Clinical Utility of OCT Compared to Other Imaging Modalities in PCI Patients

Kosin University Hospital

Division of Cardiology

Jung Ho Heo MD, PhD

Non invasive methods

EKG

Echocardiography

Scintigraphy

PET

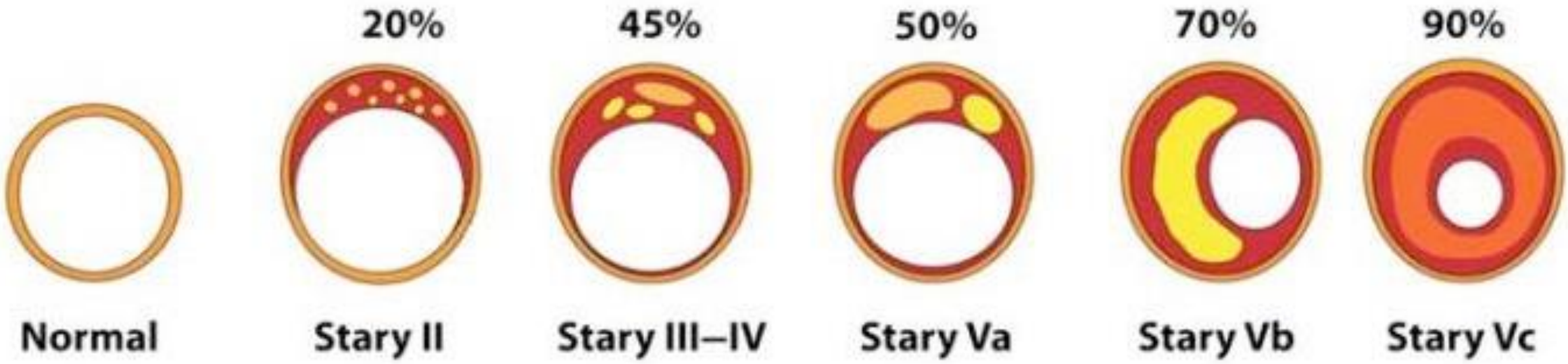
CT MRT

Endothelial dysfunction

OCT IVUS

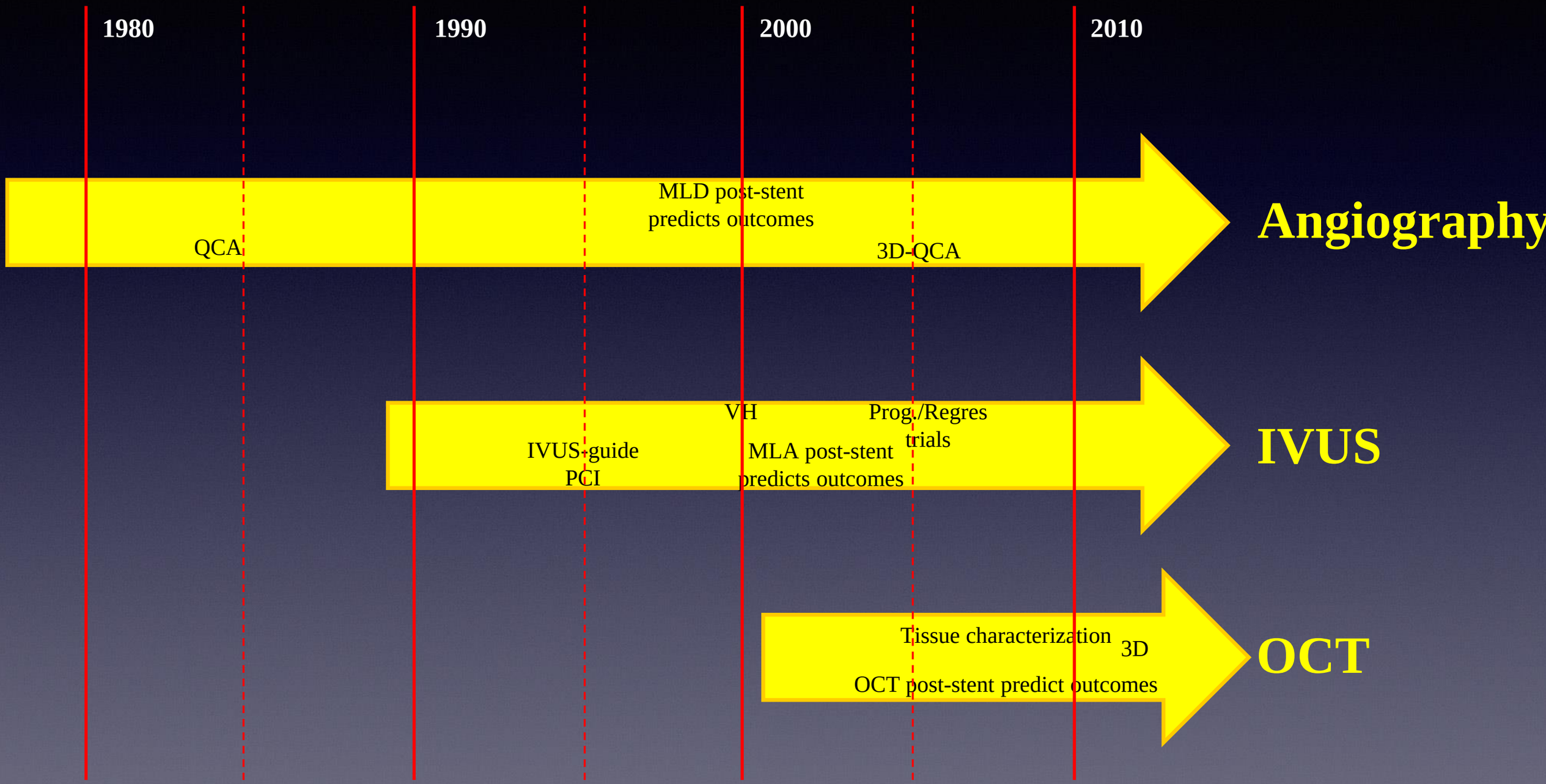
Coronary angiography

Invasive methods



Lifetime

Evolution of coronary imaging techniques



OCT ??

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   Herman C.
   Clin Cosmet Investig Dermatol. 2012;5:195-212. doi: 10.2147/CCID.S27902. Epub 2012 Nov 12.
   PMID: 23204850 [PubMed - in process] **Free Article**
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2. Optimizing visualization in enhanced depth imaging OCT in healthy subjects and patients with retinal pigment epithelial detachment.
   Reznicek L, Vounotrypidis E, Seidensticker F, Kortuem K, Kampik A, Neubauer AS, Wolf A.
   Clin Ophthalmol. 2012;6:1915-20. doi: 10.2147/OPTH.S35596. Epub 2012 Nov 21.
   PMID: 23204834 [PubMed - in process] **Free Article**
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3. Macular sensitivity and morphology after intravitreal injection of triamcinolone acetonide for macular edema secondary to central retinal vein occlusion.

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1. Morphological and Stress Vulnerability Indices for Human **Coronary** Plaques and Their Correlations with Cap Thickness and Lipid Percent: An IVUS-Based Fluid-Structure Interaction Multi-patient Study.
Wang L, Zheng J, Maehara A, Yang C, Billiar KL, Wu Z, Bach R, Muccigrosso D, Mintz GS, Tang D.
PLoS Comput Biol. 2015 Dec 9;11(12):e1004652. doi: 10.1371/journal.pcbi.1004652. eCollection 2015 Dec.
PMID: 26650721

2. Reliable and Accurate Calcium Volume Measurement in **Coronary** Artery Using **Intravascular Ultrasound** Videos.
Araki T, Ranchhor SK, Londhe ND, Ikeda N, Badeva P, Shukla D, Saba L, Polestrieri A, Nicolaides A

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1. Bioresorbable vascular scaffold for very late stent thrombosis resulting from ruptured neoatherosclerosis.
Bastante T, Rivero F, Cuesta J, Aguilera MC, Rodríguez D, Benedicto A, Alfonso F.
Rev Port Cardiol. 2015 Nov 26. pii: S0870-2551(15)00297-8. doi: 10.1016/j.repc.2015.05.008. [Epub ahead of print]
English, Portuguese.
PMID: 26632108
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2. OCT imaging of aorto-**coronary** vein graft pathology modified by external stenting: 1-year post-

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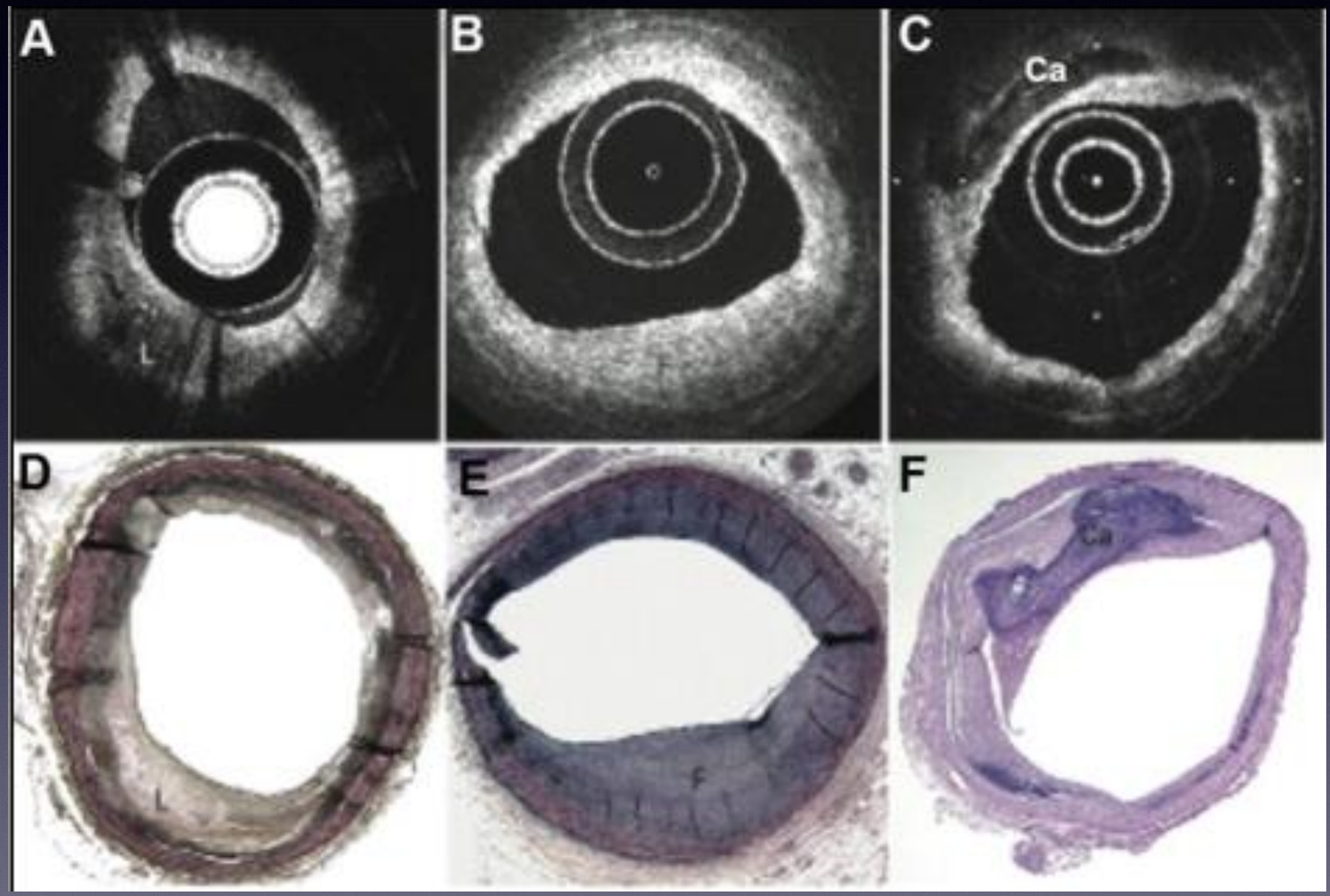
OCT ??



Lowe H.et al. J Am Coll Cardiol Intv. 2011;4(12):1257-1270

Current Status of OCT

European Heart Journal (2010) **31**, 401–415
doi:10.1093/eurheartj/ehp433

Imaging of atherosclerosis: optical coherence tomography (OC

Expert review document on met terminology, and clinical applicat coherence tomography: physical methodology of image acquisitio application for assessment of cor and atherosclerosis

Francesco Prati[1]*, Evelyn Regar[2], Gary S. Mintz[3], Eloisa A Ik-Kyung Jang[6], Takashi Akasaka[7], Marco Costa[8], Giulio Eberhard Grube[10], Yukio Ozaki[11], Fausto Pinto[12], and P Expert's OCT Review Document

European Heart Journal (2012) **33**, 2513–2522
doi:10.1093/eurheartj/ehs095

Expert review document part 2: terminology and clinical applicati coherence tomography for the as of interventional procedures

Francesco Prati[1,2]*, Giulio Guagliumi[3], Gary S. Mintz[4], M Evelyn Regar[6,7], Takashi Akasaka[8], Peter Barlis[9], Guillerr Ik-Kyung Jang[12], Elosia Arbustini[13], Hiram G. Bezerra[5], Y Nico Bruining[6,7], Darius Dudek[15], Maria Radu[6,7], Andrejs Pascale Motreff[17], Fernando Alfonso[18], Kostas Toutouzas Corrado Tamburino[21], Tom Adriaenssens[22], Fausto Pinto and Carlo Di Mario[24,25], for the Expert's OCT Review Do

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ISSN 0735-1097/$36.00
doi:10.1016/j.jacc.2011.09.079

MINI-FOCUS ISSUE: OPTICAL COHERENCE TOMOGRAPHY **Clinical Research**

Consensus Standards for Acquisition, Measurement, and Reporting of Intravascular Optical Coherence Tomography Studies

A Report From the International Working Group for Intravascular Optical Coherence Tomography Standardization and Validation

Guillermo J. Tearney, MD, PHD, *Writing Committee Co-Chair*,*
Evelyn Regar, MD, PHD, *Writing Committee Co-Chair*,† Takashi Akasaka, MD, *Writing Committee Co-Chair*,‡
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Nico Bruining, PHD, Jin-man Cho, MD, PHD, Saqib Chowdhary, PHD, Marco A. Costa, MD, PHD,
Ranil de Silva, MD, PHD, Jouke Dijkstra, PHD, Carlo Di Mario, MD, PHD, Darius Dudeck, MD, PHD,
Erlin Falk, MD, PHD, Marc D. Feldman, MD, Peter Fitzgerald, MD, Hector Garcia, MD,
Nieves Gonzalo, MD, Juan F. Granada, MD, Giulio Guagliumi, MD, Niels R. Holm, MD,
Yasuhiro Honda, MD, Fumiaki Ikeno, MD, Masanori Kawasaki, MD, Janusz Kochman, MD, PHD,
Lukasz Koltowski, MD, Takashi Kubo, MD, PHD, Teruyoshi Kume, MD, Hiroyuki Kyono, MD,
Cheung Chi Simon Lam, MD, Guy Lamouche, PHD, David P. Lee, MD, Martin B. Leon, MD,
Akiko Maehara, MD, Olivia Manfrini, MD, Gary S. Mintz, MD, Kyiouchi Mizuno, MD,
Marie-angéle Morel, MD, Seemantini Nadkarni, PHD, Hiroyuki Okura, MD, Hiromasa Otake, MD,
Arkadiusz Pietrasik, MD, Francesco Prati, MD, Lorenz Räber, MD, Maria D. Radu, MD,
Johannes Rieber, MD, Maria Riga, MD, Andrew Rollins, PHD, Mireille Rosenberg, PHD, Vasile Sirbu, MD,
Patrick W. J. C. Serruys, MD, PHD, Kenei Shimada, MD, Toshiro Shinke, MD, Junya Shite, MD,
Eliot Siegel, MD, Shinjo Sonada, MD, Melissa Suter, PHD, Shigeho Takarada, MD, PHD,
Atsushi Tanaka, MD, PHD, Mitsuyasu Terashima, MD, Thim Troels, MD, PHD, Shiro Uemura, MD, PHD,
Giovanni J. Ughi, PHD, Heleen M.M. van Beusekom, PHD, Antonius F.W. van der Steen, PHD,
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Boston, Massachusetts; Rotterdam, the Netherlands; and Wakayama, Japan

Current Status of OCT

REVIEW
Korean J Intern Med 2012;27:1-12
http://dx.doi.org/10.3904/kjim.2012.27.1.1

pISSN 1226-3303 eISSN 2005-6648
http://www.kjim.or.kr

The Role of Optical Coherence Tomography in Coronary Intervention

Mitsuyasu Terashima[1], Hideaki Kaneda[2], and Takahiko Suzuki[1]

Circulation Journal
Official Journal of the Japanese Circulation Society
http://www.j-circ.or.jp

REVIEW

Application of Optical Coherence Tomography in Percutaneous Coronary Intervention

Takashi Kubo, MD, PhD; Atsushi Tanaka, MD, PhD; Hironori Kitabata, MD, PhD;
Yasushi Ino, MD, PhD; Takashi Tanimoto, MD, PhD; Takashi Akasaka, MD, PhD

EUROPEAN SOCIETY OF CARDIOLOGY®

European Heart Journal – Cardiovascular Imaging (2012) **13**, 370–384
doi:10.1093/ehjci/jes025

REVIEW

Optical coherence tomography: from research

The International Working Group
For Intracoronary OCT Standardization And Validation

- **400+ members world wide**
- **12 international meetings**
- **Established Supp. 151 DICOM standard**
- **Consensus Document** *JACC 2012 59(12)*
  - This presentation is high-level summary reporting of image interpretation consensus by IWG-IVOCT

Evidence Levels for IVOCT Interpretation

- **Evidence Level: High**
  - *multiple*, well-designed, cohort (descriptive) trials or
    - *multiple* histopathologic correlative studies
- **Evidence Level: Medium**
  - at least *one* well-designed trial or
  - a *single* histopathologic correlative study
- **Evidence Level: Low**
  - clinical experience,
  - descriptive studies,
  - reports of expert committees, or
  - histopathologic correlative case studies

