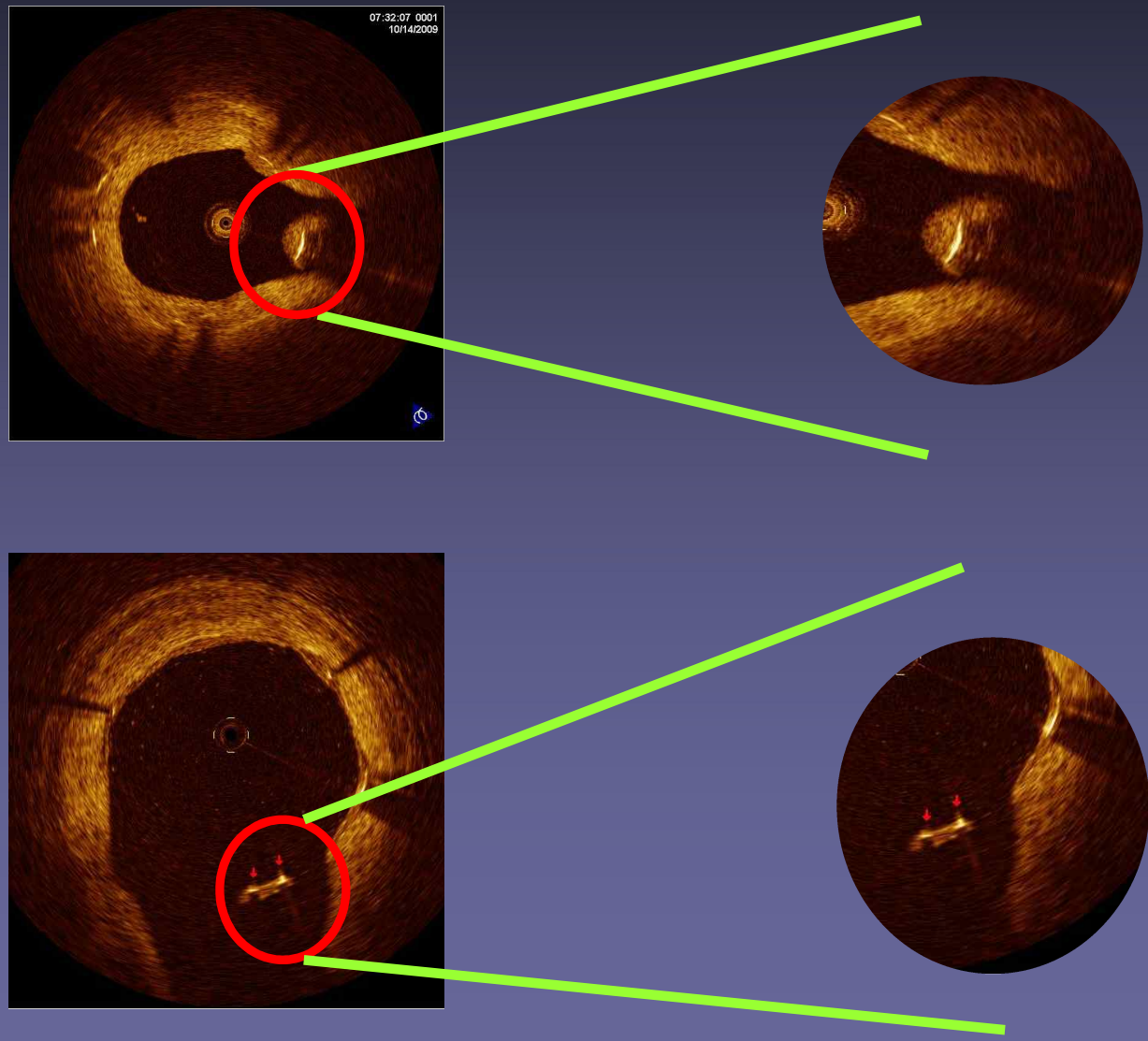
Interesting image 1



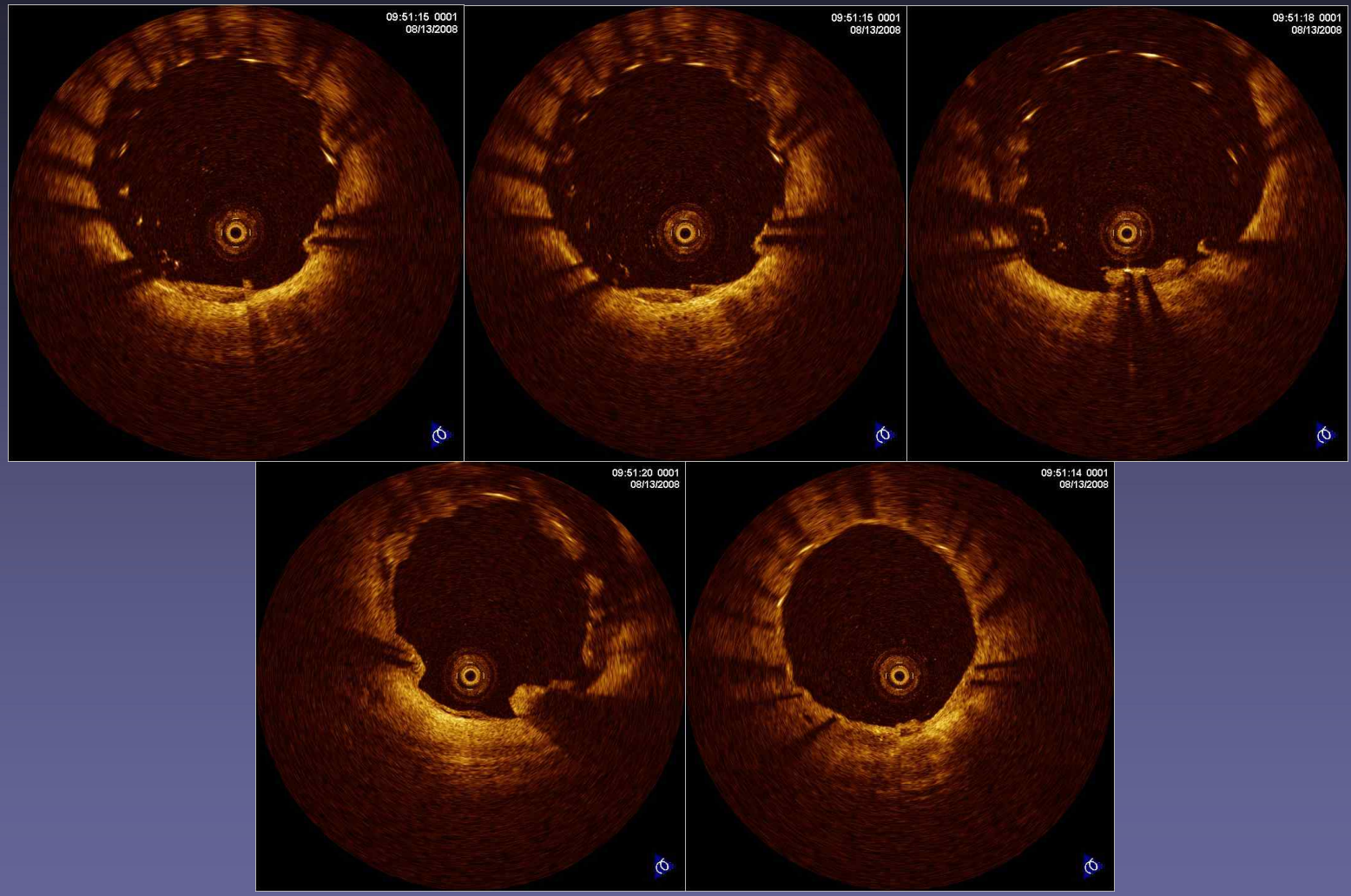
Proximal

Distal

Interesting image 2

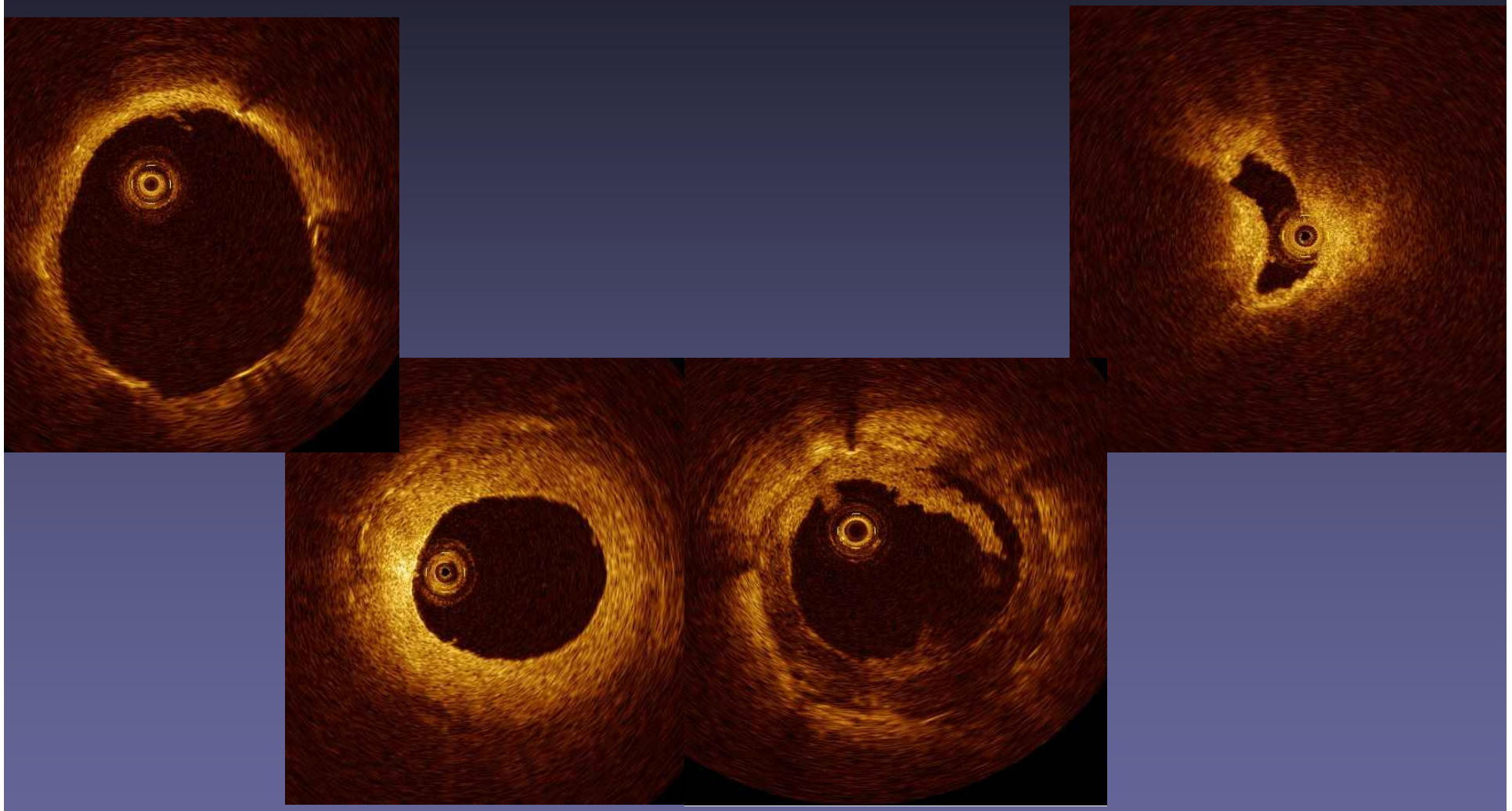


Interesting image 3



Cypher/Taxus stent f/u

Interesting image 4



Cypher stent f/u

Interesting image 5

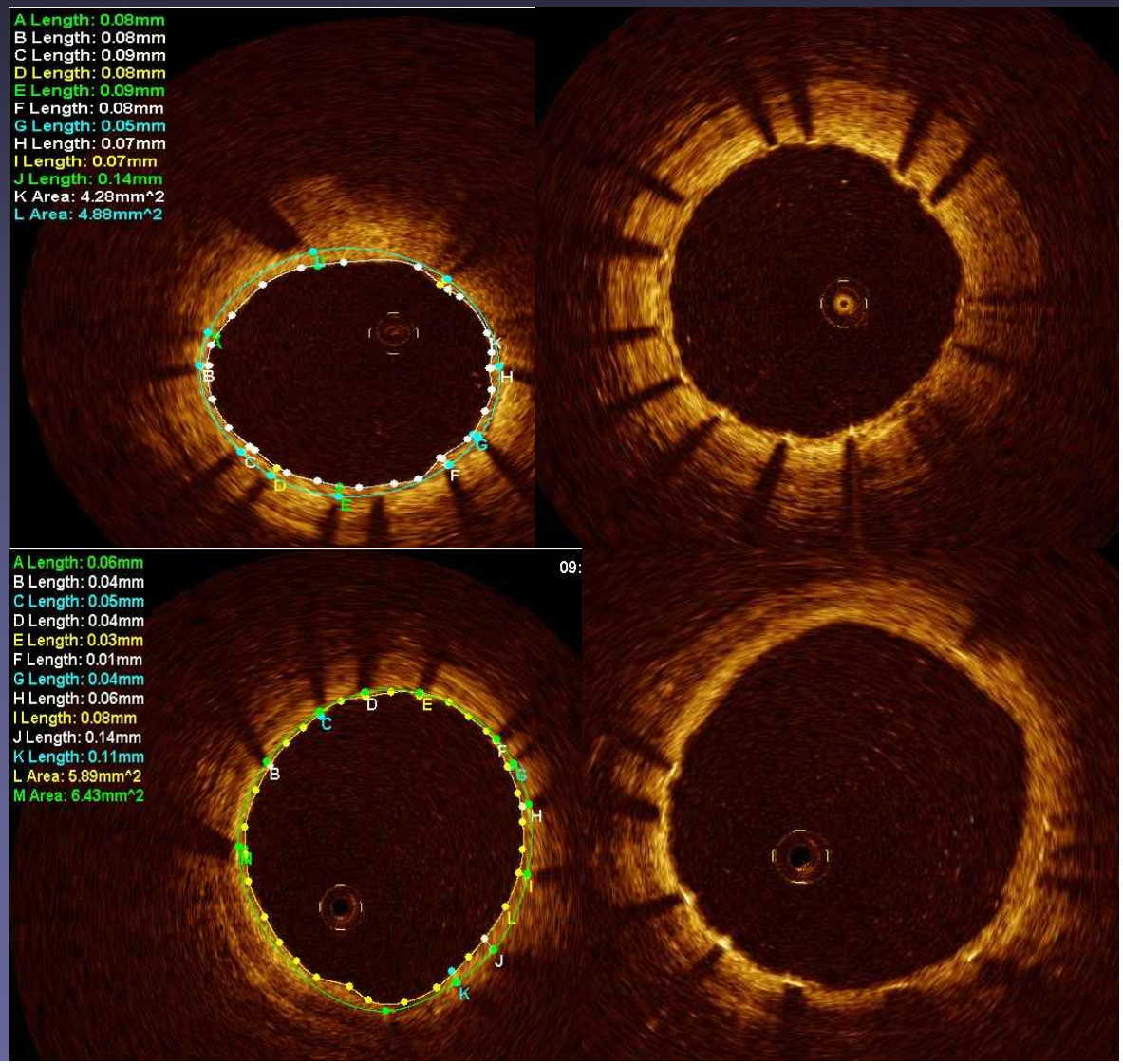
Late loss !