Tearney at ACC 2014

Diagnostic Category Listing As Determined by Working Group

- Normal artery wall (intimal hyperplasia)

<u>Lesion diagnosis</u>

- Plaque (EEM +/-)
- Fibrous plaque
- Fibrocalcific plaque
- Fibroatheroma
- Necrotic core
- Thin cap
- OCT-TCFA
- Macrophage accumulations
- Intimal vasculature
- Cholesterol crystals
- Mixed plaque

<u>Related to clinical events</u>

- Thrombus
- OCT erosion
- Rupture
- Dissections

<u>Stents</u>

- Prolapse
- Apposition
- Thrombus
- Dissections
- OCT strut coverage
- Restenosis
- Bioabsorbable scaffolds

Tearney at ACC 2014

Progressive atherosclerotic lesions

Pathologic intimal thickening (PIT)

PIT without

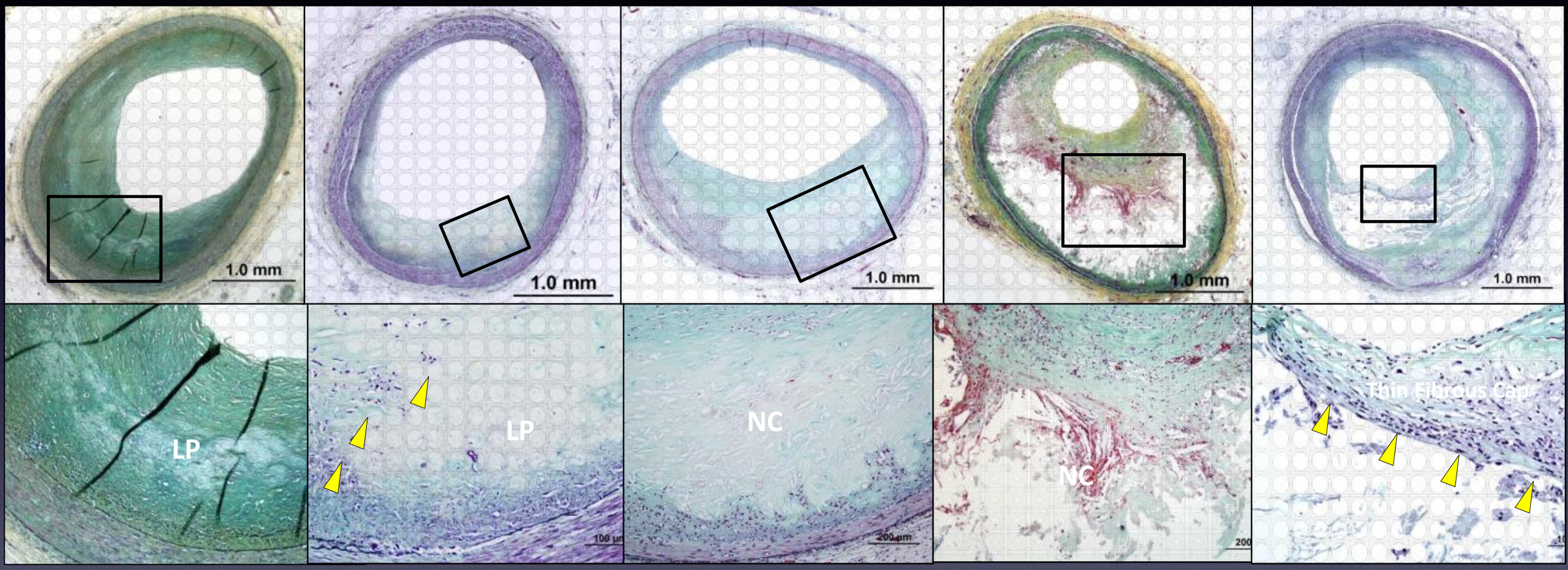
PIT with macrophage macrophage

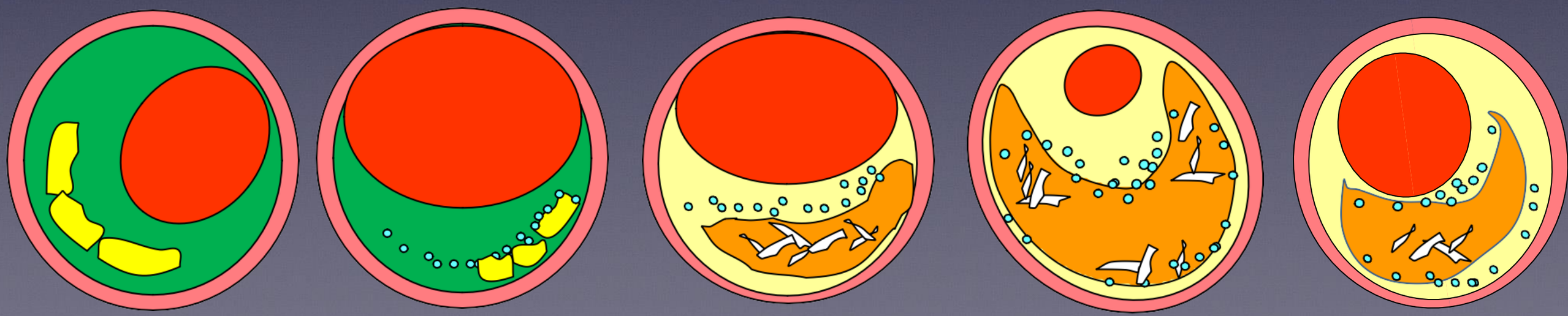
Fibroatheroma (FA)

Early FA

Late FA

Thin-cap Fibroatheroma (TCFA)

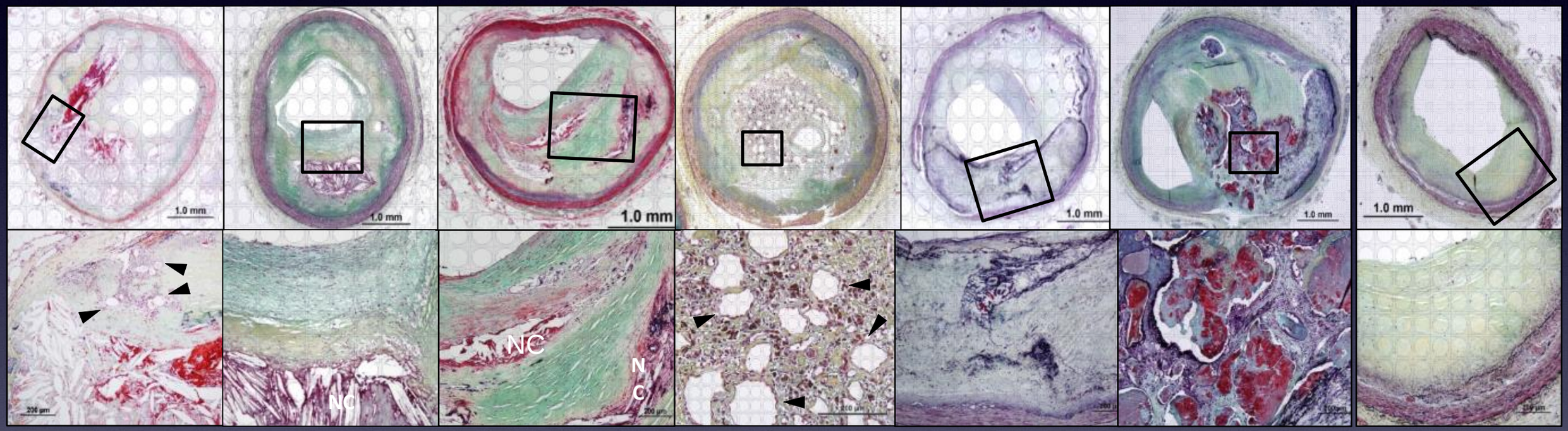


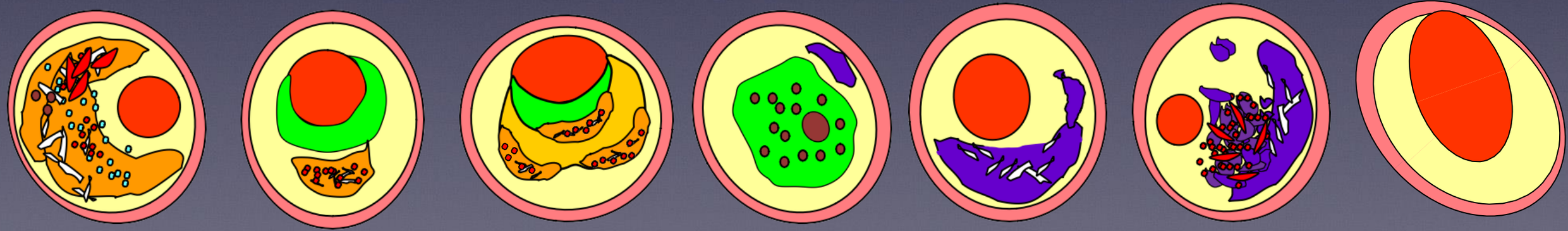


Joner M at CRT 2015

Progressive atherosclerotic lesions

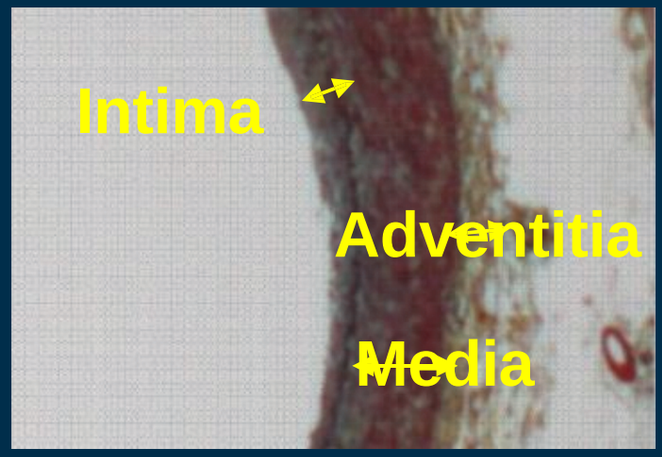
Intraplaque Hemorrhage | Healed Rupture | Chronic Total Occlusion | Fibrocalcific Plaque | Nodular Calcification | Fibrous Plaque



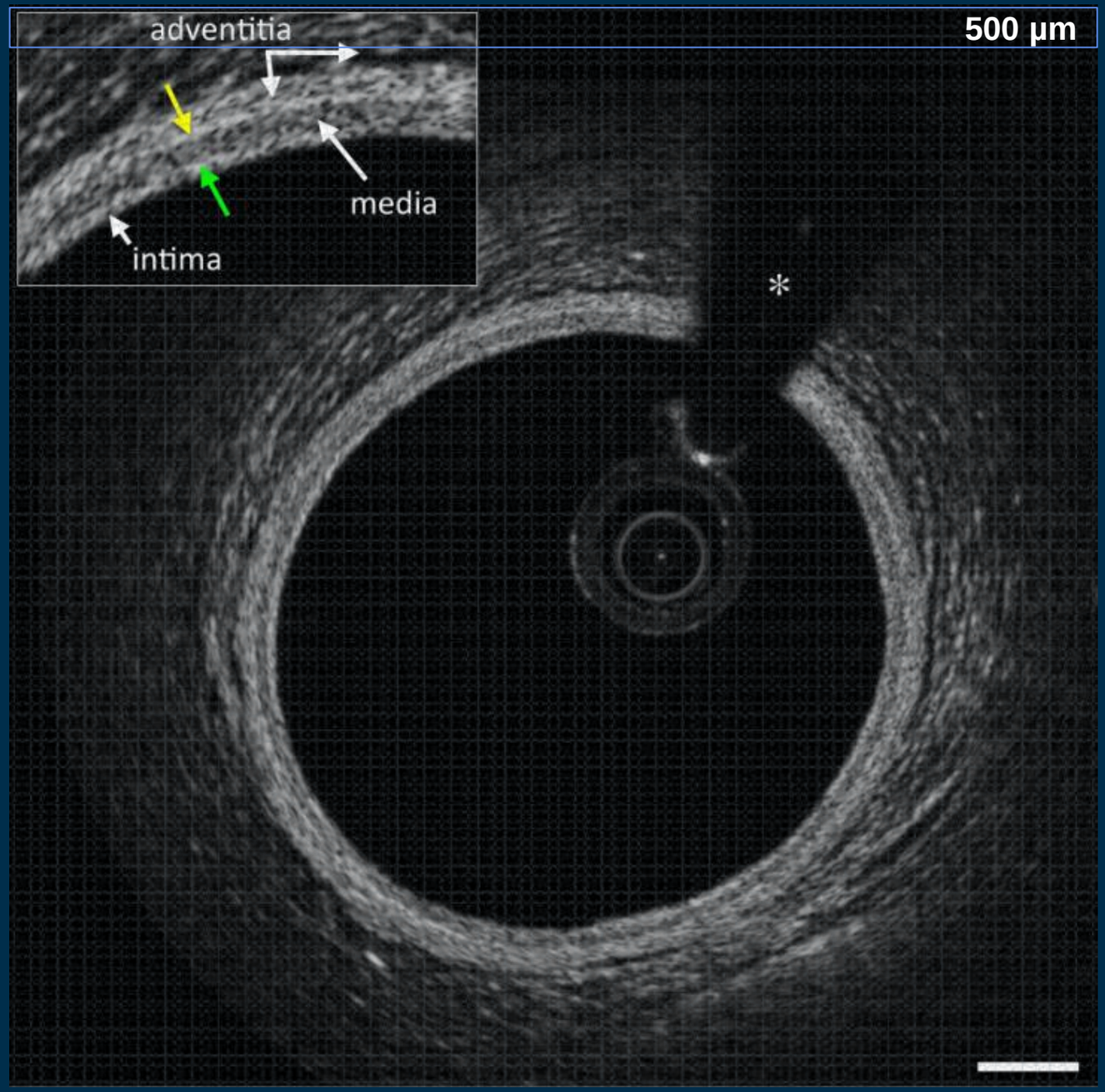


Joner M at CRT 2015

Normal Artery Wall
Intimal Hyperplasia

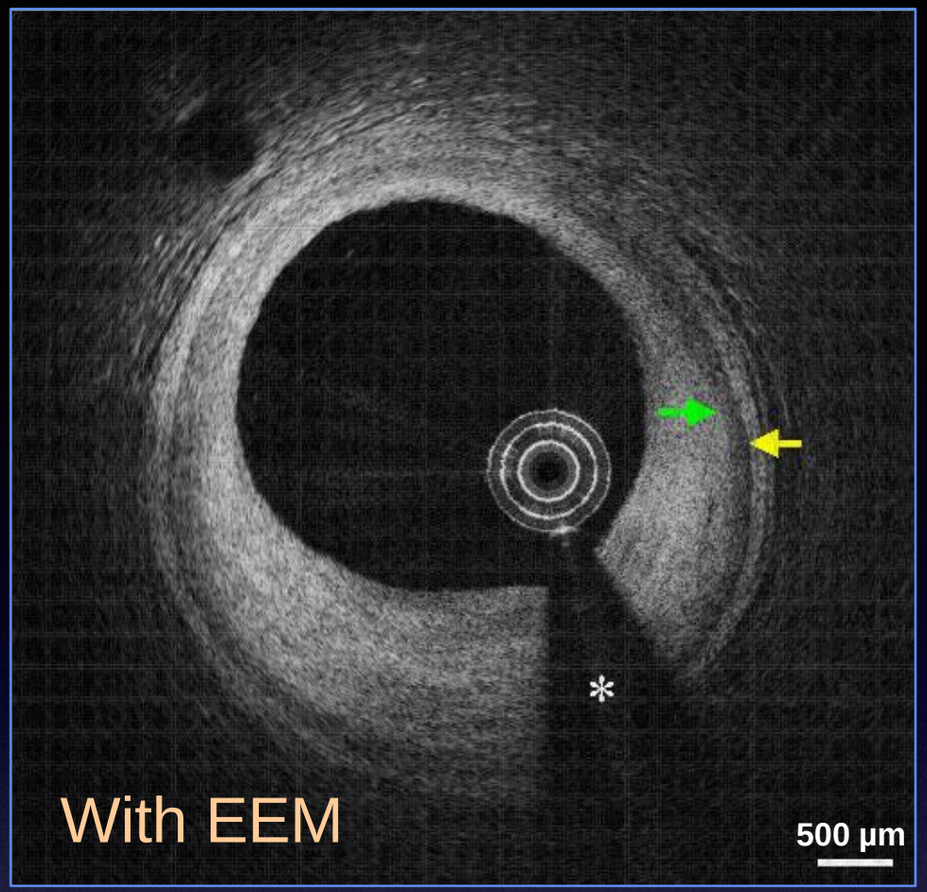


- **Description:**
  - Layered architecture
  - High backscattering intima (thin)
    - Low backscattering media
    - Heterogeneous adventitia
      - Vaso vasorum vessels
        - Adipocytes
- **Level of Evidence:**
  High