Endeavor sprinter stent f/u

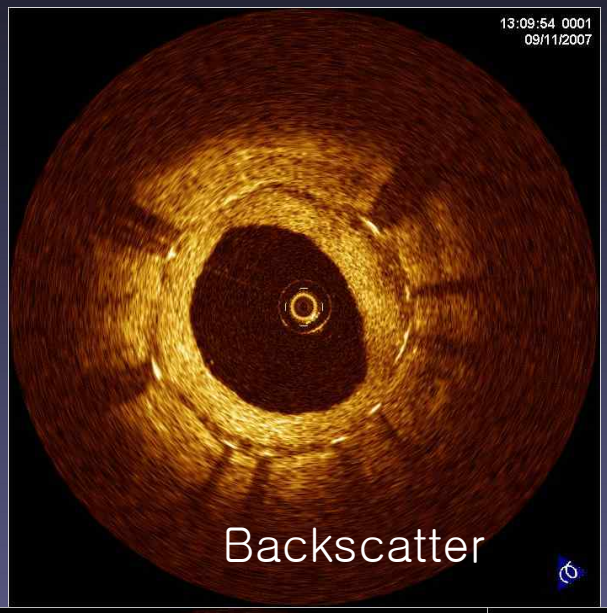
Interesting image 6

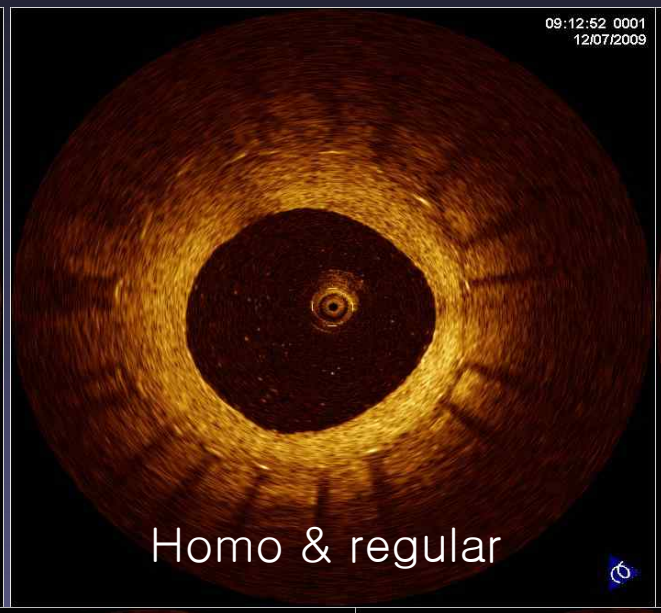
Endeavor Resolute Stent f/u

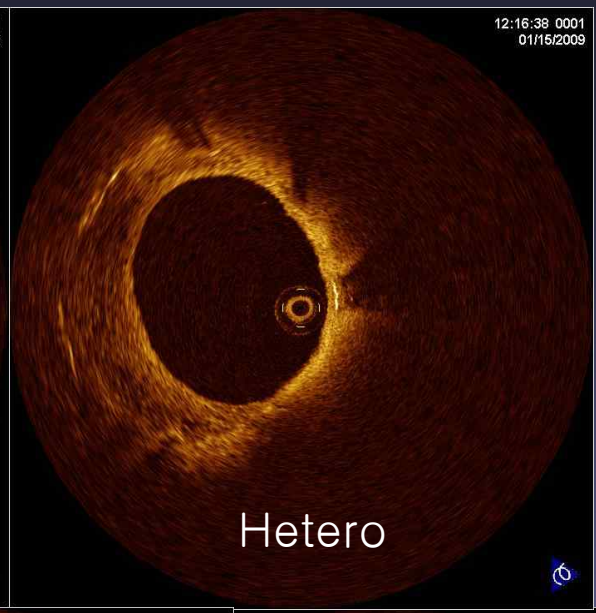
Xience stent f/u

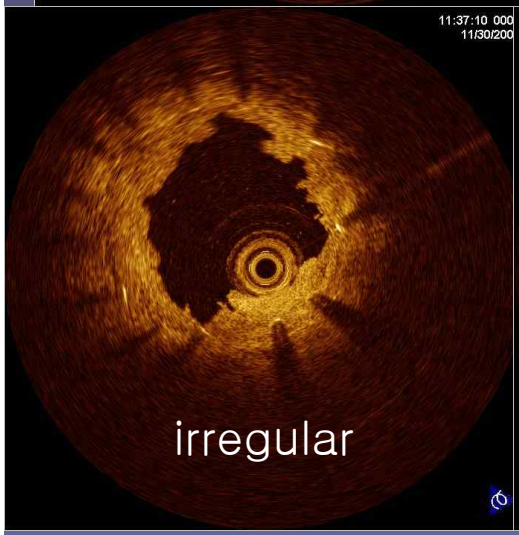


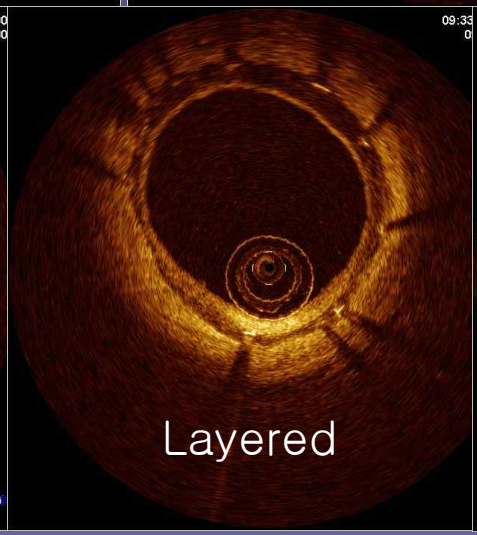
OCT image of Neo-intima

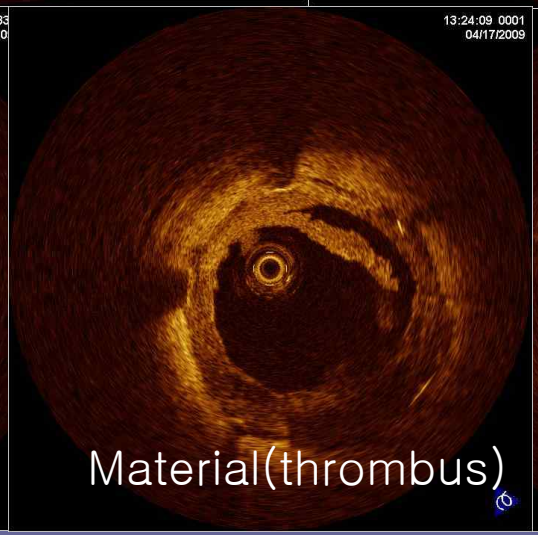


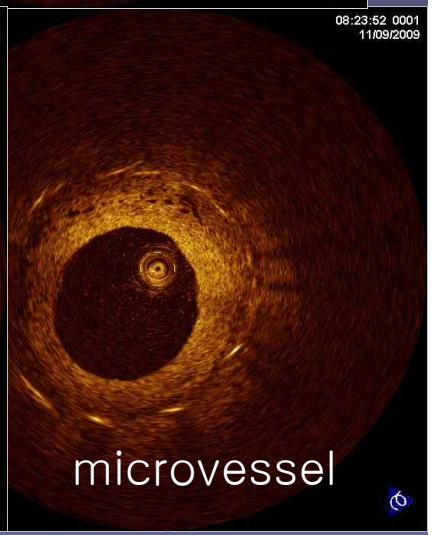






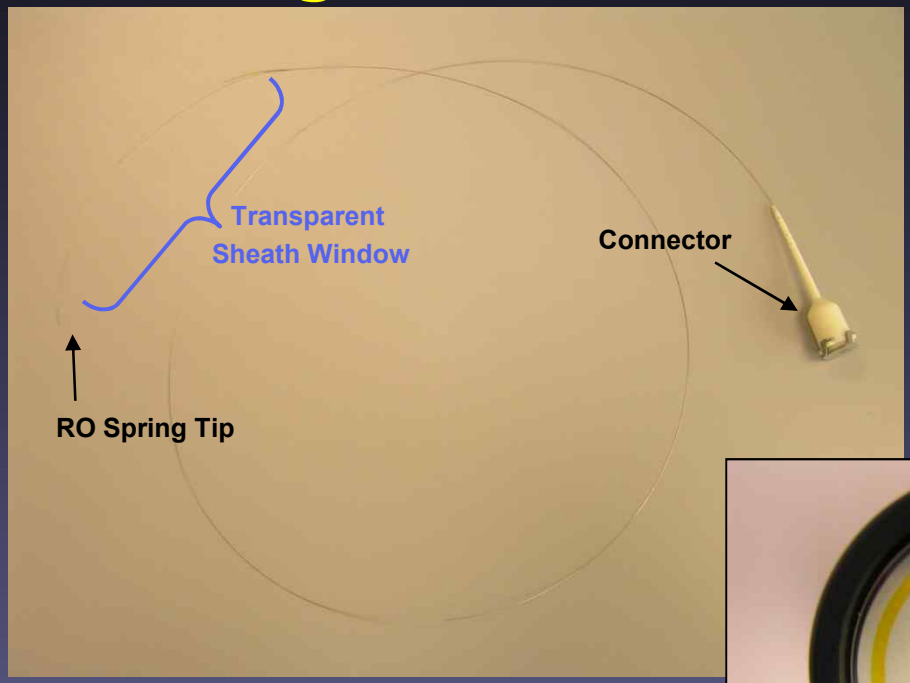






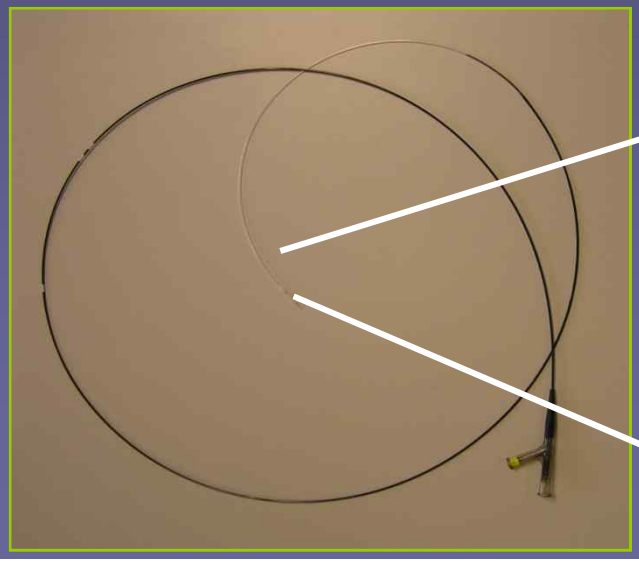
II. Upgrade of OCT equipment

ImageWire

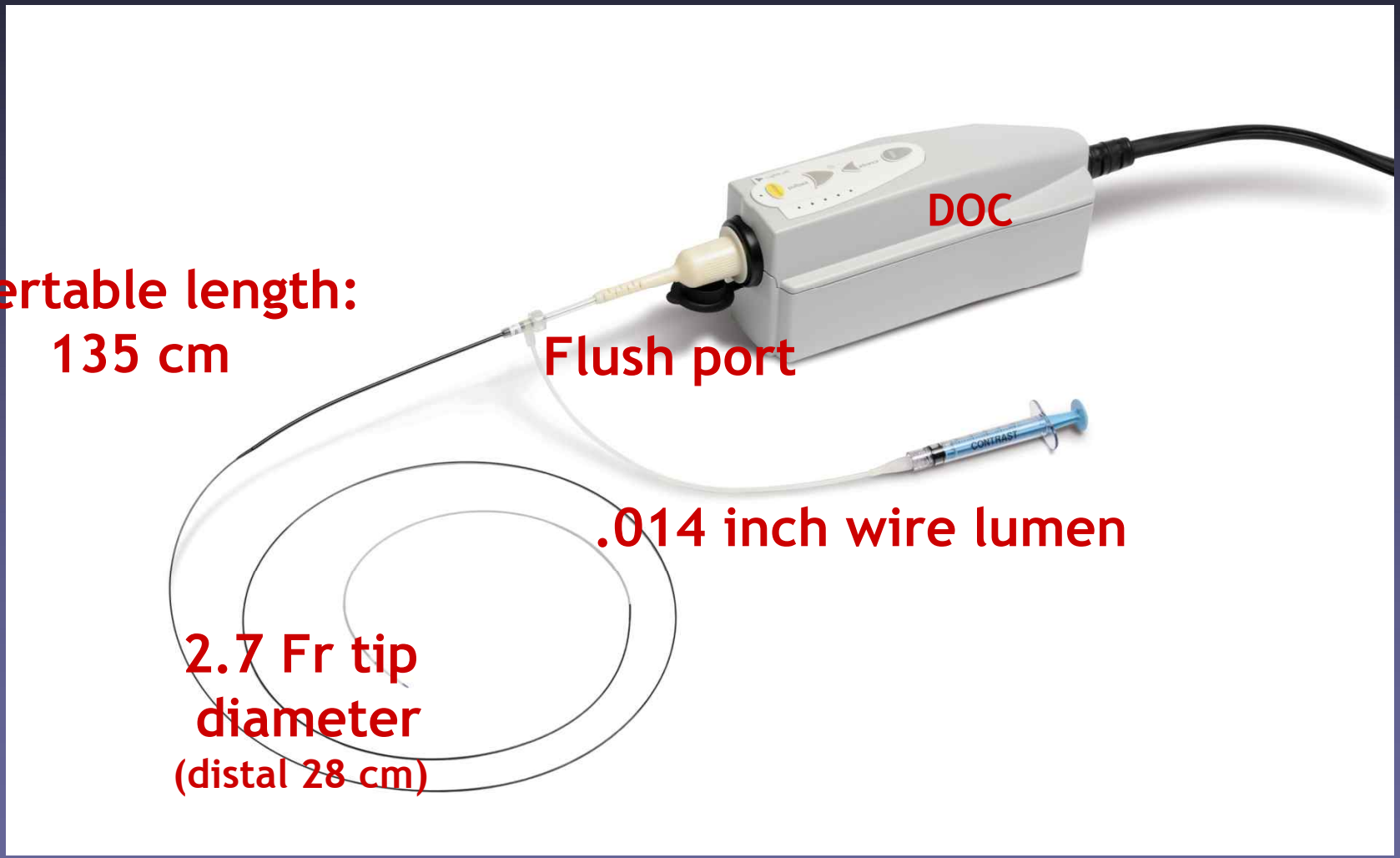


Indeflator LID-1

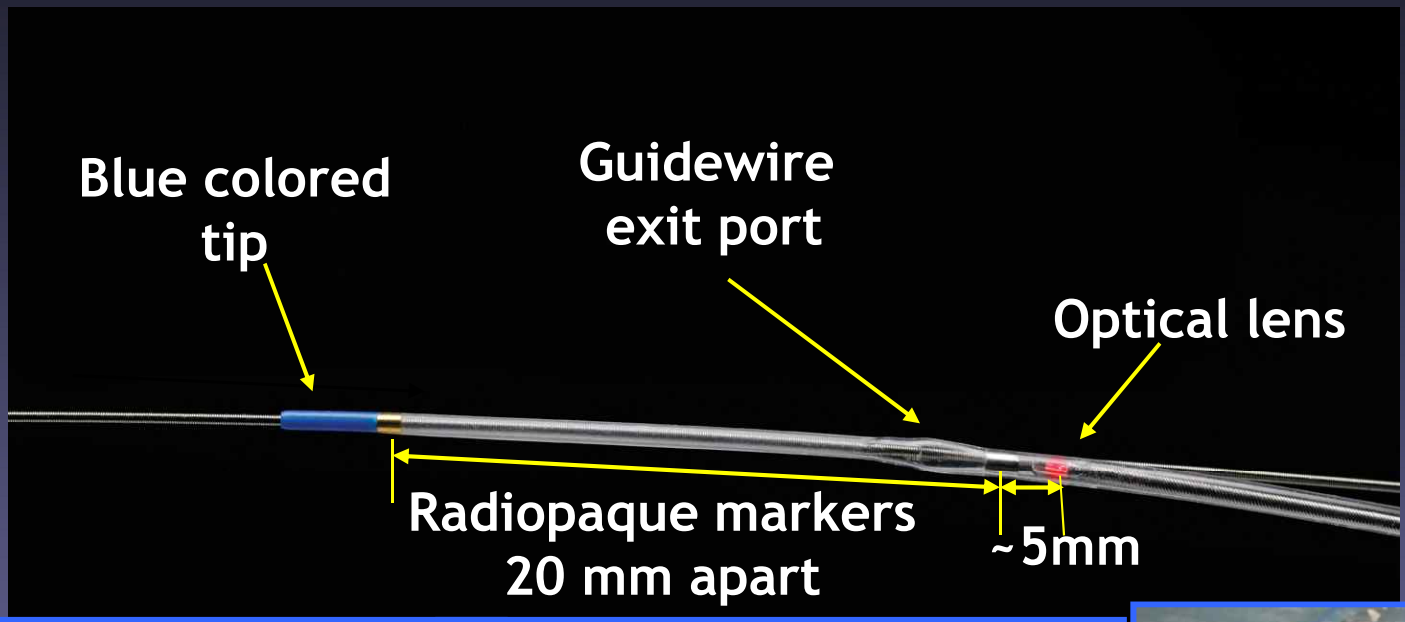
Helios

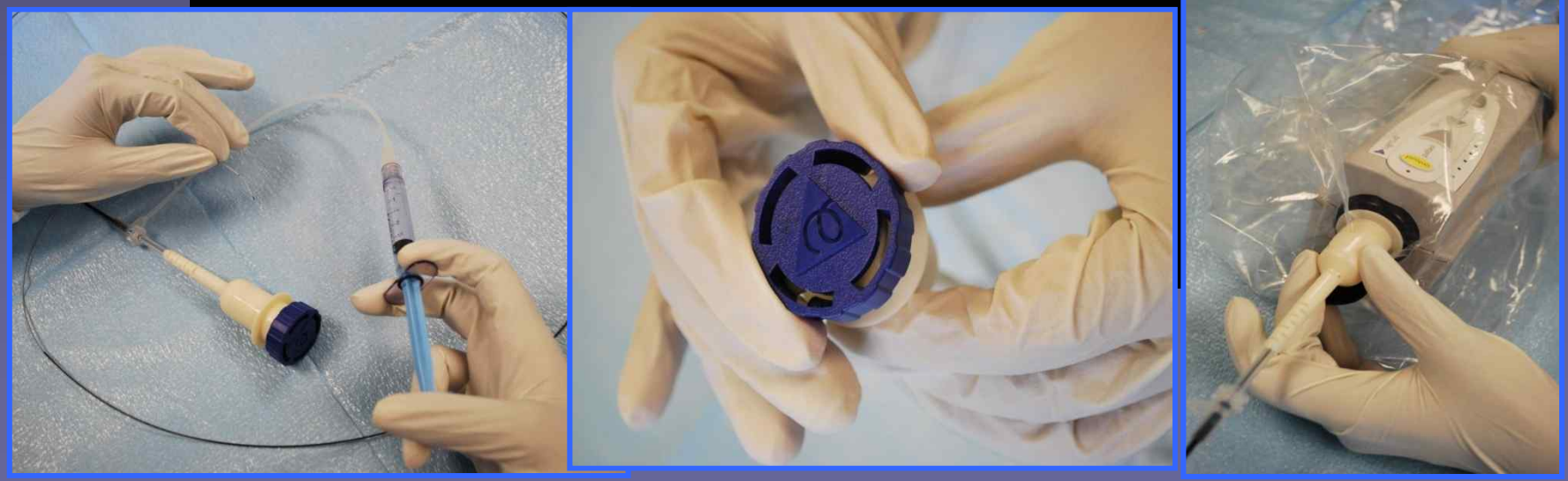


C7-XR Dragonfly Imaging Catheter



Dragonfly Tip



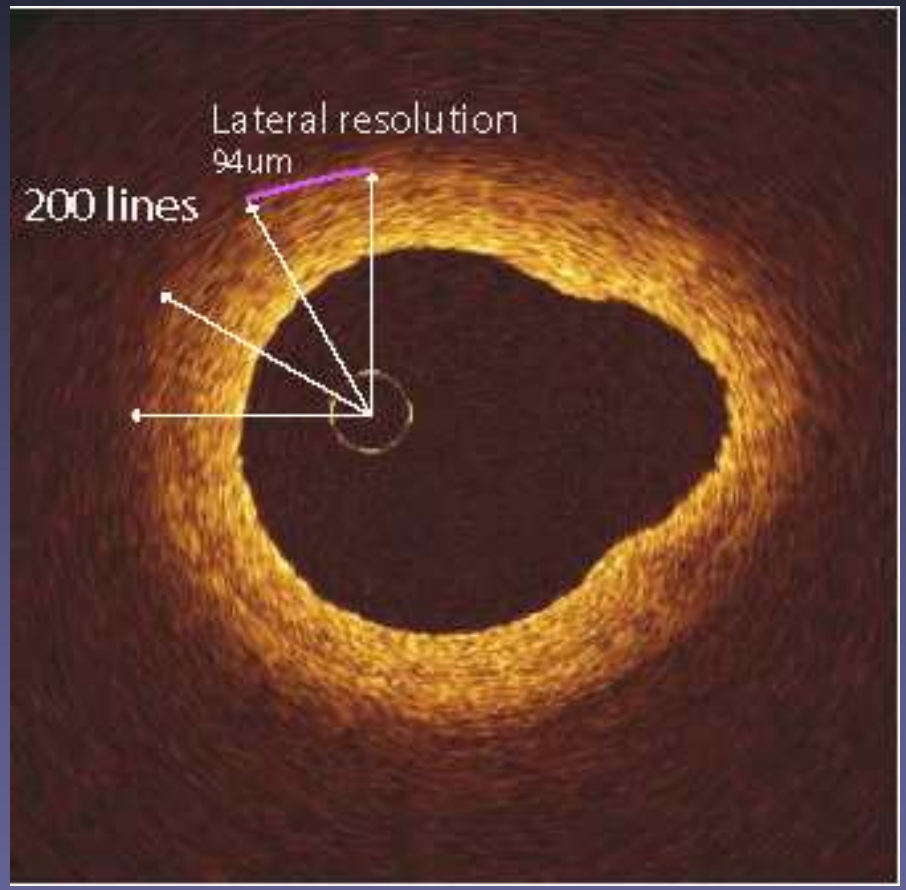


C7-XR System

DOC = Drive-motor and Optical Controller (Pullback Device)

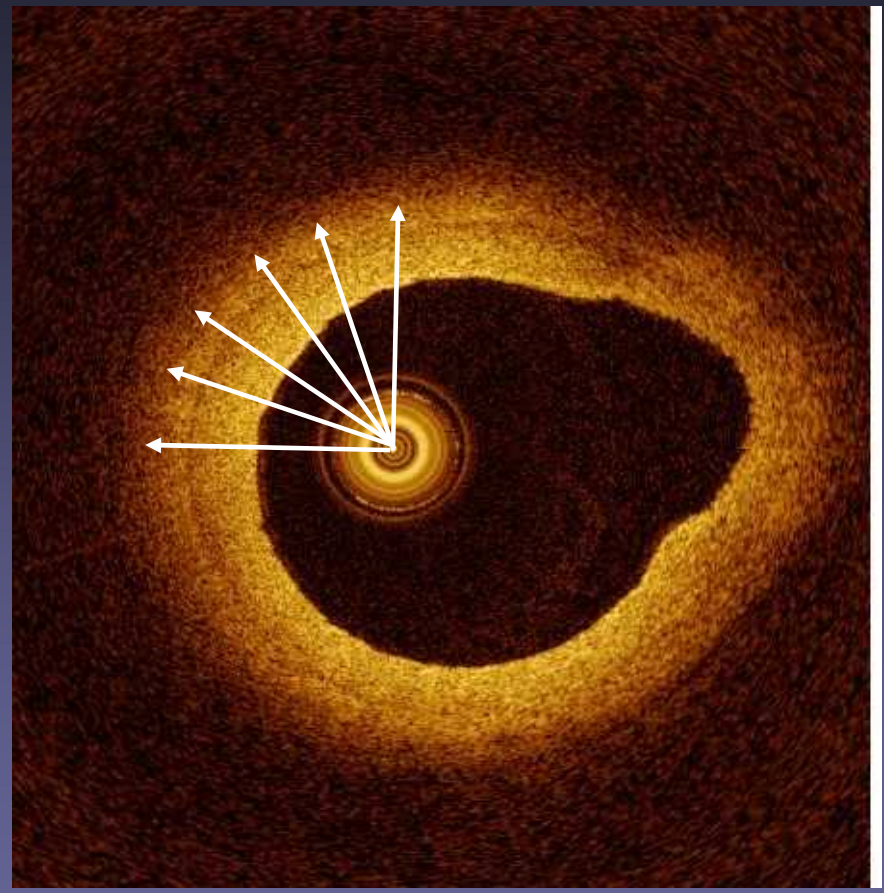
OCT Image M3 vs C7

M2



15 f/s, 200 lines/frame

M4/C7



80 f/s, 562 lines/frame

Formalin-fixed coronary artery (pig)