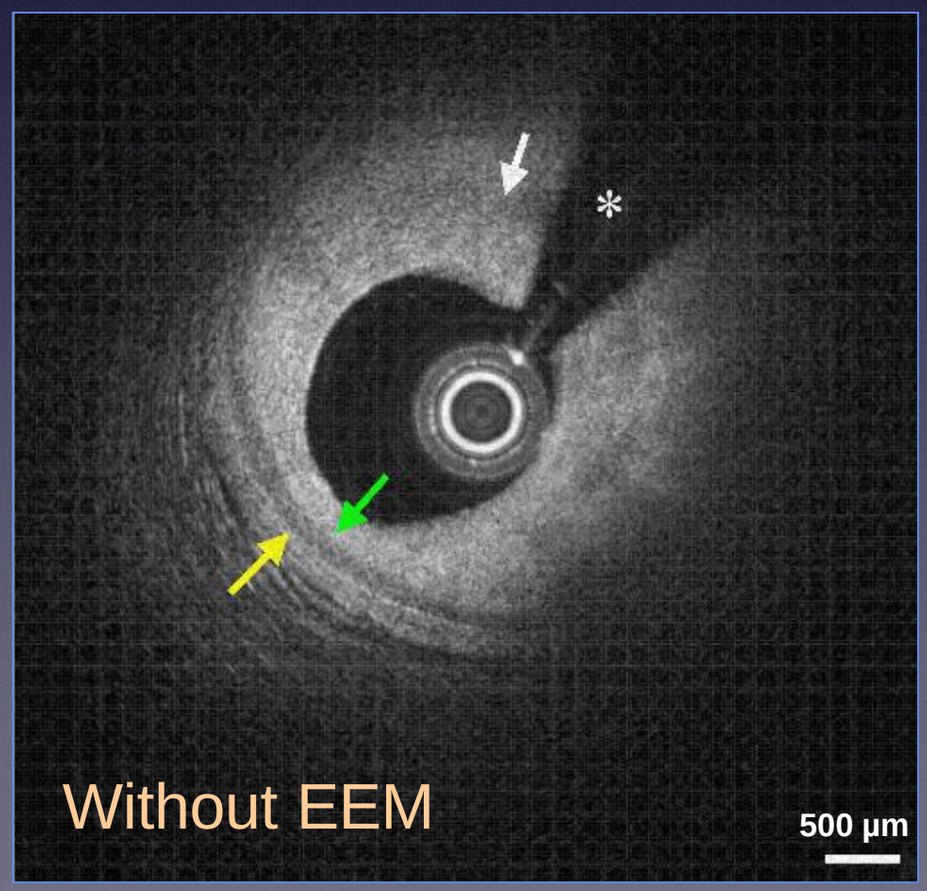
Atherosclerotic Plaque

- **Description:**
  - Mass lesion (focal thickening)
  - Loss of layered architecture
  - May or may not display EEM
- **Level of Evidence: High**



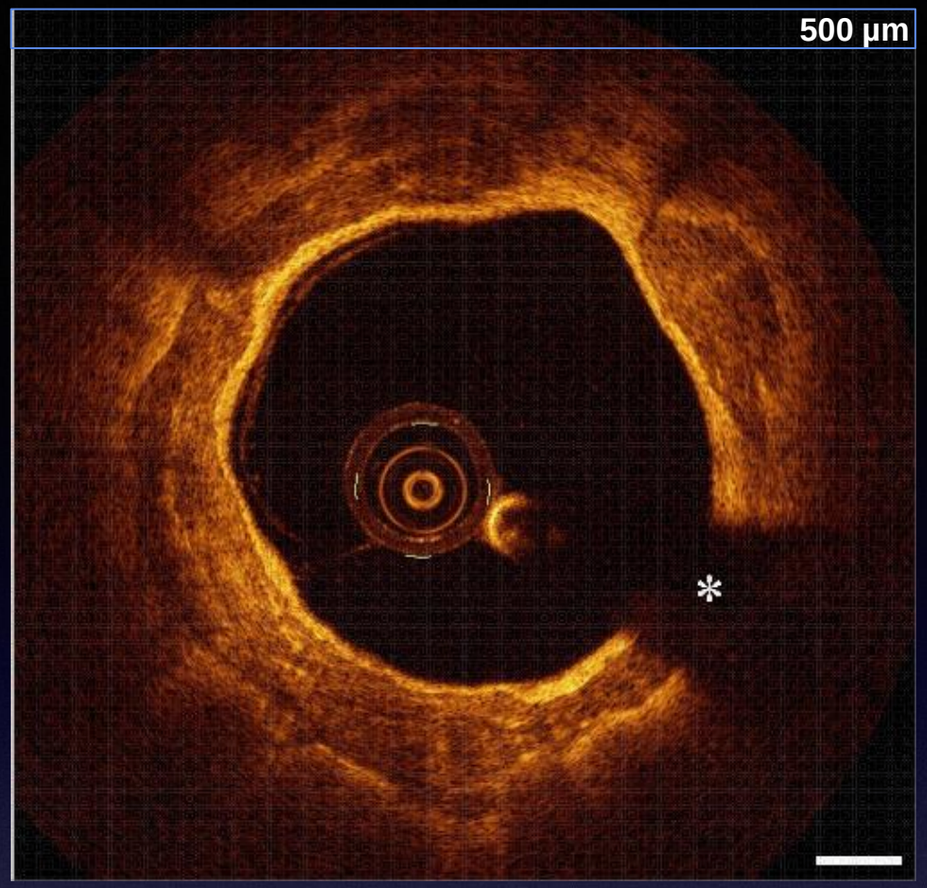
Fibrous Plaque

- **Description:**
  - High backscattering
  - Relatively homogeneous
- **Level of Evidence: High**

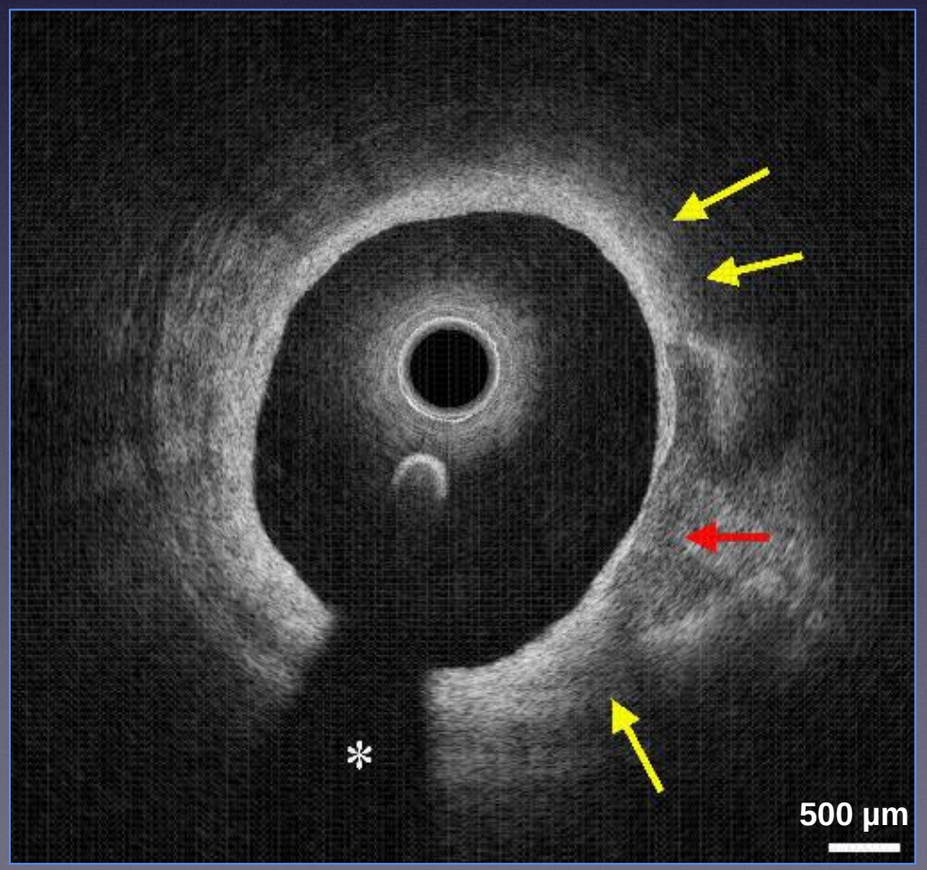


Fibrocalcific Plaque

- **Description:**
  - Evidence of fibrous tissue
    - Signal poor region
    - Sharply delineated borders
- **Level of Evidence: High**
- **Unknown:**
  - IVOCT appearance of microcalcifications

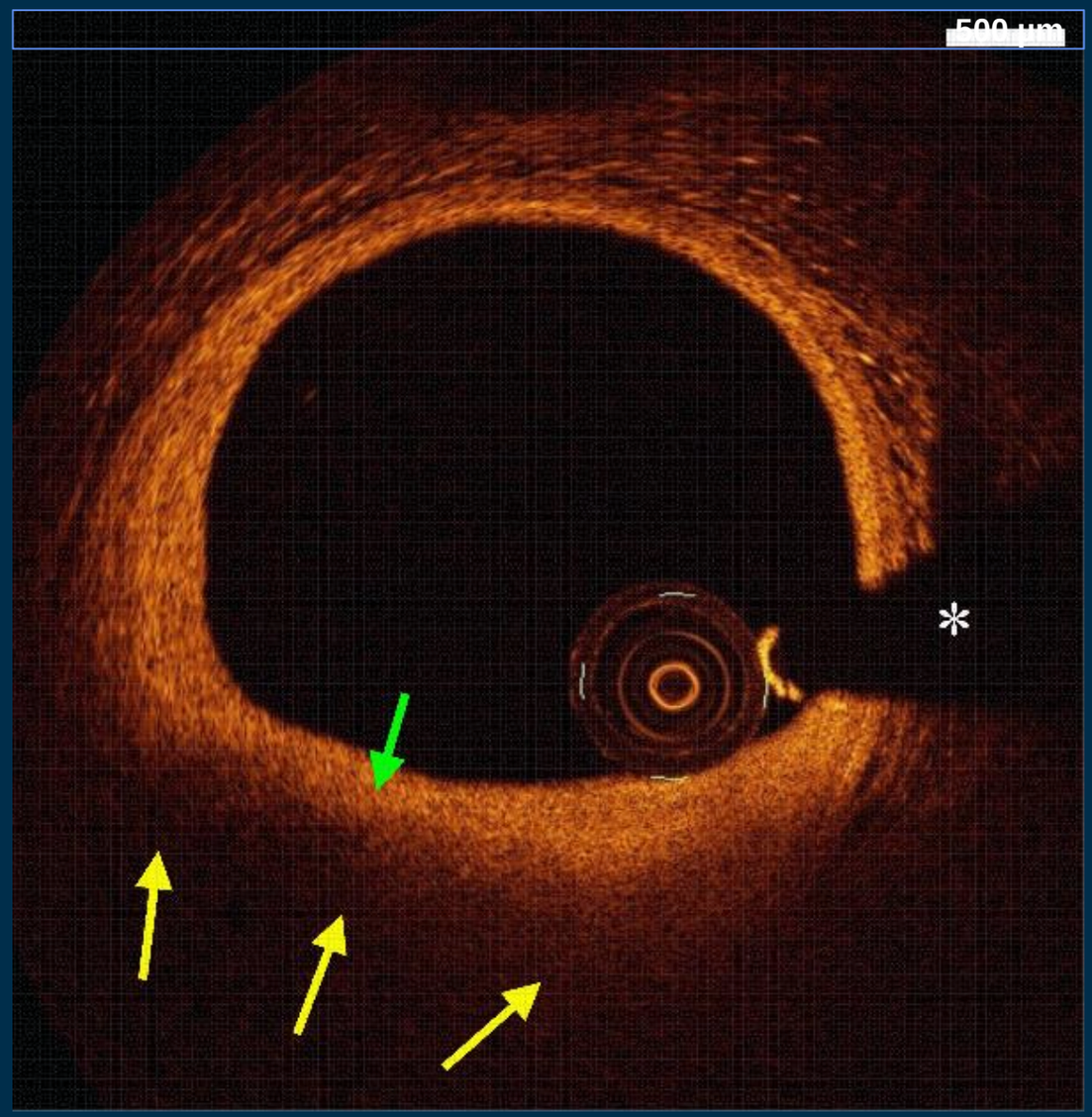


FD-OCT; Nieves Gonzalo Hospital Clinico San Carlos, Madrid; Lightlab/St. Jude C7 system.



Lipid Pool

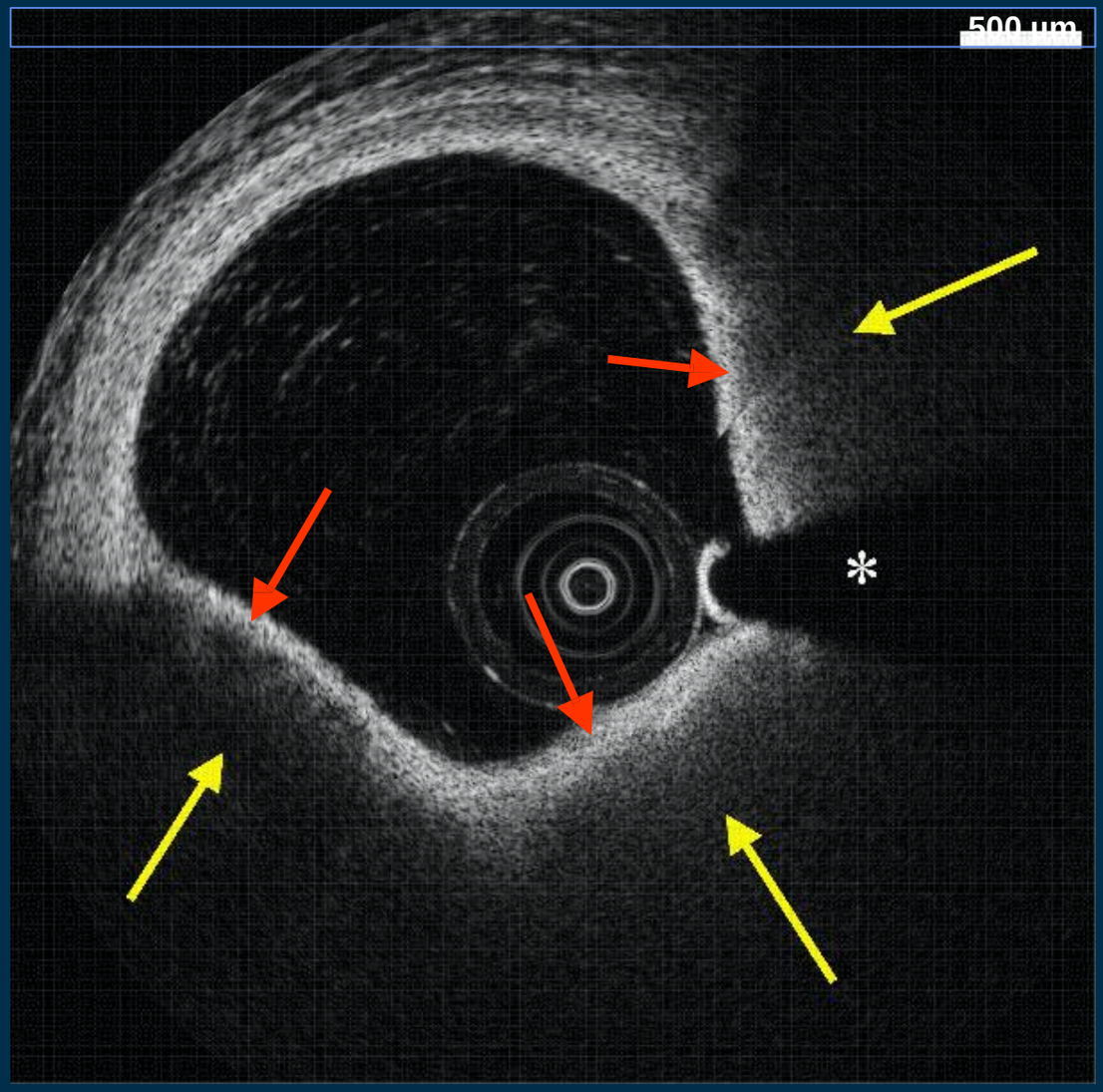
- **Deprecated term**
  - Either a necrotic core or
  - region within pathological intimal thickening that contains extracellular lipid or proteoglycans
- **Description:**
  - Signal poor region
  - Poorly delineated borders
- **Level of Evidence: High**



FD-OCT; Evelyn Regar, ERMC, Nieves Gonzalo, Hospital Clinico San Carlos, Madrid; Lightlab/St. Jude C7 system.