Merit & demerit of OCT & IVUS

◆ IVUS 장점

1. To evaluate atheroma & vessel wall
   - Aneurysm & Pseudoanerysm
   - Positive & negative Remodeling
2. To achieve stent optimization & to detect post stenting complication & Rapidly check lesion length
   - Stenting Sizing
   - Stent expansion
   - Geographic miss
   - Major complications
3. 시술이 용이하여 복잡한 중재적 시술 시 자주 이용된다.
   - Bifurcation & CTO 중재술시 용이함.
   - Indec system 측정이 가능

◆ IVUS의 단점

1. 해상도가 낮아 Image quality가 떨어진다.
2. Flushing 시 air embolism을 유발할수가 있다.
3. Acoustic shadowing에 의해 Calcium 성분에 대한 분석이 어렵다.

◆ OCT의 장점

1. 해상도가 뛰어나 **ivus**가 볼수 없는 정보를 제공한다.

- 시술 전후에 대한 **Dissection, Stent apposition, Plaque Prolapse, Vulnerable plaque, Thrombus**등을 좀더 명확히 알 수 있다.

2. DES implantation후 **F/u**시 혈관의 반응여부를 알 수 있으며, **Stent strut**과 혈관의 관계를 알수가 있다.**(**즉, **Neointima**에 대한 정확한 정보를 알수가 있다.**)**

◆ OCT의 단점

1. Blood에 대한 **Attenuation**을 줄이기 위해 하트만 용액을 계속해서 주입해야 하며, **Length**에 비해 시술시간이 다소 길다.

2. 측정길이에 제한이 있으며**(25m/0.5s), Shallow penetration depth(<2mm)**이하로 혈관 분석에 제한이 있다.

- **Ture vessel sizing** 및 **plaque burden, large vessel or plaque**에 대한 분석이 어렵다.

3. 측정시 **Ballooning**에 의한 위험을 초래 할수 있다.

- **Balloon rupture** 및 하트만 **Injection**으로 인한 **air embolism.(Rupture** 거의 없음**)**
- **Balloon injury**로 인한 **Plaque rupture.**

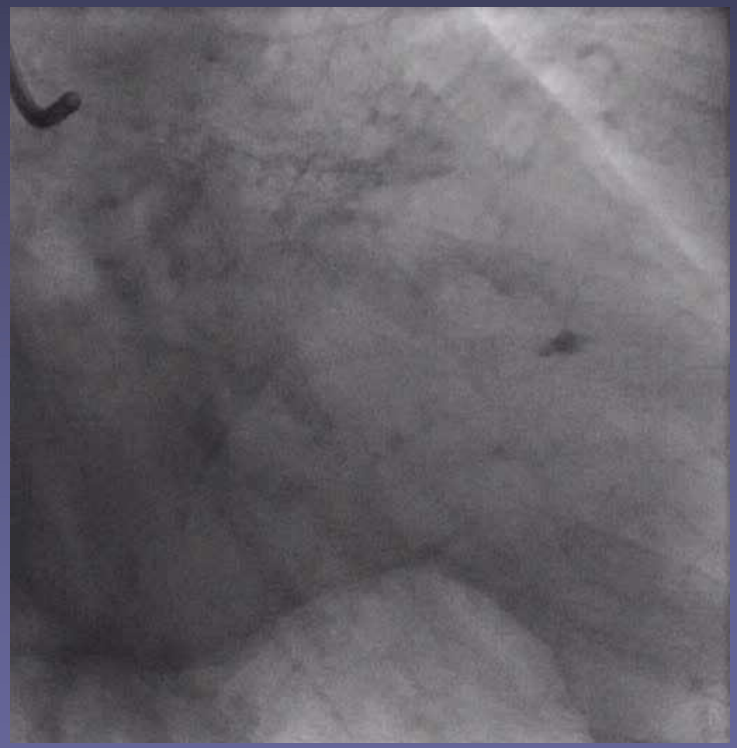
Platform Comparison

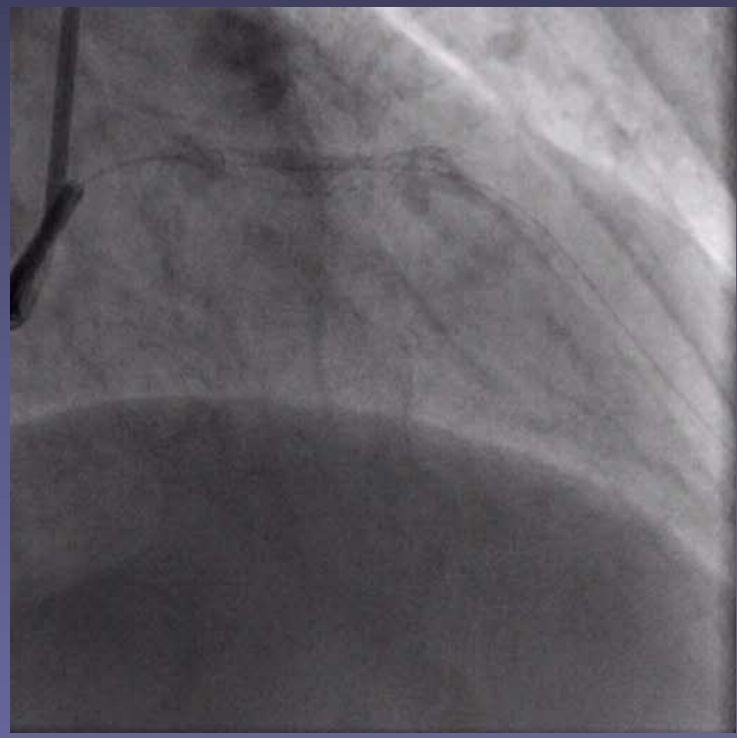
	C7-XR (2009)	M3 (2007)	IVUS (current)
Frame rate Frames/sec (fps)	100	20	30
Pullback speed (default/max)	20/25 mm/sec	1.5/3.0 mm/sec	0.5 or 1.0 mm/sec
Lines per frame	500	240	256
Lateral sampling (3 mm artery)	19 µm	39 µm	225 µm
Axial resolution	15 µm	15 µm	150 µm
Scan diameter (in saline)	10 mm	6.8 mm	10-15 mm
Length(mm)	55mm	55mm	100mm

III. Review of OCT data

Sirolimus eluting Stent

Stopping Aspirin and Clopidogrel for EGD and Colonoscopy at 17M after stent implantation





Pathological Correlates of Late Drug-Eluting Stent Thrombosis

Strut Coverage as a Marker of Endothelialization

Aloke V. Finn, MD*; Michael Joner, MD*; Gaku Nakazawa, MD; Frank Kolodgie, PhD; John Newell, AB; Mike C. John, MPH; Herman K. Gold, MD; Renu Virmani, MD

The most powerful histological predictor of stent thrombosis was endothelial coverage.

The best morphometric predictor of LST was the ratio of uncovered to total stent struts.

How can we evaluate endothelial coverage ?

Finn AV, et al. Circulation 2007;115:2435-41

Endothelial Cell Recovery Between Comparator Polymer-Based Drug-Eluting Stents

Michael Joner, MD,* Gaku Nakazawa, MD,† Aloke V. Finn, MD,‡ Shawn Chin Quee, MS,§ Leslie Coleman, DVM,§ Eduardo Acampado, DVM,† Patricia S. Wilson, BA,† Kristi Skorija, BS,† Qi Cheng, MD,† Xin Xu, PHD,† Herman K. Gold, MD,‖ Frank D. Kolodgie, PHD,† Renu Virmani, MD, FACC†¶

Munich, Germany; Gaithersburg, Maryland; Atlanta, Georgia; Santa Clara, California; Boston, Massachusetts; and Orangeburg, New York

endothelial coverage over stent struts. The restoration of endothelial function within the stent may be further impaired because of an underlying dysfunctional endothelium in symptomatic plaques. Moving beyond the exuberance of curing restenosis, attention should focus on stent strut coverage rather than late loss alone because the persistent lack of coverage as reported in recent clinical (47) and autopsy (3) studies may serve as a nidus for thrombosis.

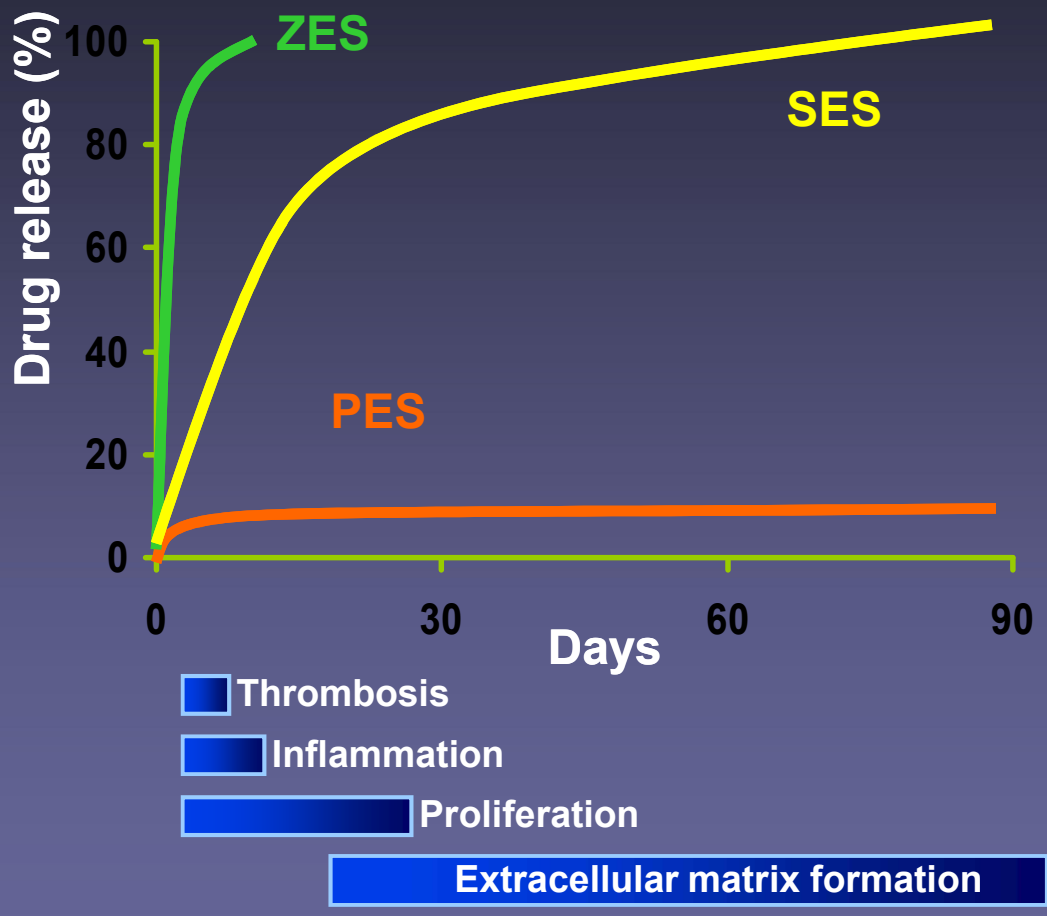
the current generation of FDA-approved stents. (J Am Coll Cardiol 2008;52:333–42)

How long does it take to complete a Neointimal Coverage over stent ?

Especially, Drug Eluting Stent ?

(Dual antiplatelet therapy)

Different Characteristics in DESs



SES
Initial small burst & controlled release over 90 days;
80% eluted at 30 days,
complete at 90 days

PES
Bimodal release of 10% of the drug,
completed in 2 weeks,
90% sequestered on stent

ZES
Nearly 100% of the drug elutes
in the first 7 days
and complete at 12 days

1. Nikol et al: Atherosclerosis 123:17, 1996 2. Stone G: Presented at ACC, 2004
3. Ormiston J, Endeavor I Study: Presented at AHA, 2004

Evaluation by Optical Coherence Tomography of Neointimal Coverage of *Sirolimus*-Eluting Stent Three Months After Implantation

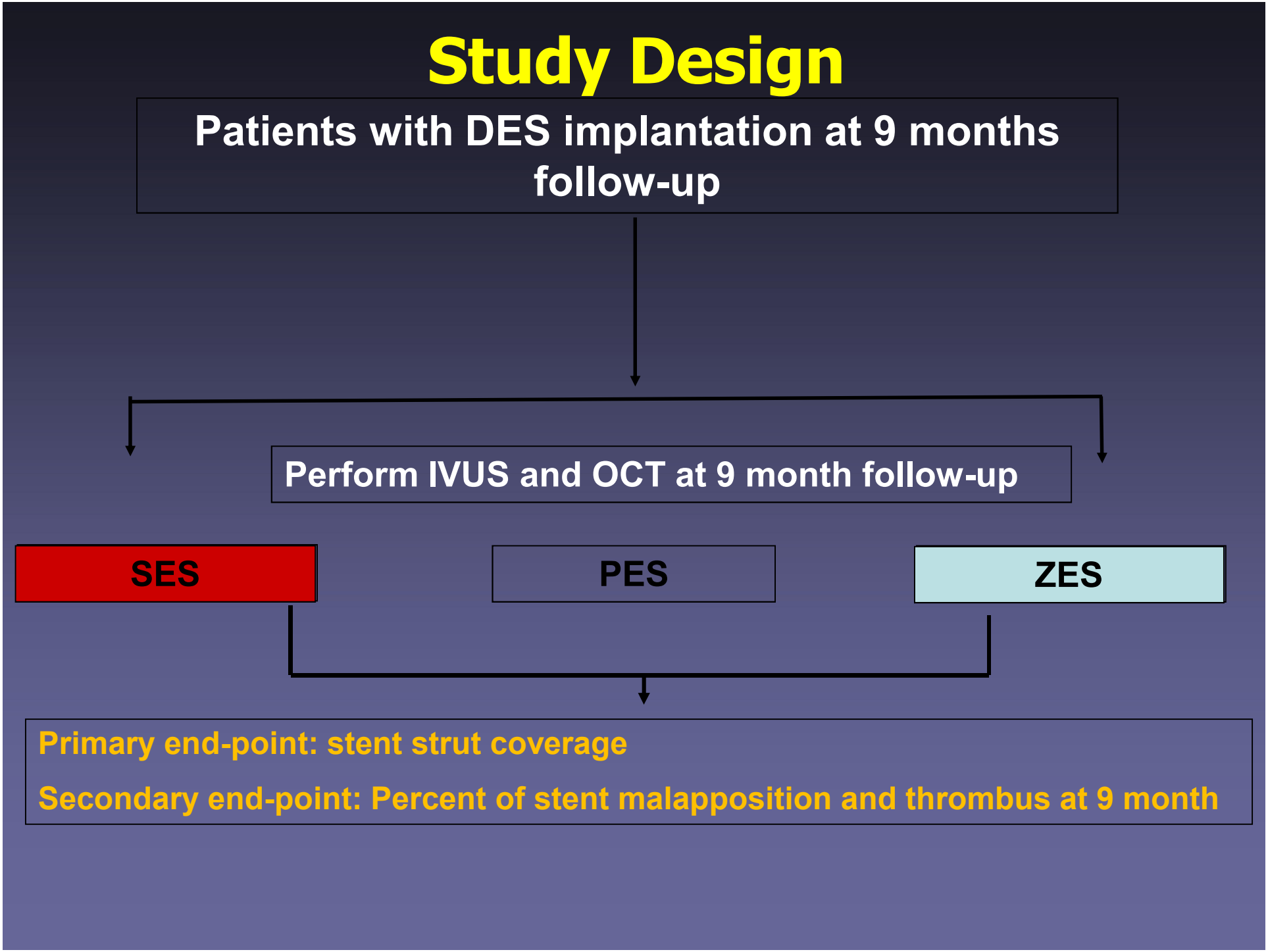
Masamichi Takano, MD[a,*], Shigenobu Inami, MD[a], Ik-Kyung Jang, MD, PhD[b], Masanori Yamamoto, MD[a], Daisuke Murakami, MD[a], Koji Seimiya, MD[a], Takayoshi Ohba, MD[a], and Kyoichi Mizuno, MD, PhD[a]

Confirming complete neointimal coverage after implantation of a drug-eluting stent is clinically important because incomplete stent coverage is responsible for late thrombosis

NIH thickness and percent NIH area were 29 ± 41 μm and 10 ± 4%, respectively. Rates of exposed struts and exposed struts with malapposition were 15% and 6%, respectively. These were more frequent in patients with ACS than in those with non-ACS (18% vs. 13%, p <0.0001; 8% vs 5%, p <0.005, respectively).

In conclusion, neointimal coverage in a SES at 3-month follow-up is incomplete in ACS and non-ACS. Our study suggests that dual antiplatelet therapy might be continued >3 months after SES implantation.