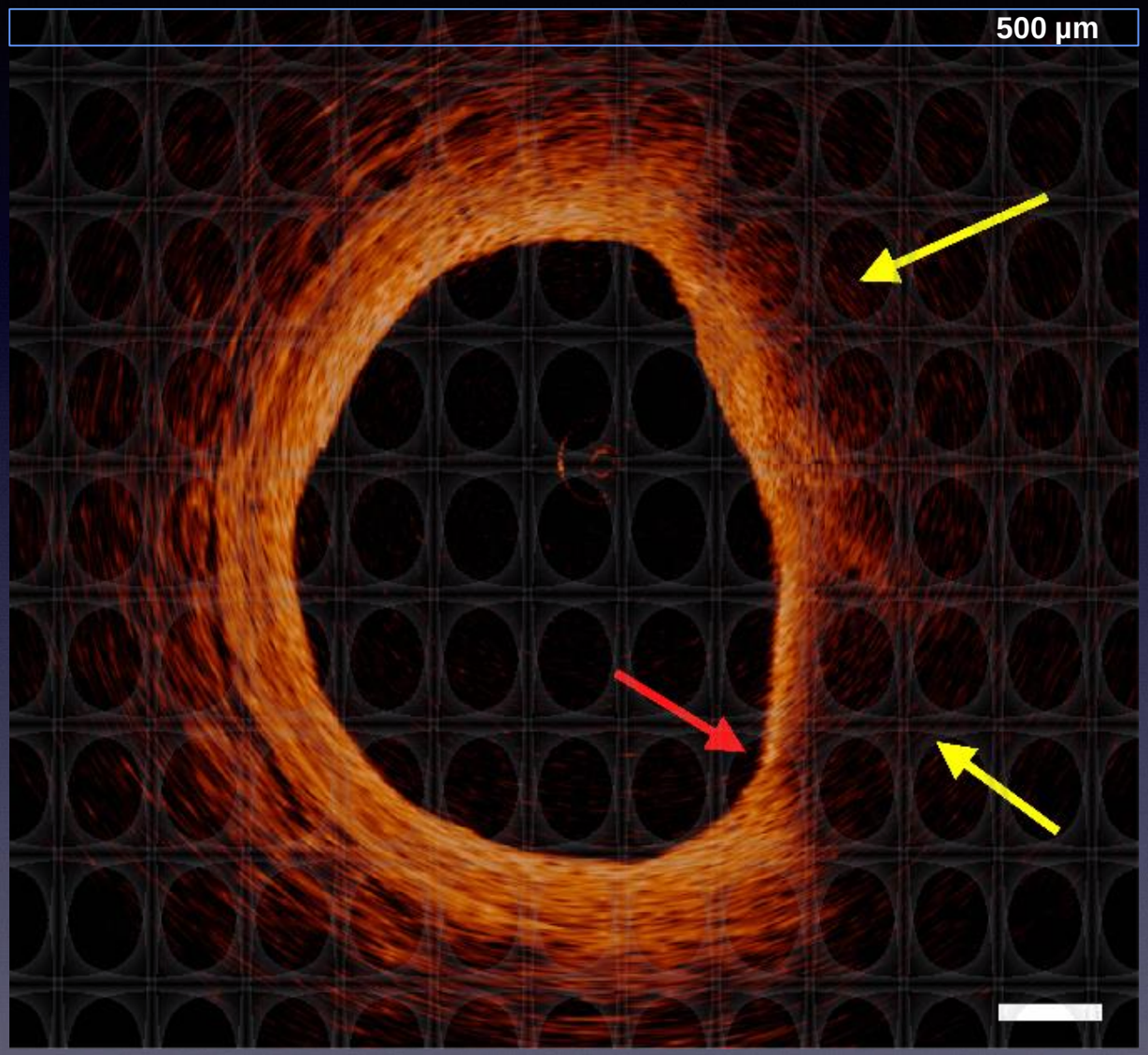
Necrotic Core

- **Description:**
  - Signal poor region
  - Poorly delineated borders
  - Fast signal drop-off
  - Covered by fibrous cap
- **Level of Evidence: Low**
- **Unknown:**
  - Relationship between “lipid pool” and necrotic core – recommendation that studies be conducted to answer this question



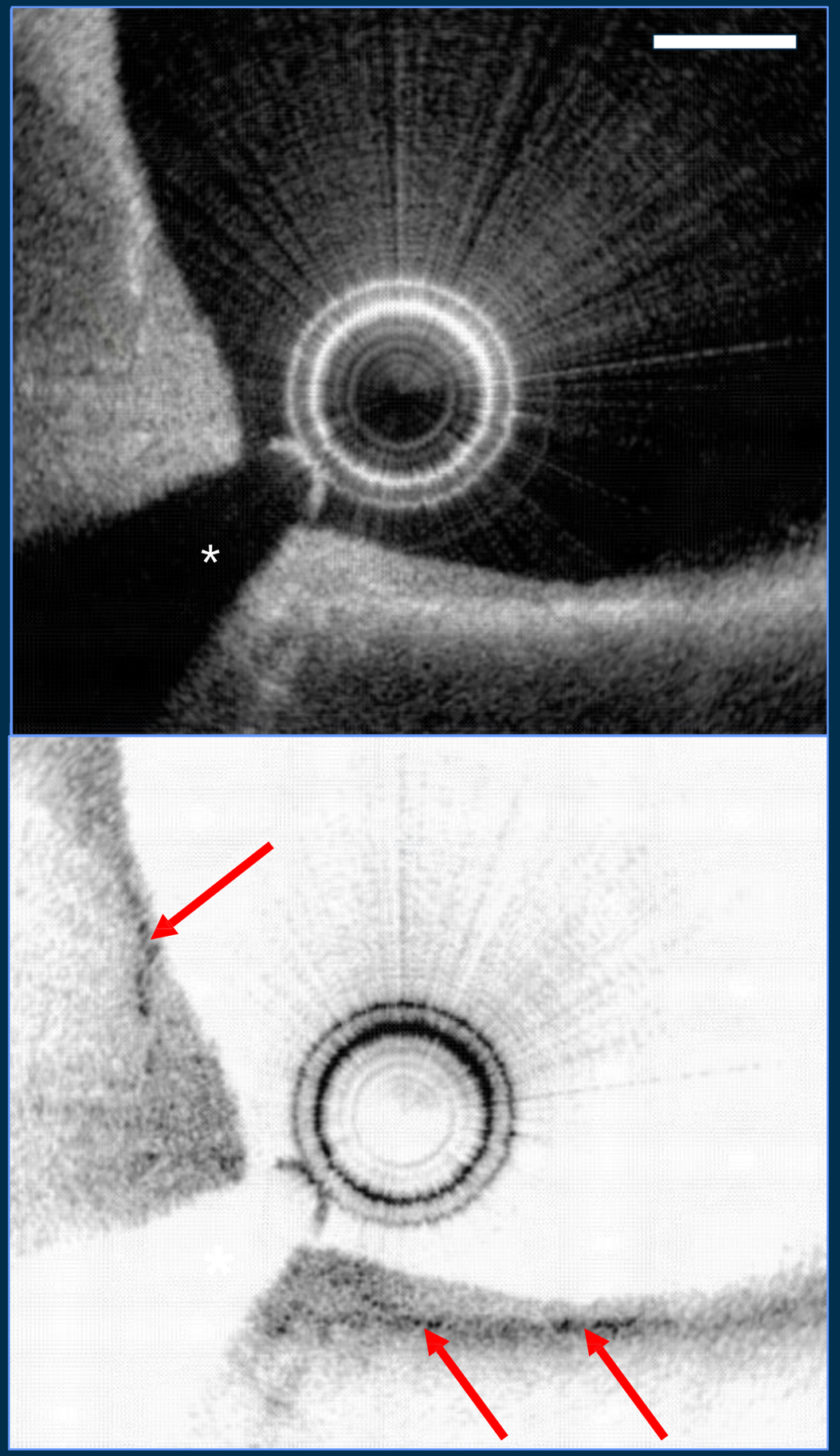
OCT Thin Capped Fibroatheroma (OCT-TCFA)

- **Description:**
  - OCT-delineated necrotic core
    - Overlying fibrous cap
  - Minimum thickness of the fibrous cap is less than a predetermined threshold
- **Level of Evidence:**
  High
- **Unknown:**
  - Relevance of number of quadrants



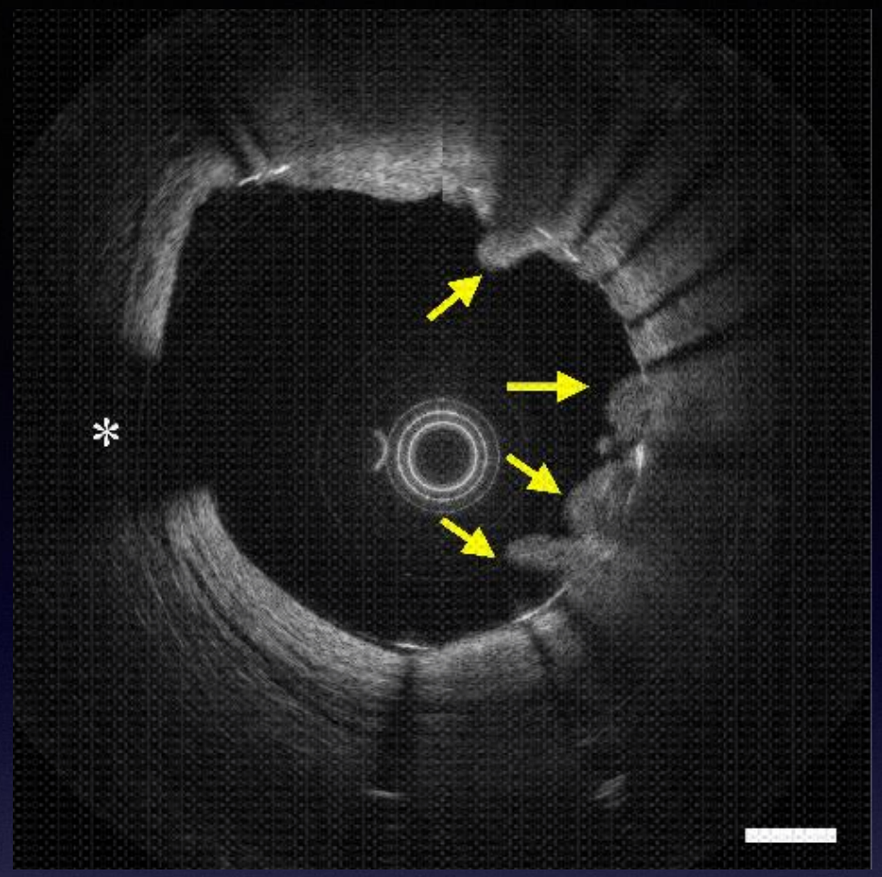
Macrophage Accumulations

- **Description:**
  - Defined only in plaque
  - Signal-rich, distinct or confluent punctate regions
  - Exceed the intensity of background noise
    - Can create shadows
- **Level of Evidence: Med**
- **Unknown:**
  - IVOCT ability to discriminate microcalcifications from macrophages



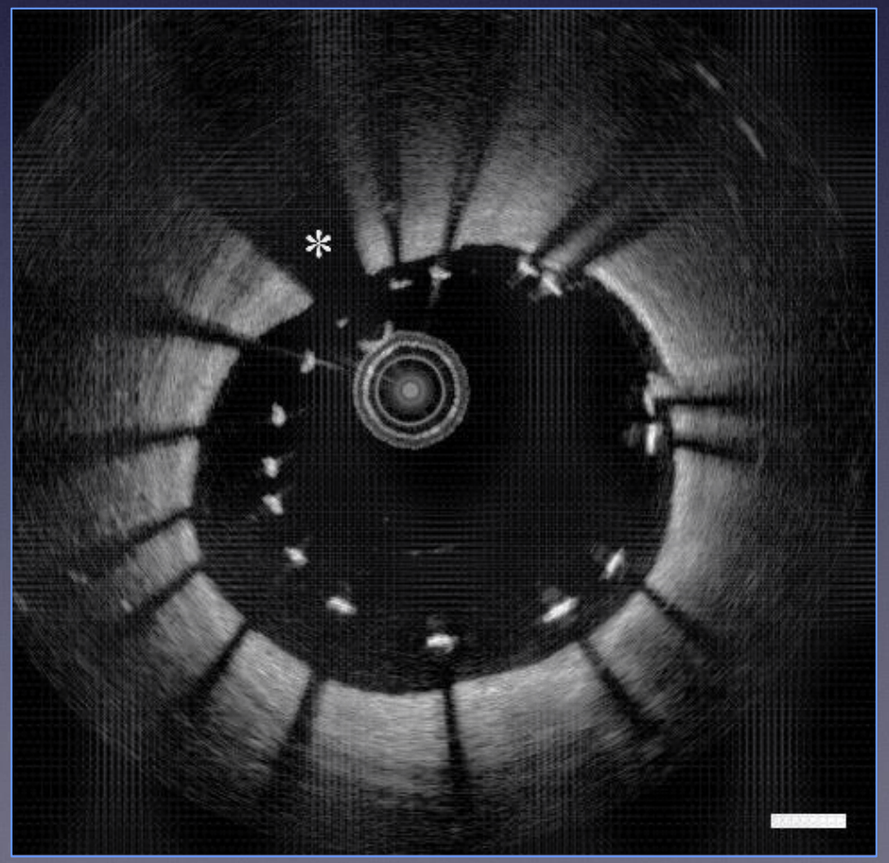
Prolapse

- **Description:**
  - Projection of tissue into the lumen between stent struts following implantation
- **Level of Evidence: High**



Malapposition

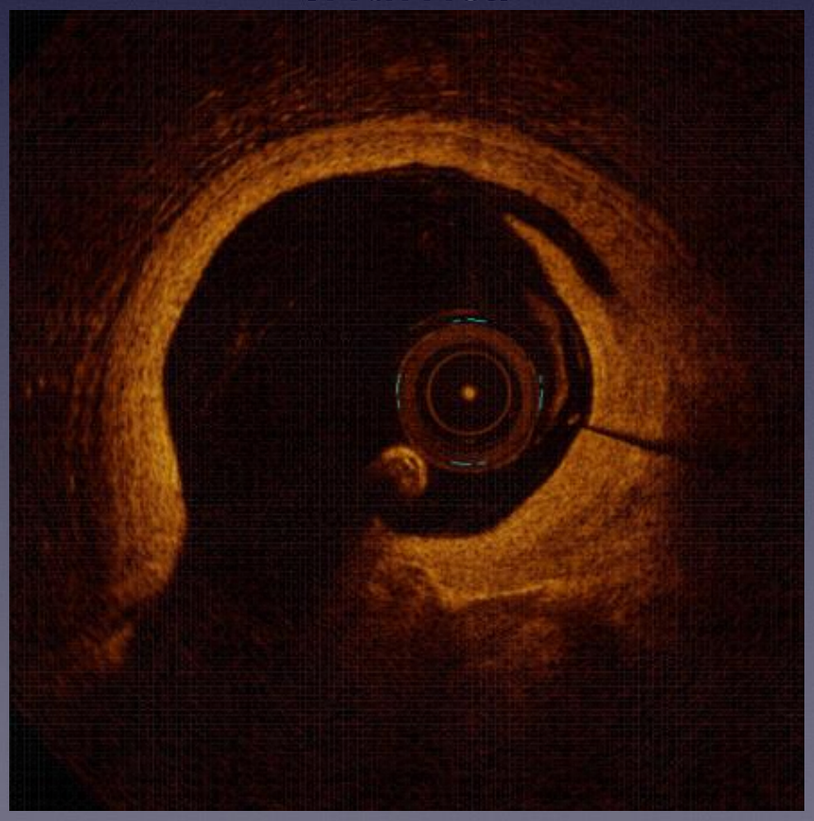
- **Description:**
  - Axial distance between the strut's surface to the luminal surface is greater than the strut thickness
- **Level of Evidence: High**



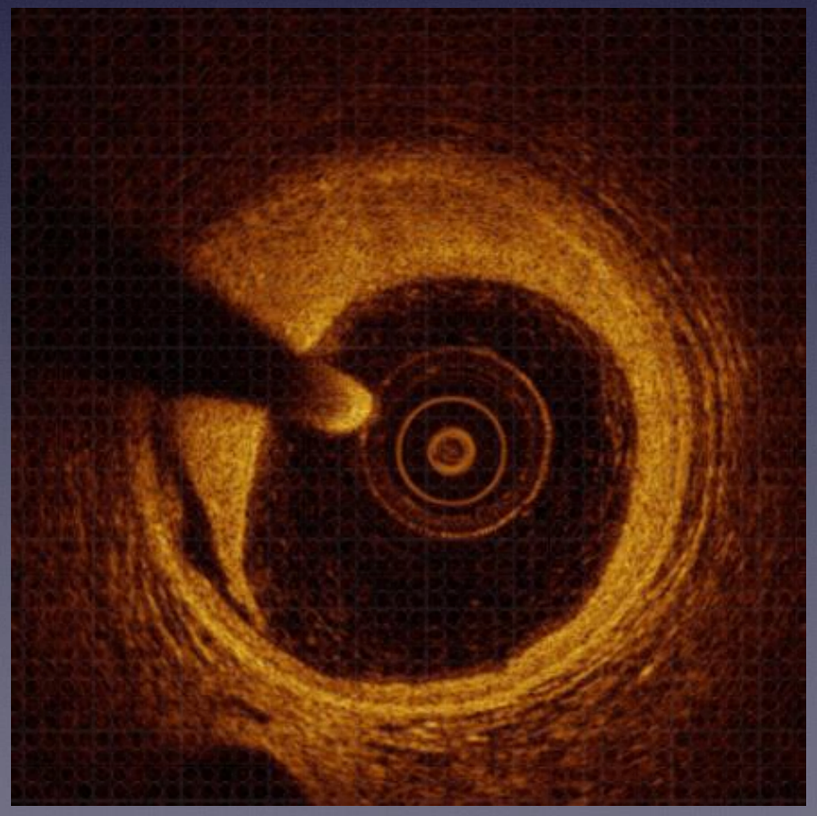
Dissections

- **Description:**
  - Disruption of vessel wall
  - Classification scheme same as that of IVUS
  - Can be seen at stent edge
- **Level of Evidence: High**

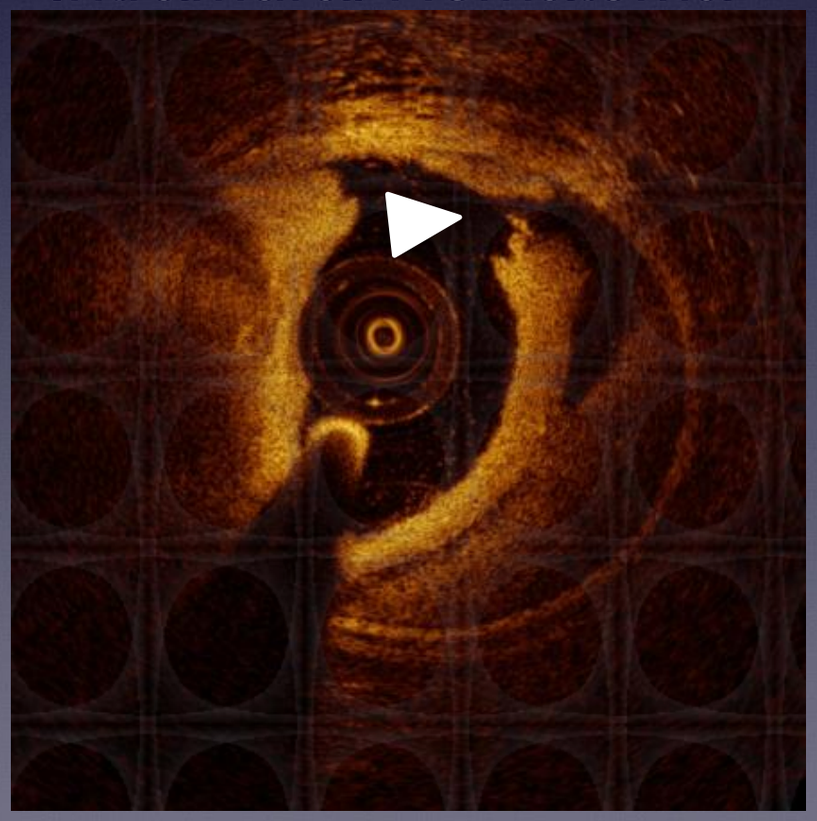
Intimal



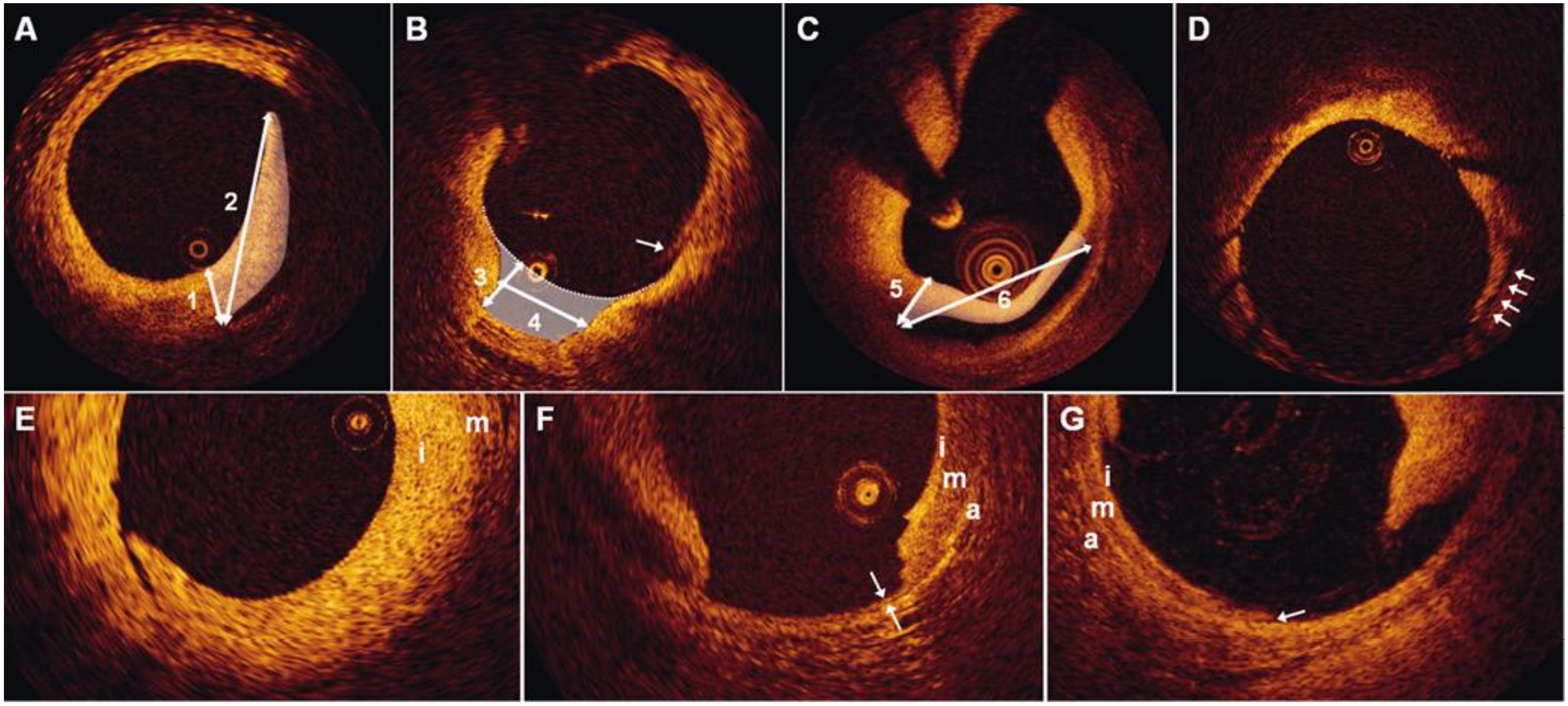
Medial



Intramural Hematoma



EuroIntervention



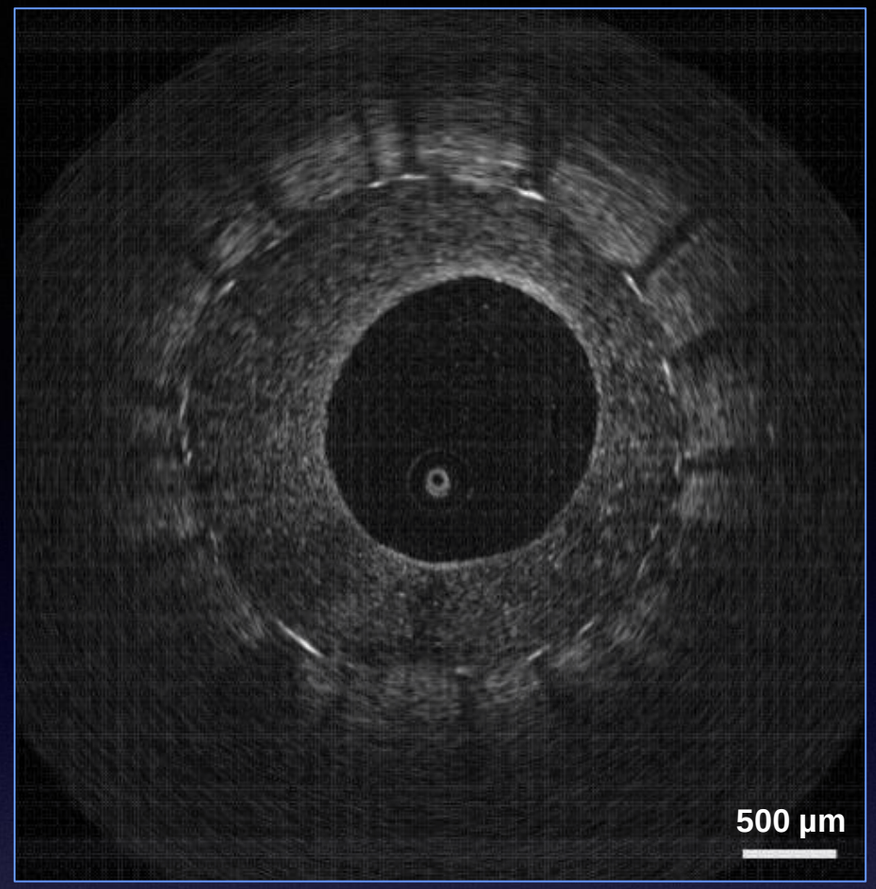
EuroIntervention 2014;9:1085-1094 published online ahead of print August 2013

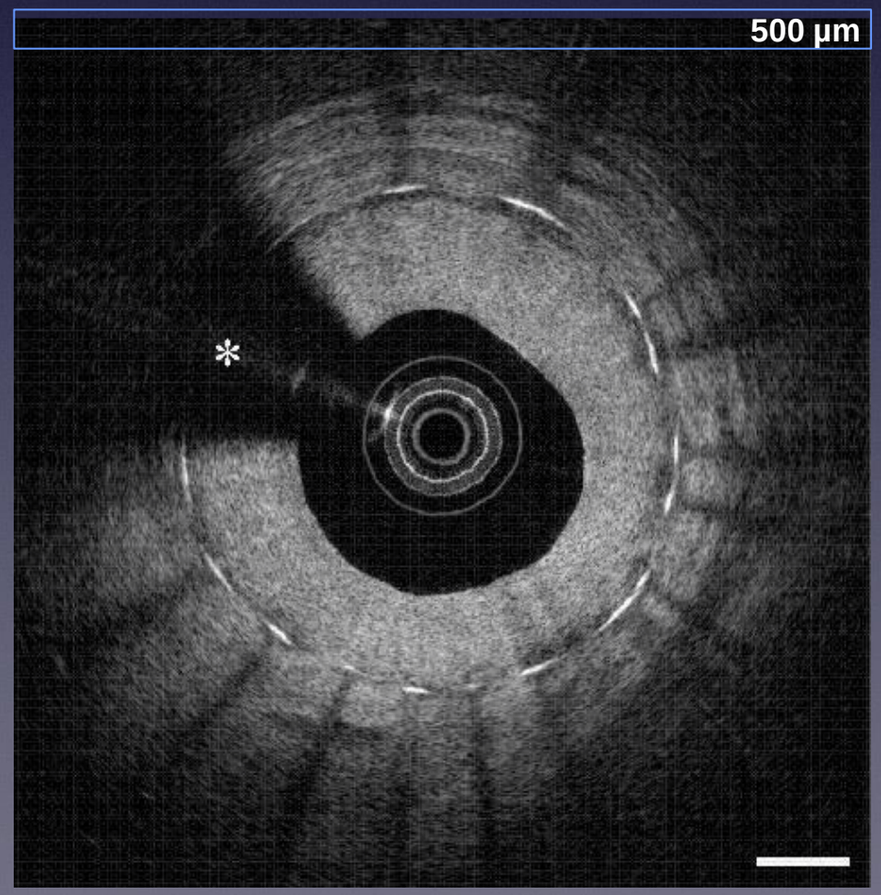
Natural history of optical coherence tomography-detected non-flow-limiting edge dissections follo wing drug-eluting stent implantation

M Radu , J Heo etc..

Restenosis

- **Description:**
  - signal-poor, layered, or signal-rich tissue overlying stent struts
- **Level of Evidence: High**
- **Unknown:**
  - Relationship between the IVOCT backscattering signal intensity and tissue composition





Role of OCT in PCI

- Pre-PCI
- During PCI
- Post-PCI

Lesion Evaluation

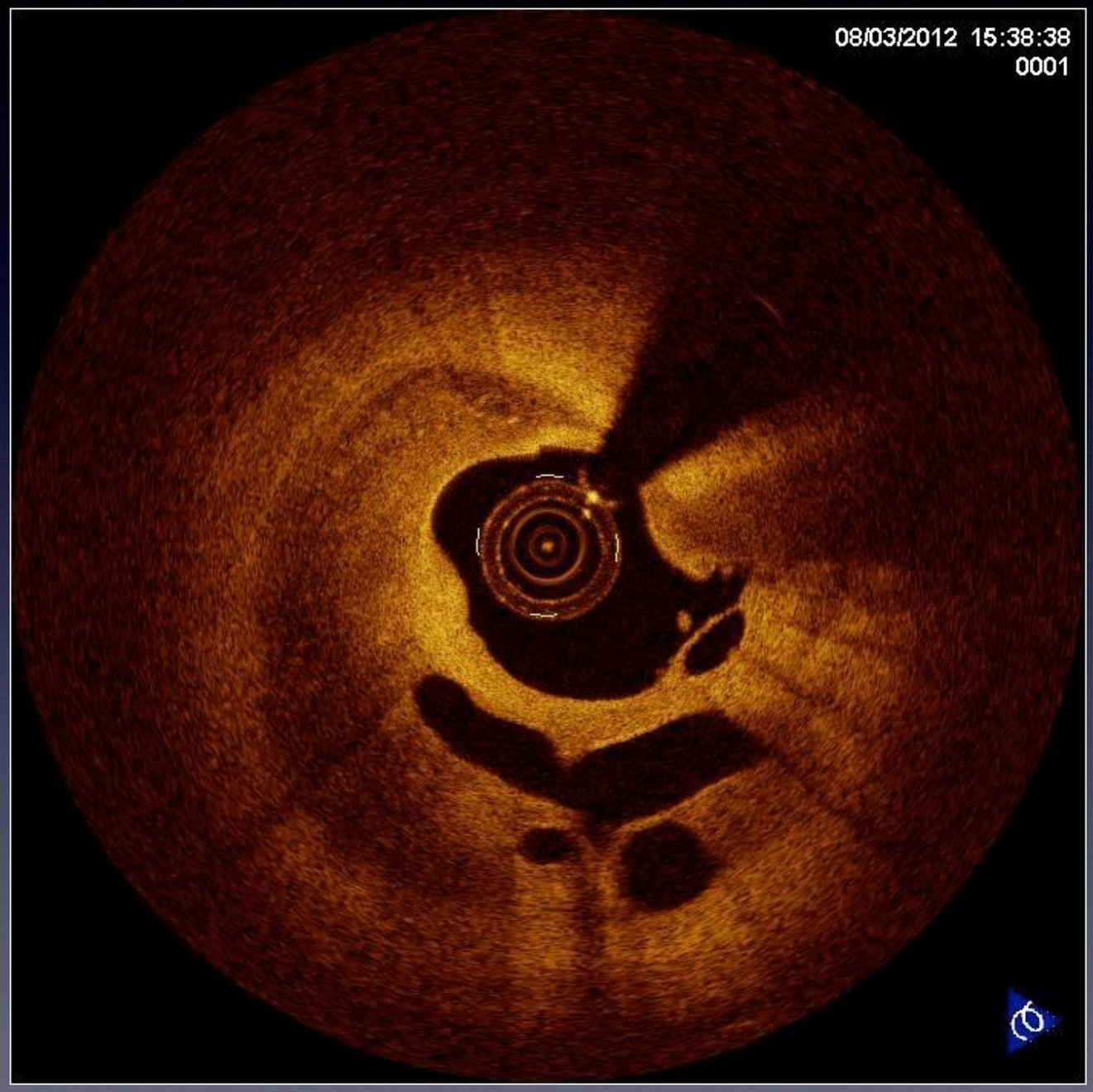
Guidance of Procedure

Therapeutic Result Evaluation

Role of OCT in PCI

- Pre-PCI
  - Diagnosis of CAD
  - Plaque Characterization
    - Complex Lesions
    - Ambiguous Lesions
    - Unclear Culprit Lesions

Precise Assessment of ambiguous lesion

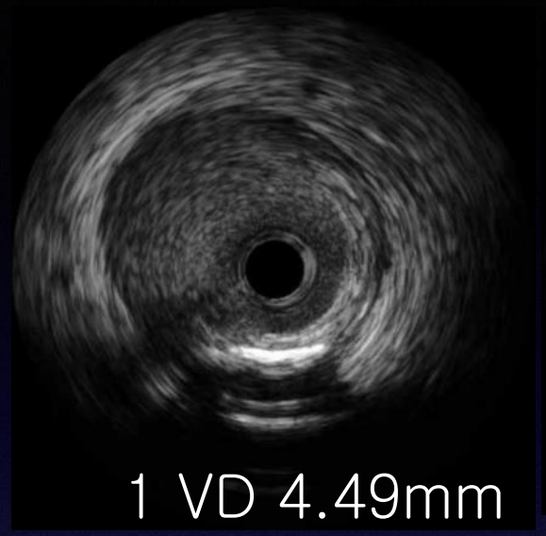


Courtesy by YHJ,Keimyung Univ. OCT Registry

Complex Lesion

How to Treat This Lesion ??

Keimyung Univ. OCT Registry



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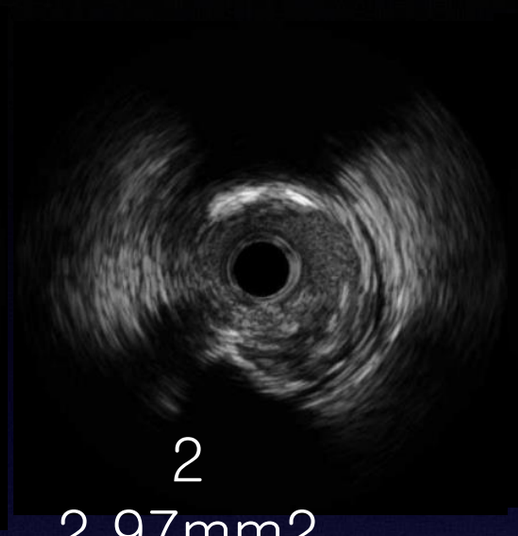
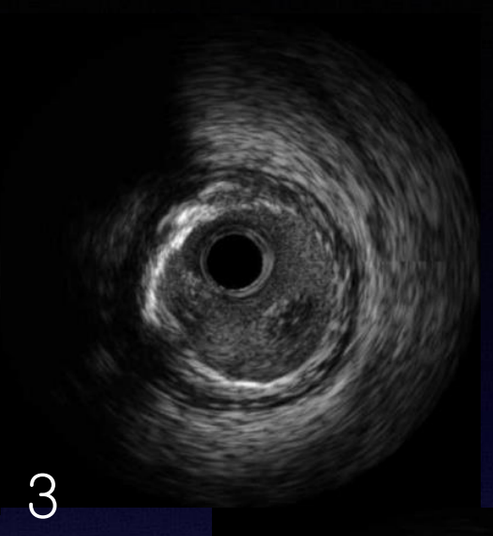
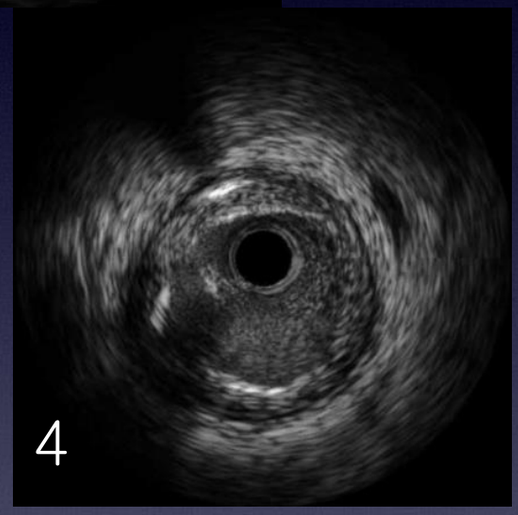