Study Design



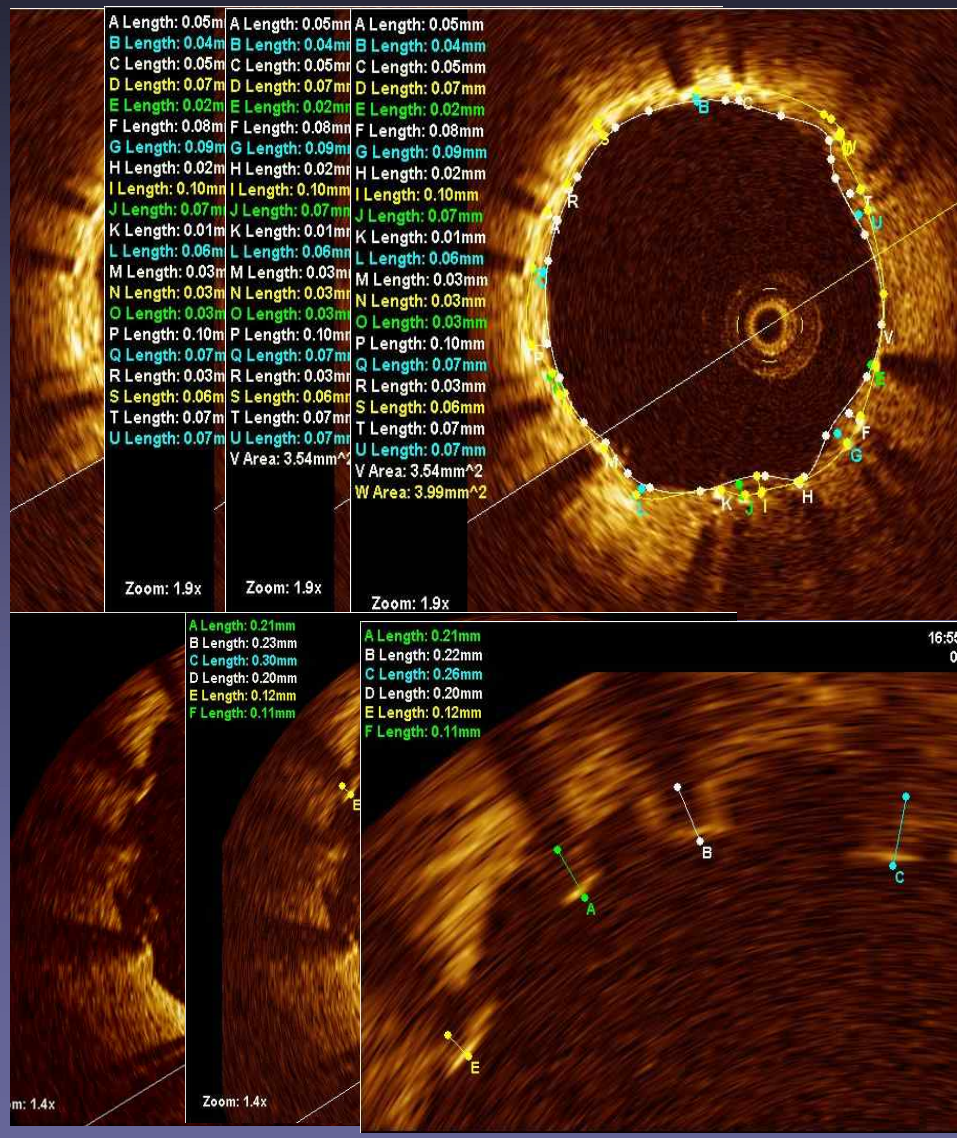
Optical Coherence Tomography Image Analysis

1. **Neointimal thickness**

The distances between the endo-luminal surface of neointimal and the strut reflection

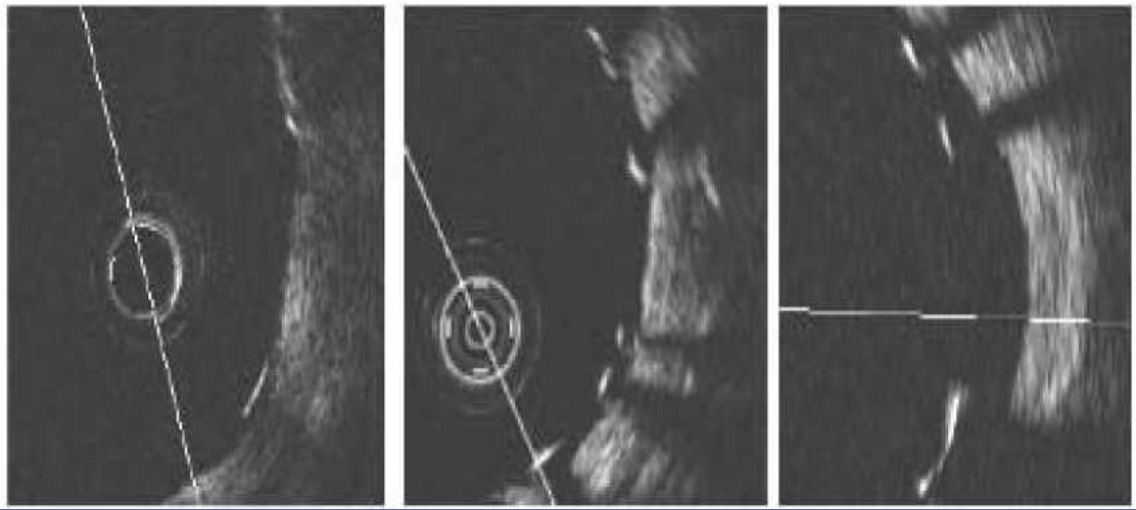
2. Stent apposition

The distances between the endo-luminal surface of the strut reflection and the vessel wall



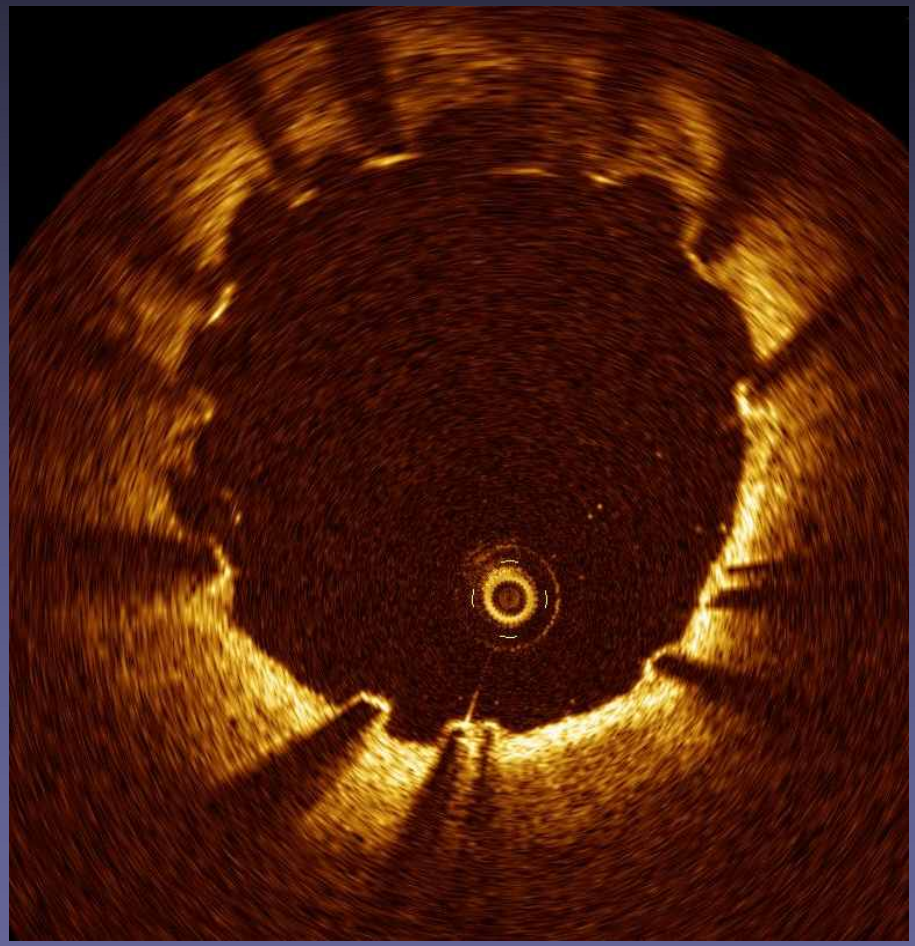
Evaluation of Neointima and Apposition of stent

	Apposed		Malapposed
	Embedded	Protruding	Malapposed
Cypher Select	< 80 μm	80-160 μm	≥ 160 μm
Taxus Liberte	< 65 μm	65-130 μm	≥ 130 μm
Endeavor	< 55 μm	55-110 μm	≥ 110 μm