2
2.97mm2

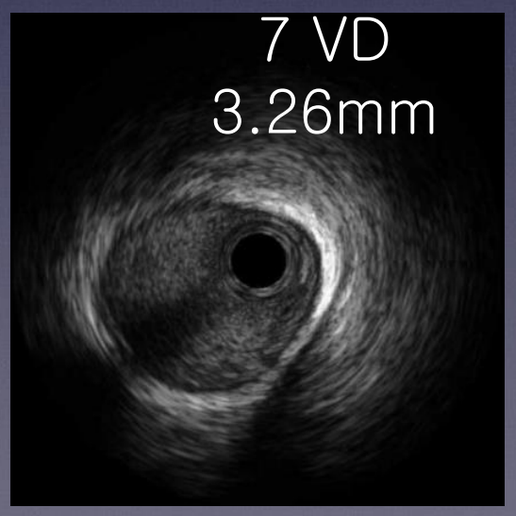


3

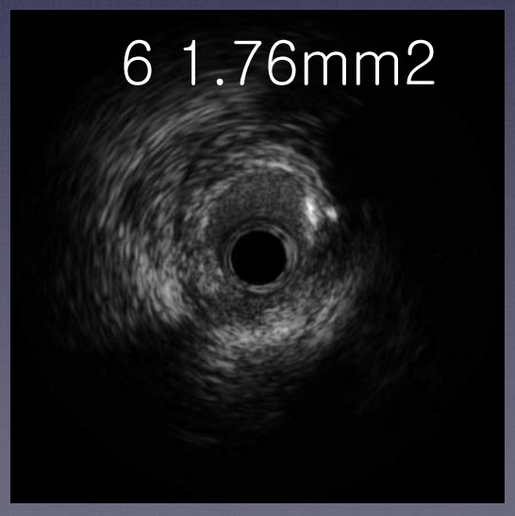
Proximal→



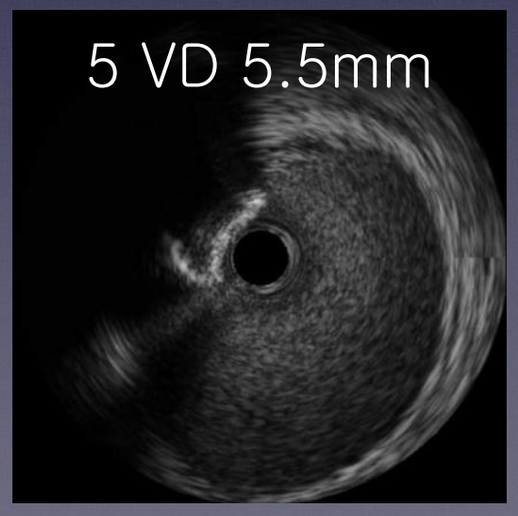
←Distal



7 VD
3.26mm

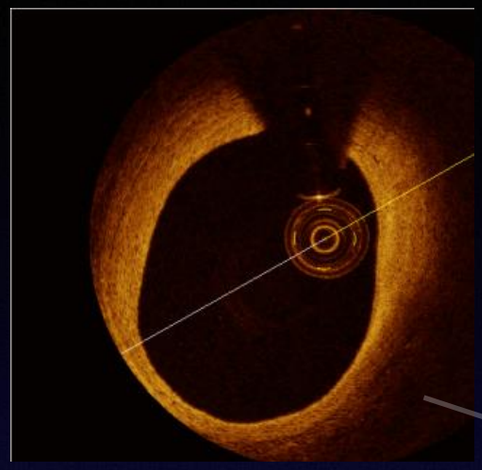


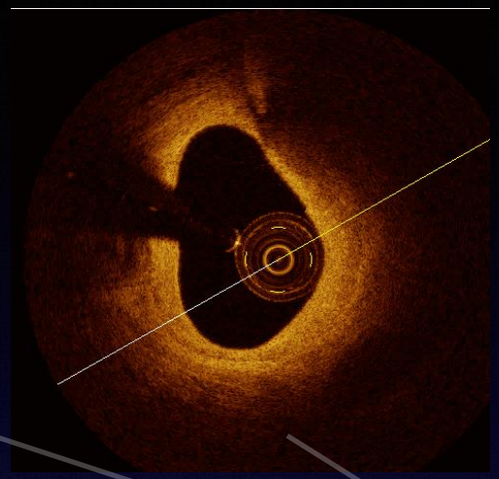
6 1.76mm2

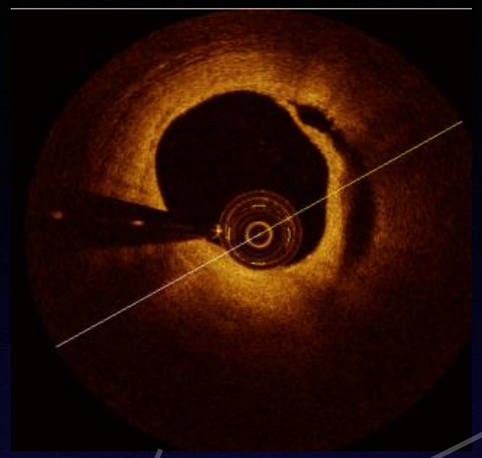


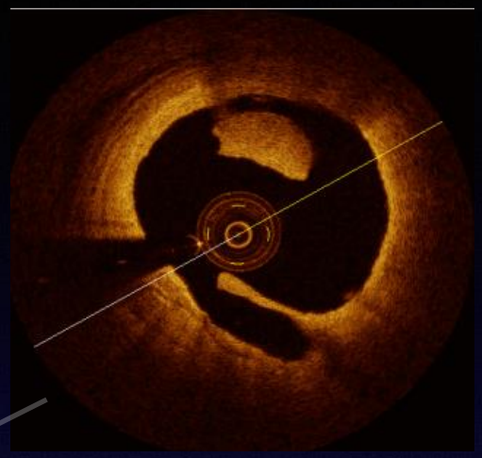
5 VD 5.5mm

Courtesy by YHJ,Keimyung Univ. OCT Registry

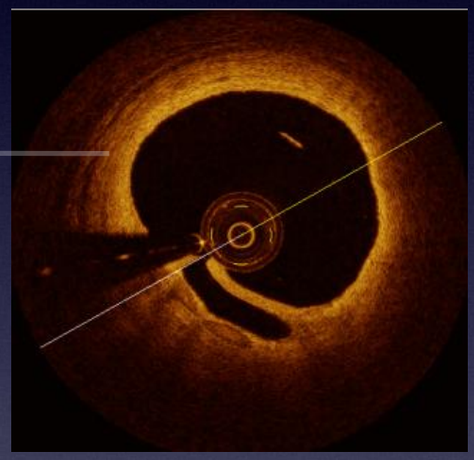




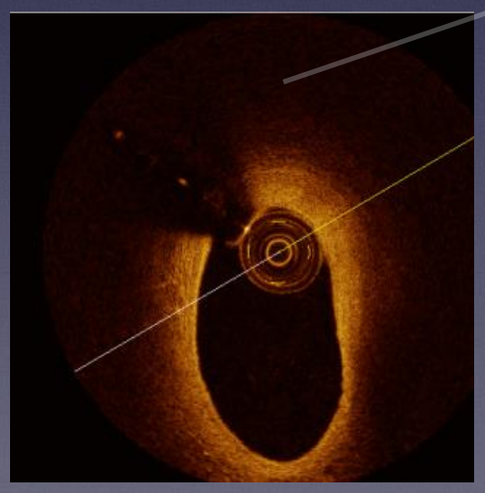


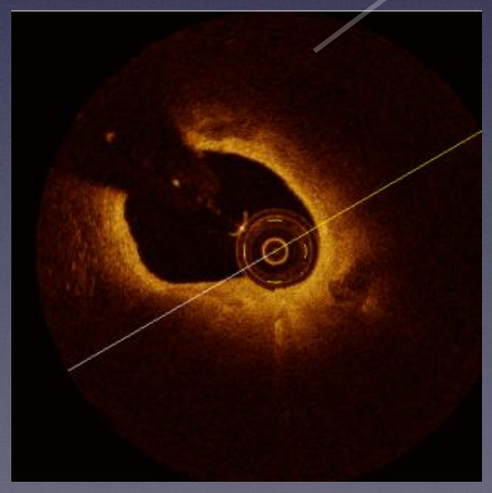


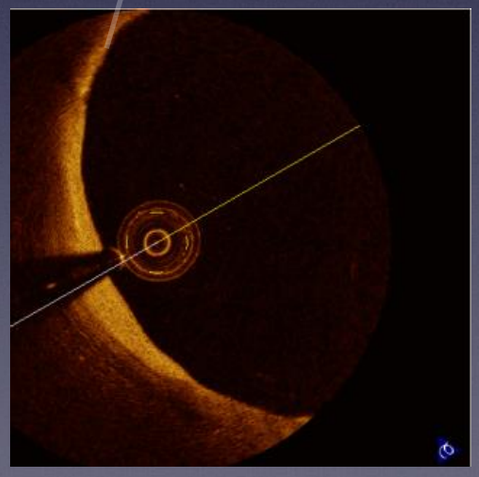
Proximal→

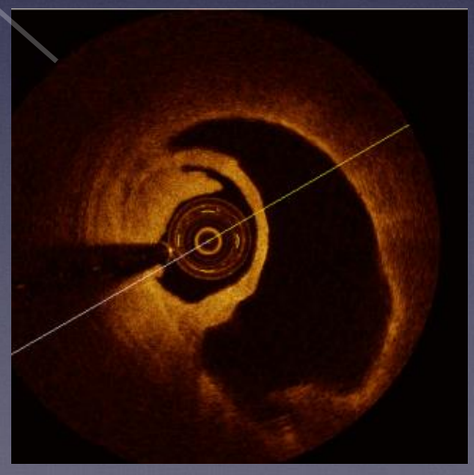


←Distal



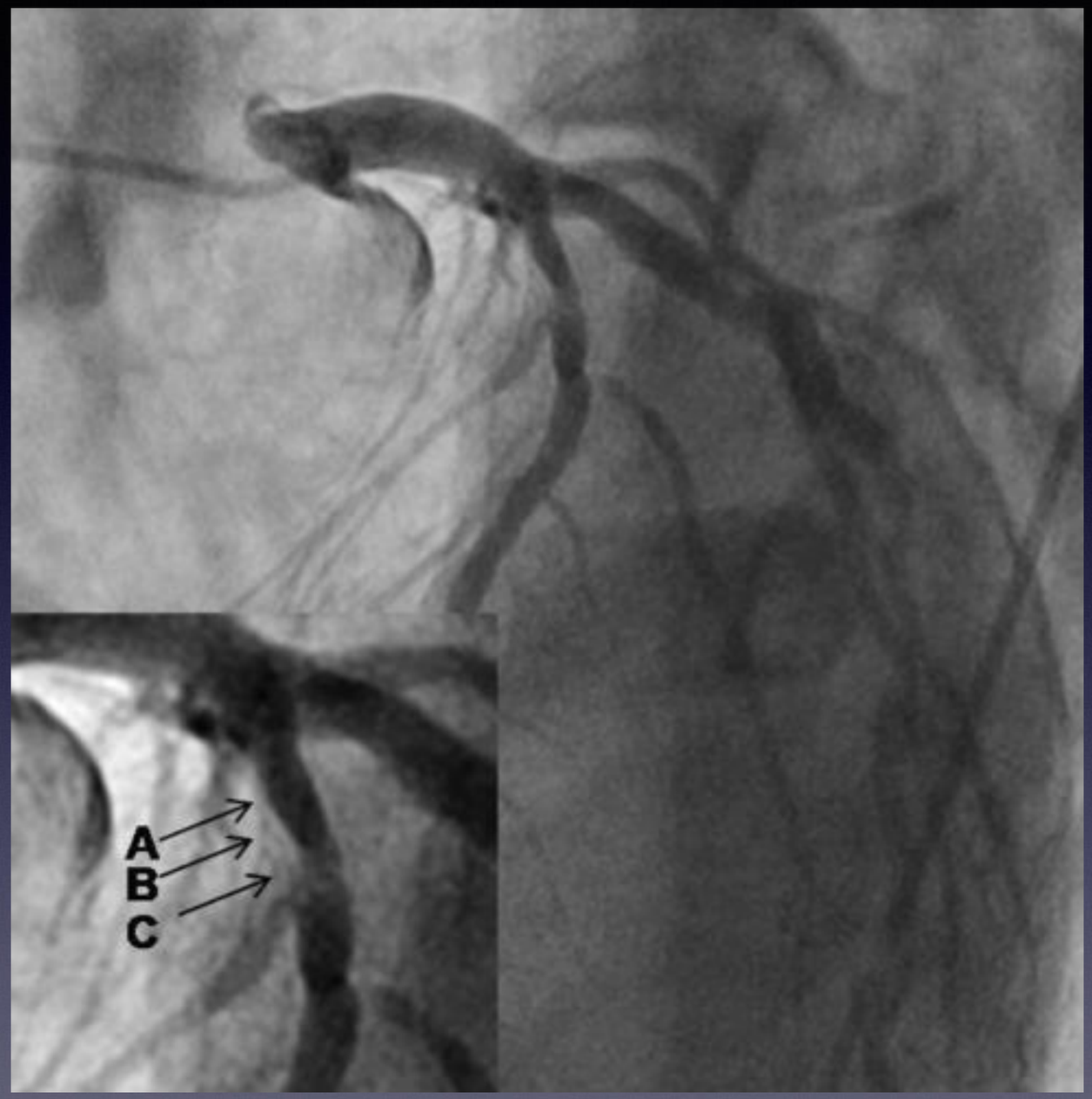






Courtesy by YHJ,Keimyung Univ. OCT Registry

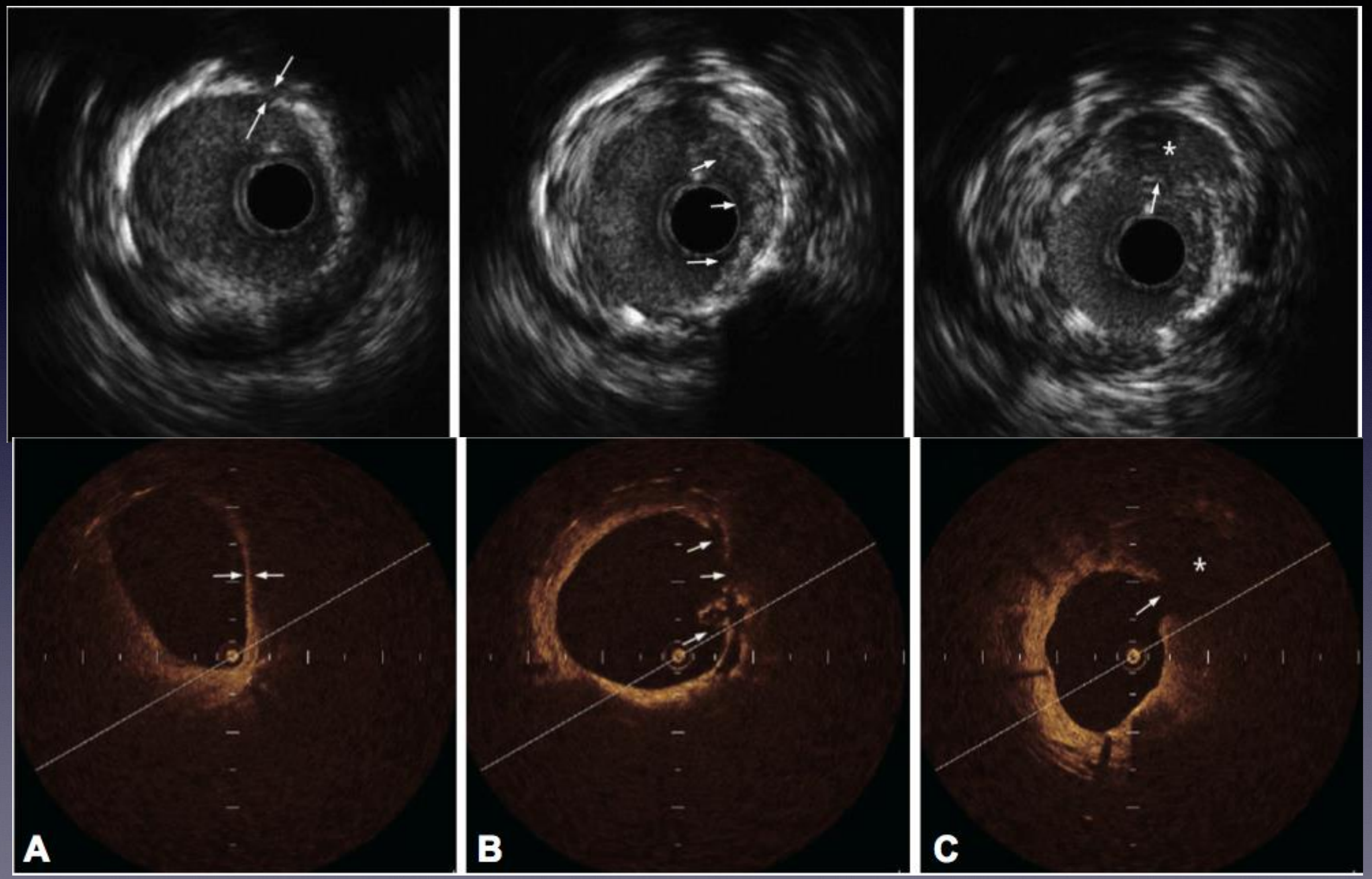
Ambiguous Lesion Evaluation



A case of ACS 10 Yrs after BMS implantation

HJ Yoon, et al.
KCJ, 2011.41