9 Month Follow-Up OCT finding

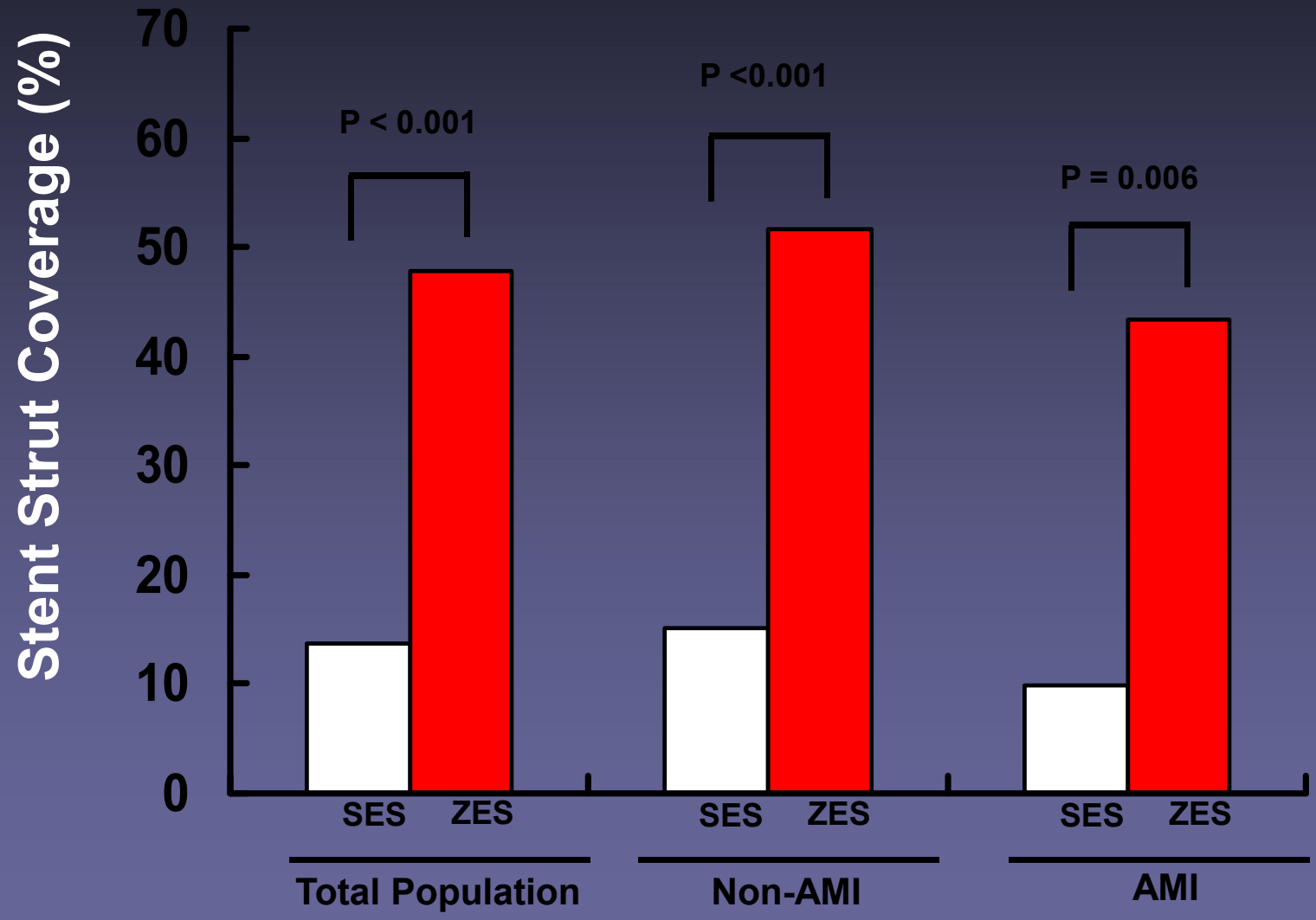
SES



ZES

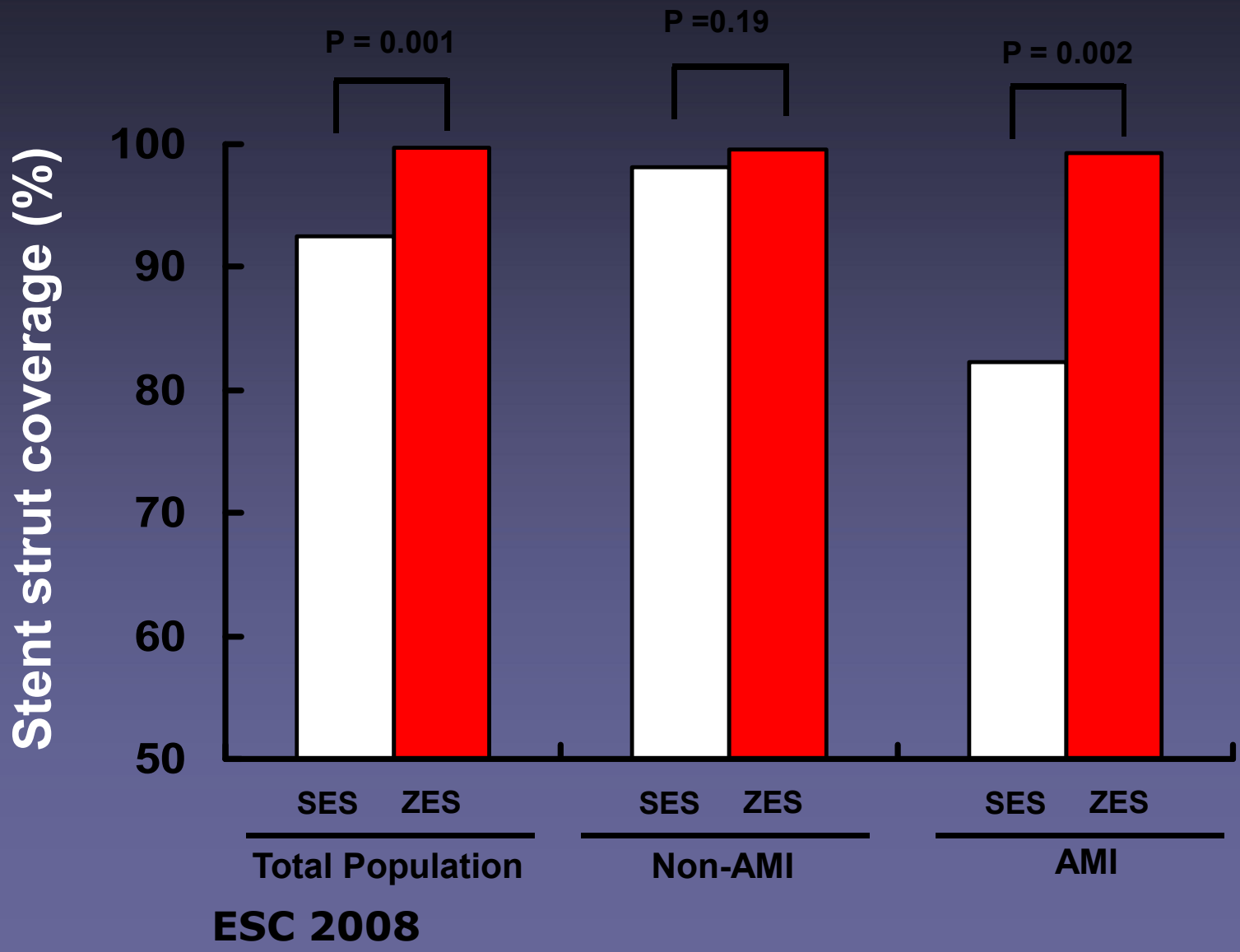
IVUS Findings 58 patients (28 SES and 30 ZES)

using Miyazawa's method (*Am Heart J* 2008;155:108-113)



OCT findings 58 patients (28 SES and 30 ZES)

1306 mm in stent length including 13556 struts



ESC 2008

OCT findings 58 patients (28 SES and 30 ZES)

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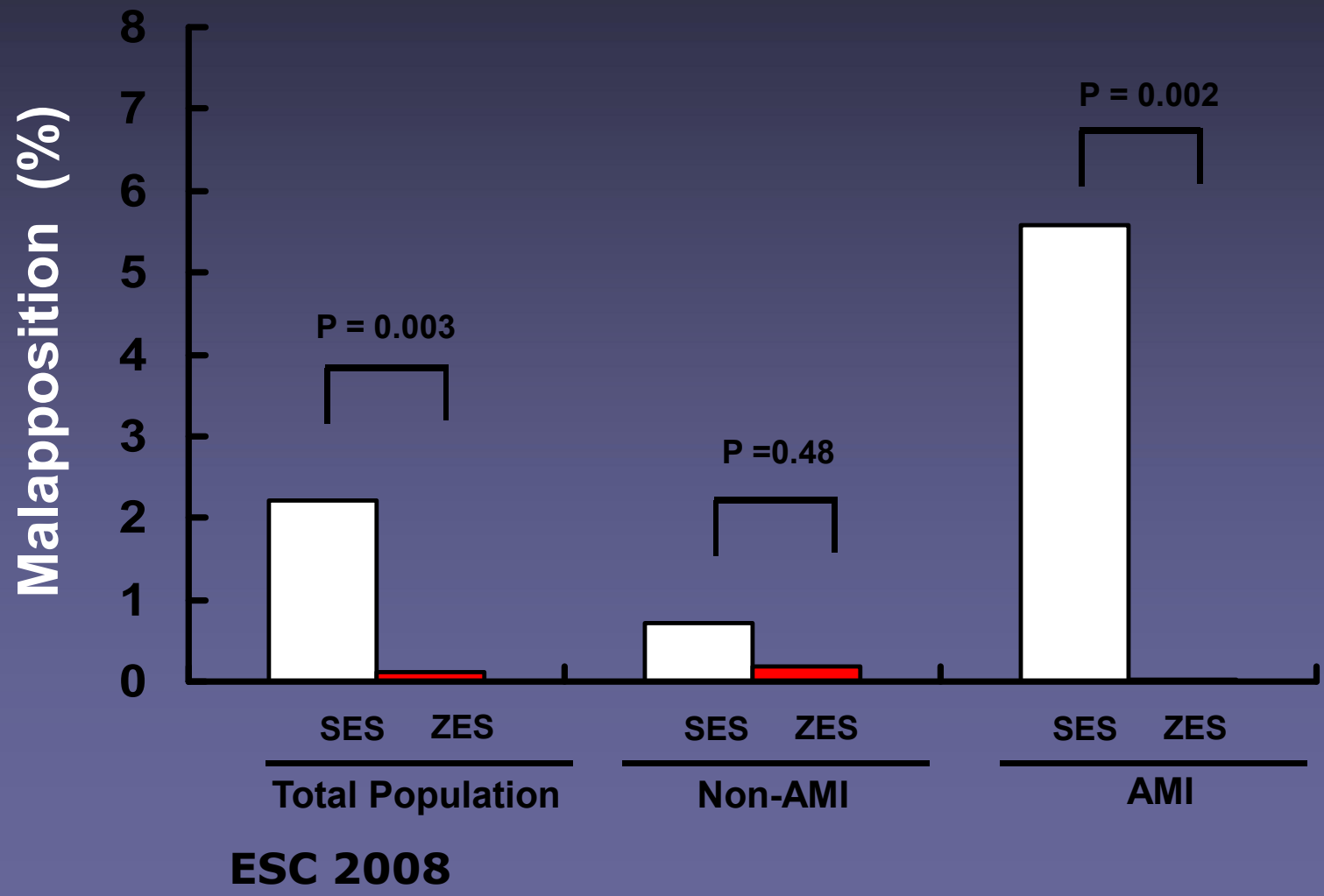

ESC 2008

Important findings in this study

Neon-intima coverage of stent struts at 9-month was nearly complete in ZESs.

But in SESs, exposed struts and malapposed struts were more frequently observed than in ZESs.

This means that 9 month-maintenance of dual antiplatelet therapy may be enough for patients with ZES.

Therefore, in the cases of SESs, prolonged use of dual anti-platelet therapy may be required more than 9 months

IV. Summary

- **OCT** 는 생물학적이나 스텐트의 상태를 보기 위해 가장 훌륭한 장비이다.
- **Stent strut** 의 **Neontimal coverage**에 대한 정확한 정보를 제공한다.
- **OCT**장비를 **Upgrade**함으로써 현재 **OCT**를 사용하기에 부담으로 작용 되는 **ballooning**이 필요 없으며, 빠른 시간 내 측정으로 환자의 부담을 줄이며, 보다 넓은 **diameter**를 측정할 수가 있어 향후, 관상동맥 내 평가를 위해서는 **Routinely**사용하는 장비가 될 것으로 사료된다.

Thanks your Attention!