Precise Assessment of ambiguous lesion



Role of OCT in PCI

- Pre-PCI
- During PCI
- Post-PCI

Role of OCT in PCI

- During PCI

Decision of Optimal Strategy

Determination of Stent Optimization

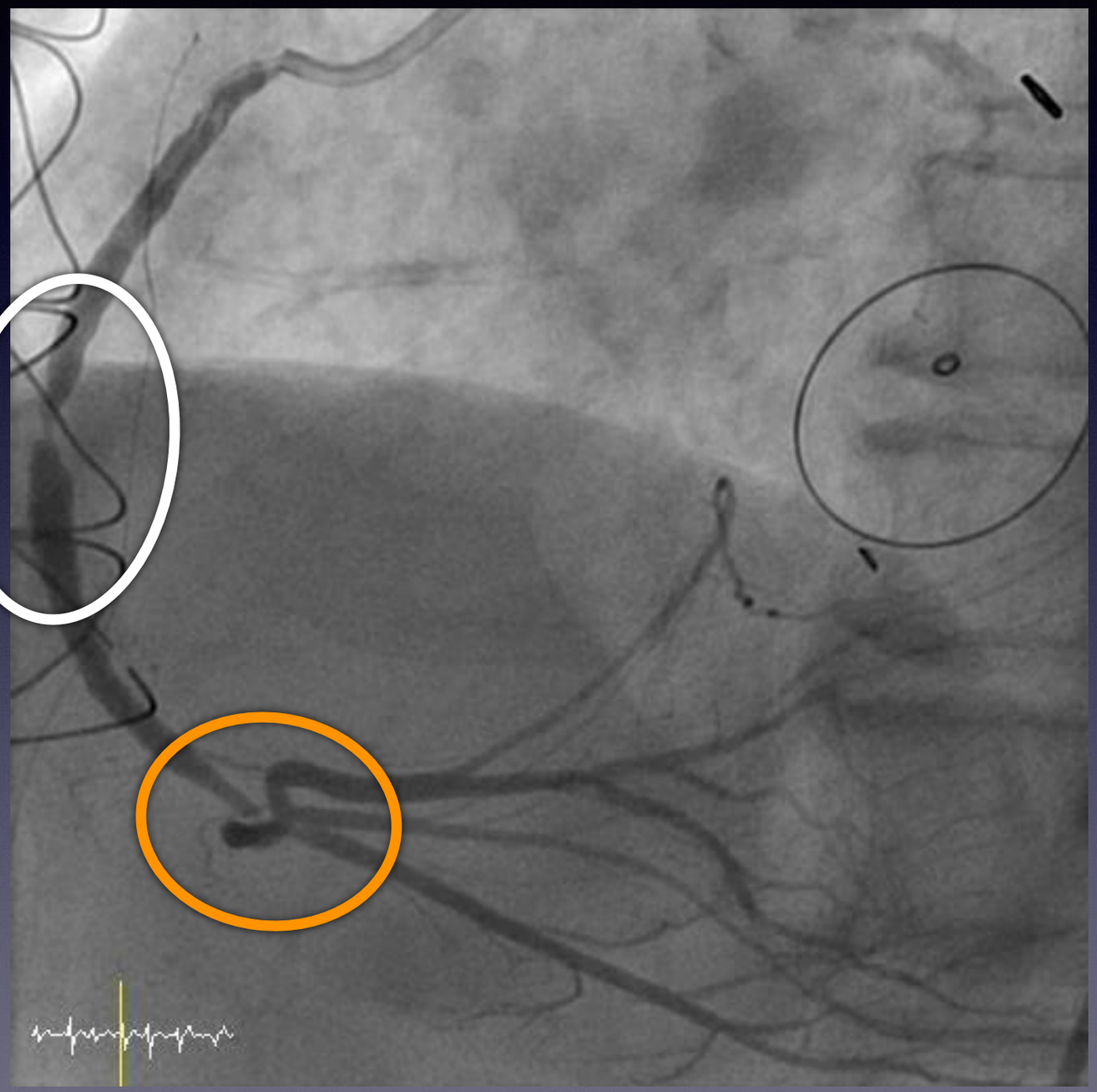
Detection of Acute Stent Related Complication

Decision of Optimal Strategy

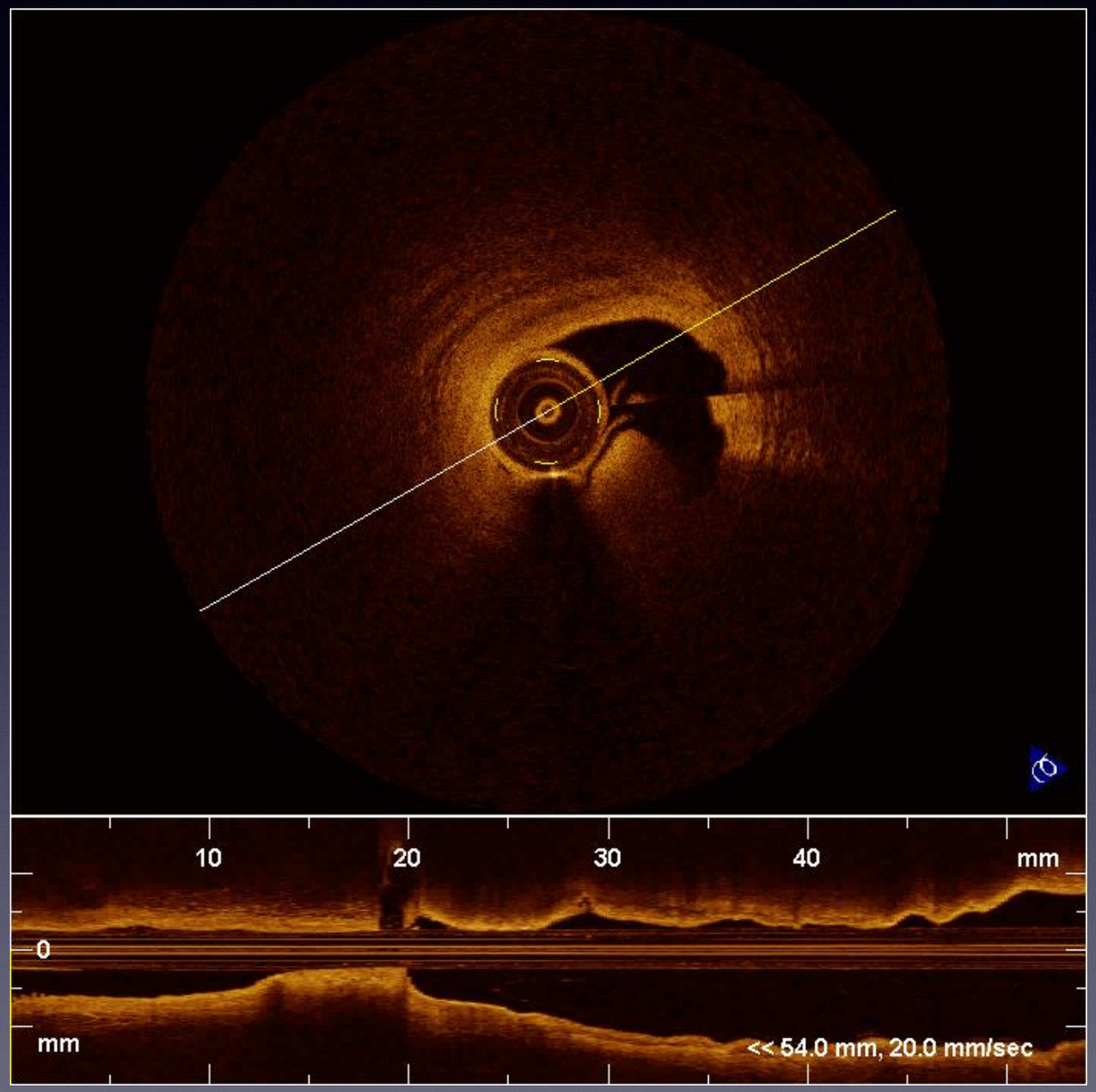
77YO MALE

CABG 20YR

SVG Failure

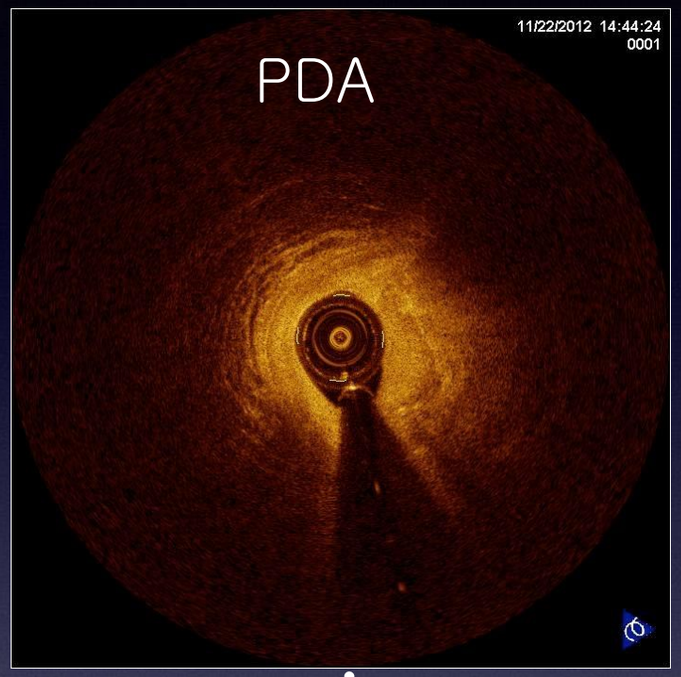


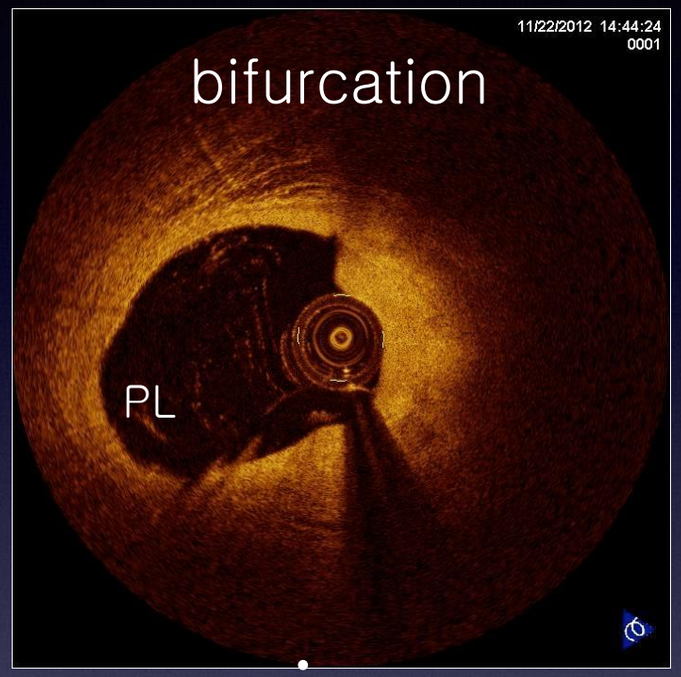
Decision of Optimal Strategy

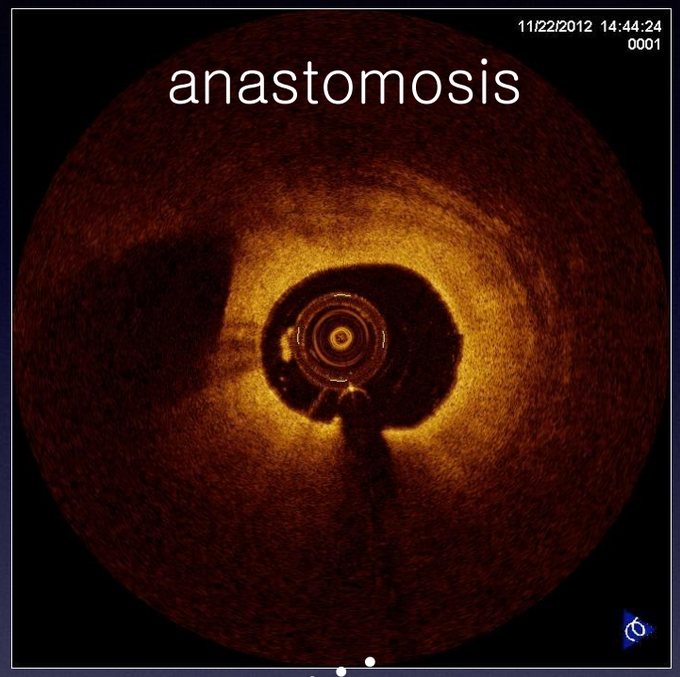


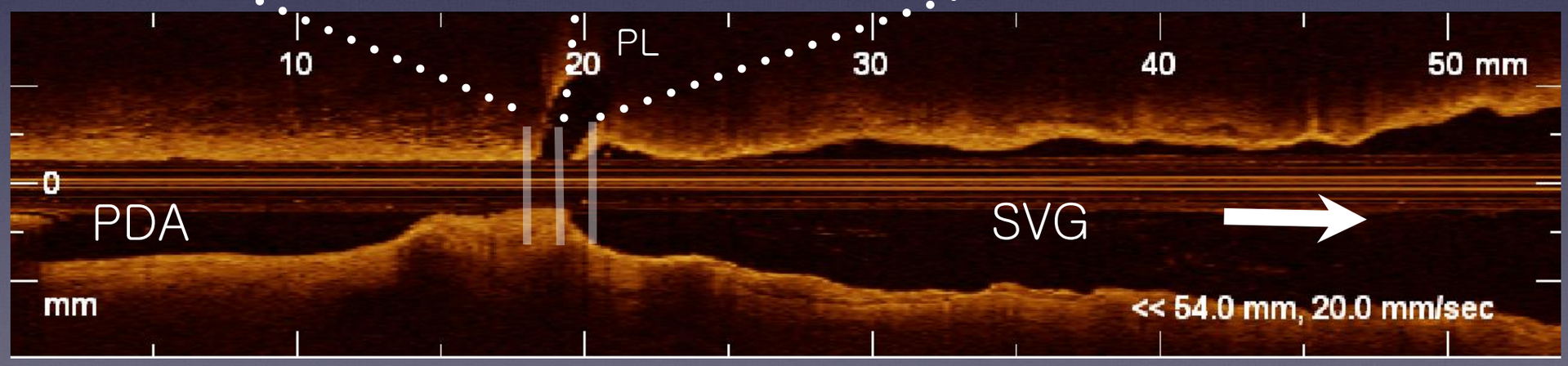
Courtesy by YHJ,Keimyung Univ. OCT Registry

Decision of Optimal Strategy



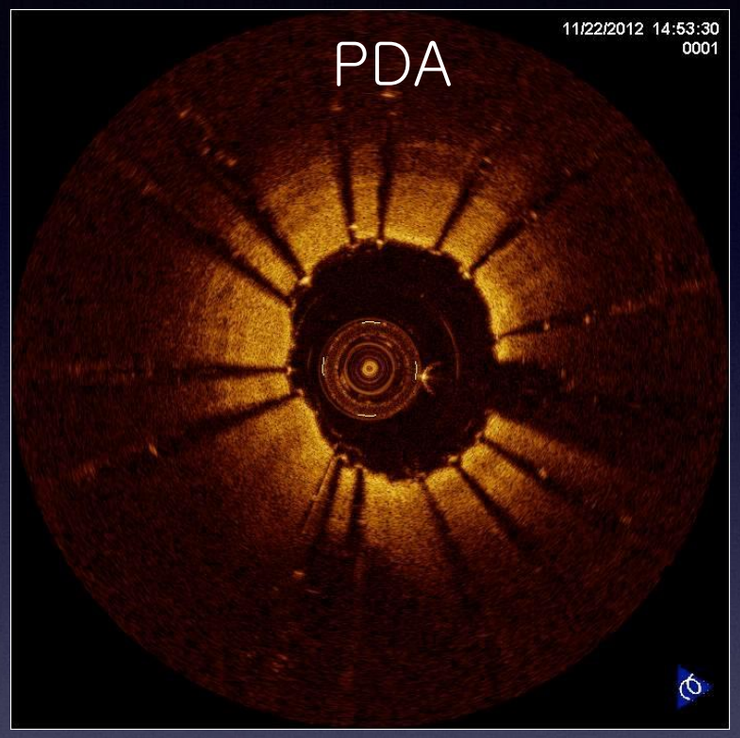


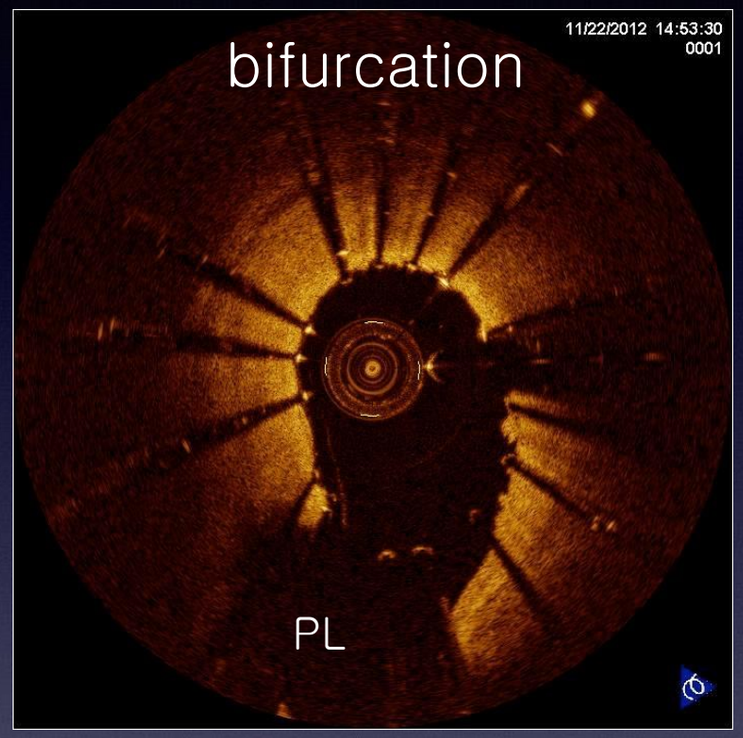


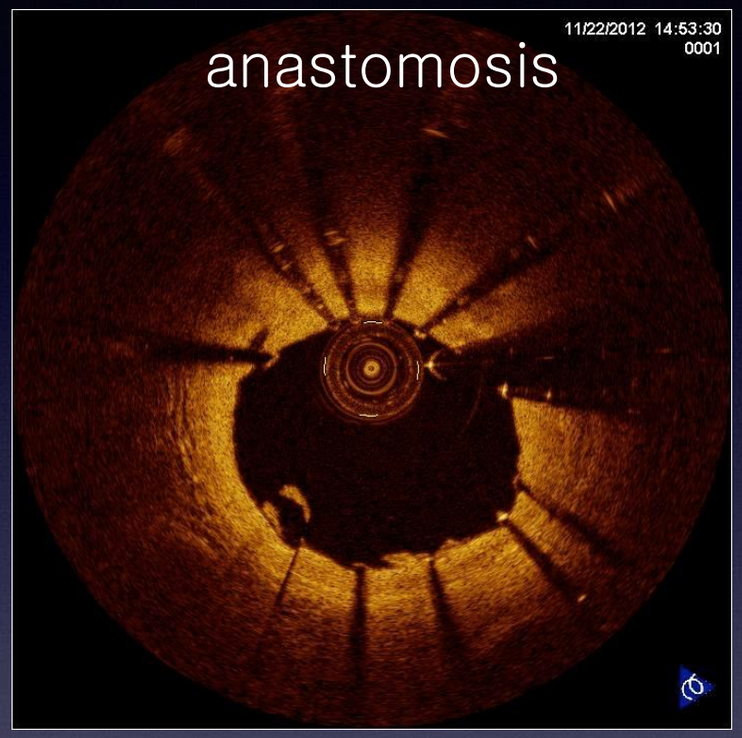


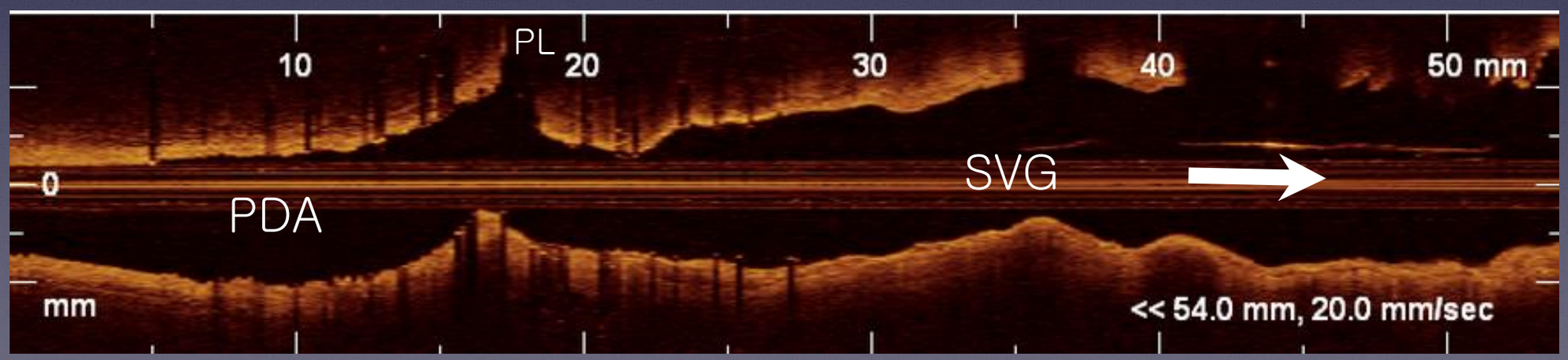
Courtesy by YHJ,Keimyung Univ. OCT Registry

Decision of Optimal Strategy







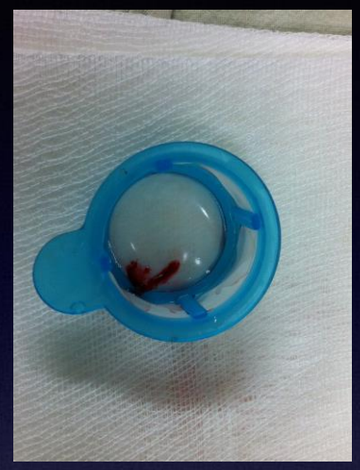


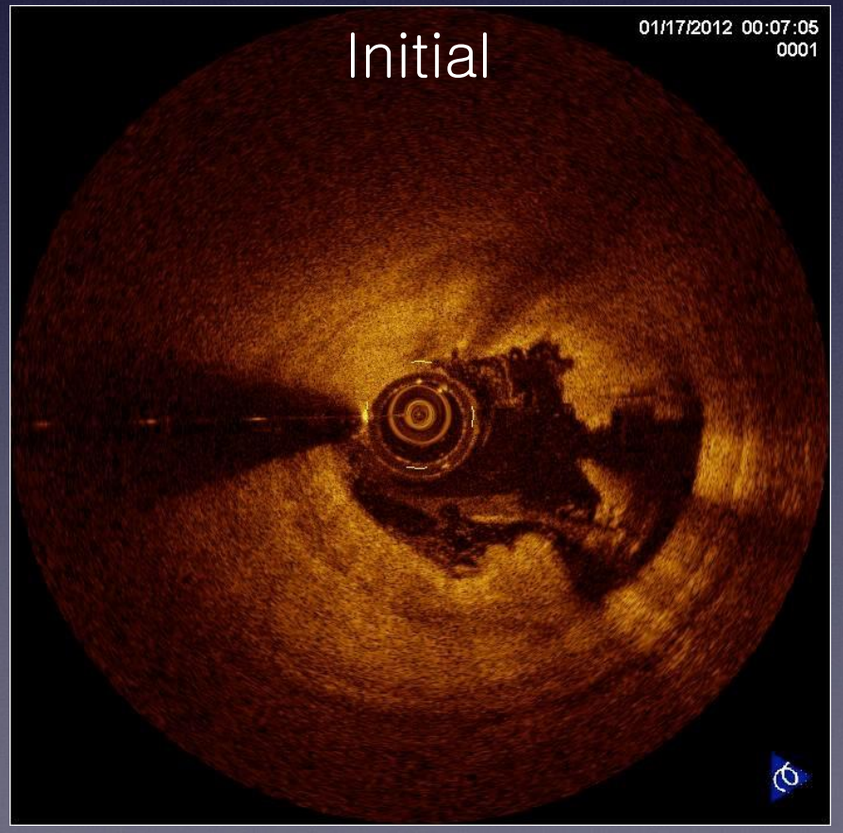
Courtesy by YHJ,Keimyung Univ. OCT Registry

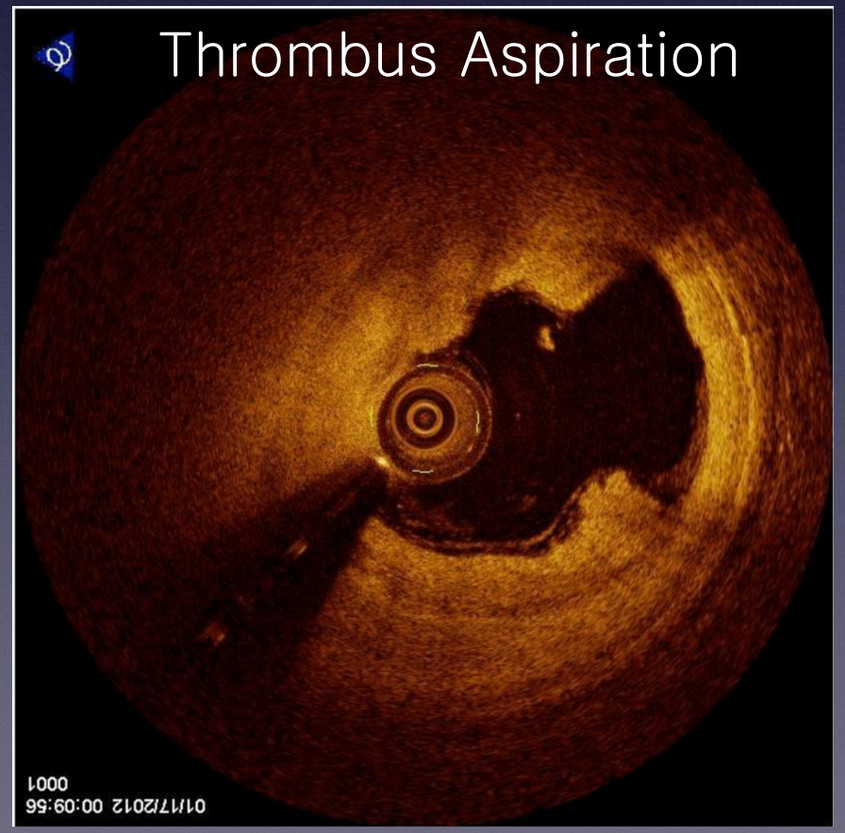
Decision of Optimal Strategy

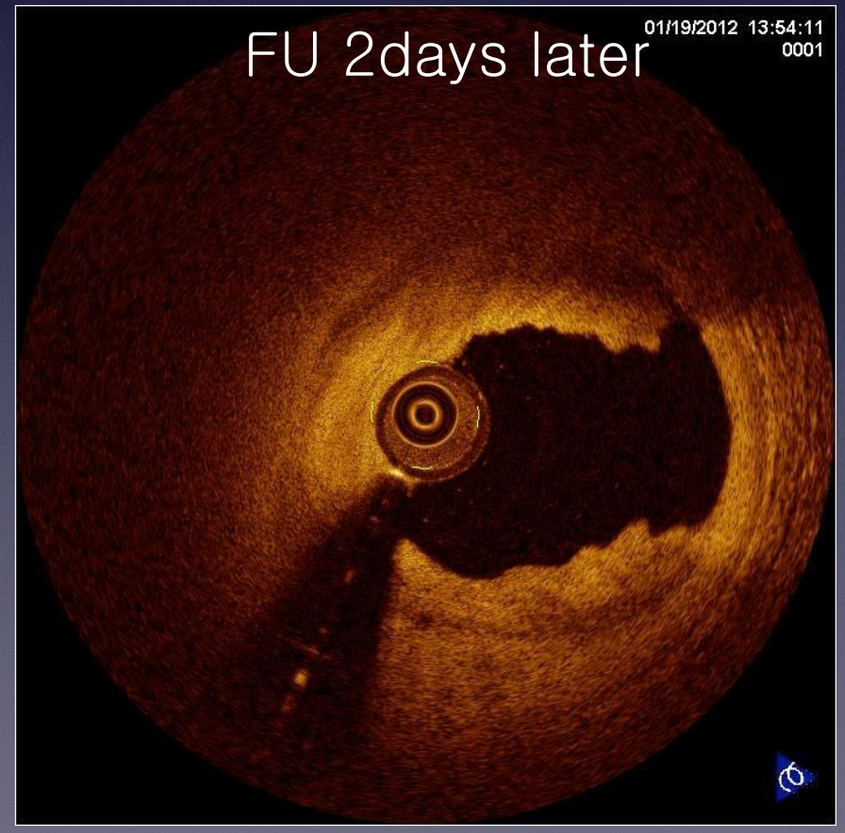
50YO Male

ACS









Courtesy by YHJ,Keimyung Univ. OCT Registry

Role of OCT in PCI

- Pre-PCI
- During PCI
- Post-PCI

Role of OCT in PCI

- Post-PCI

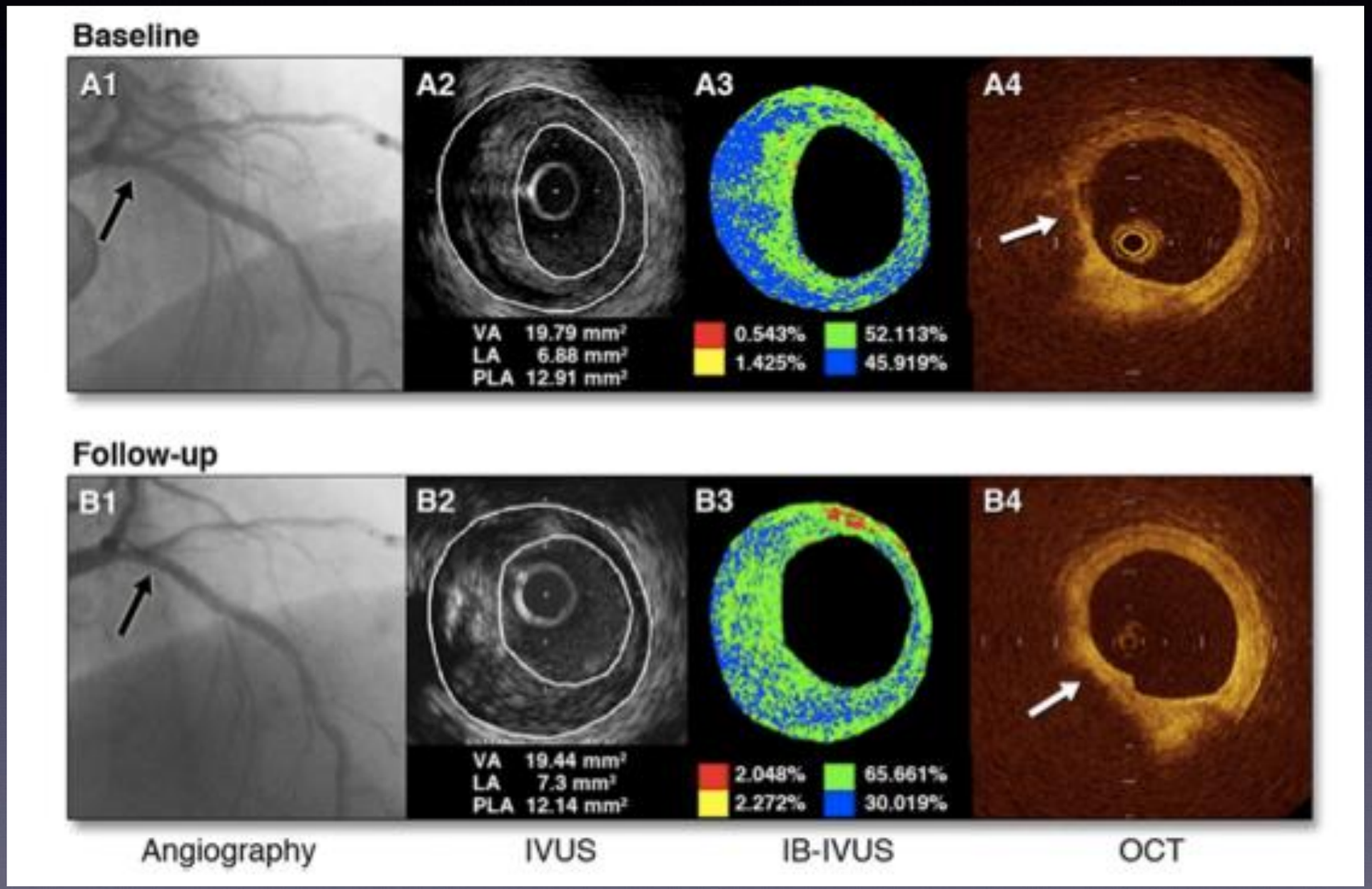
  Determination of Therapeutic Response

  Evaluation of Stent Restenosis

  Evaluation of Stent aneurysm

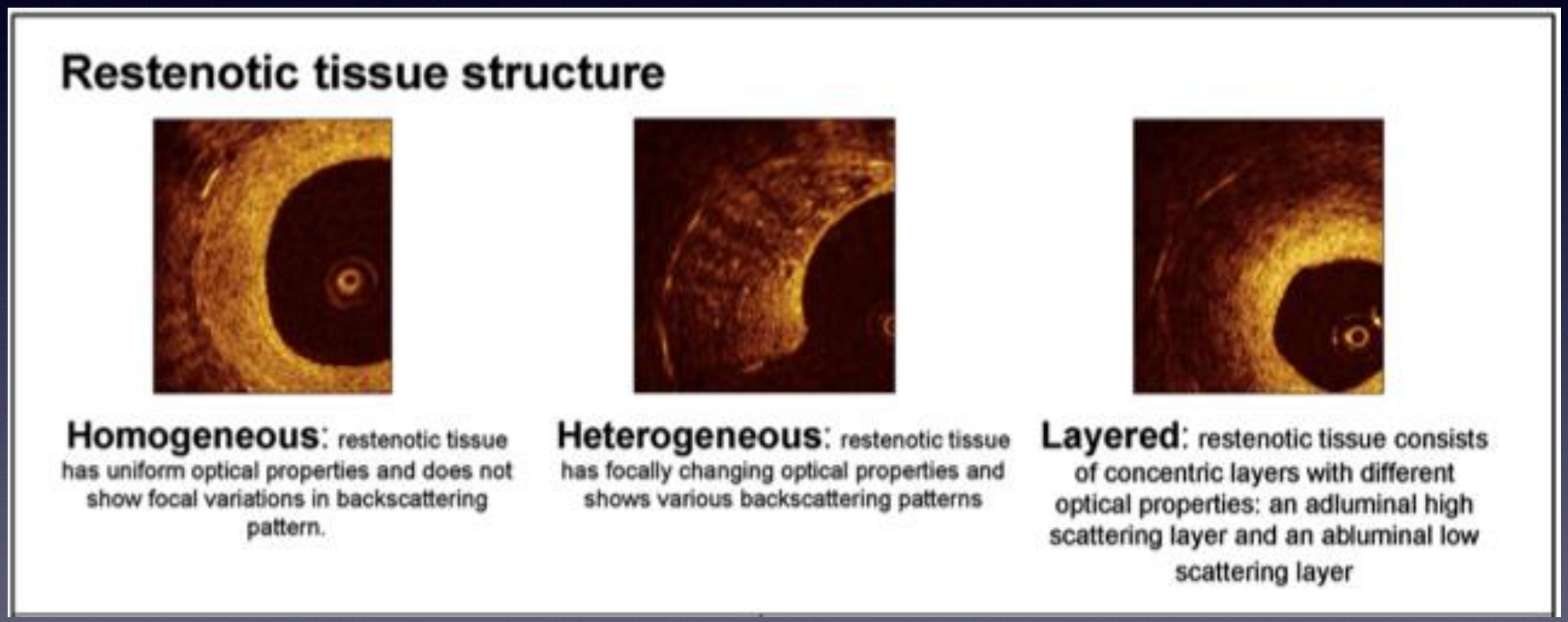
Therapeutic Response

Pitavastatin
4mg
9month FU



Impact of Statin Therapy on Plaque Characteristics
Hattori et al. JACC cardiovasc imaging, 2012.

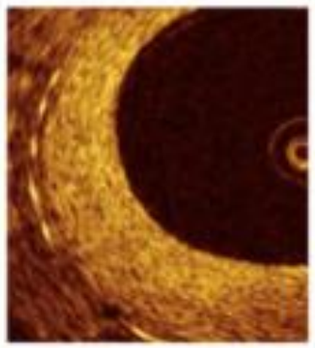
Stent Restenosis



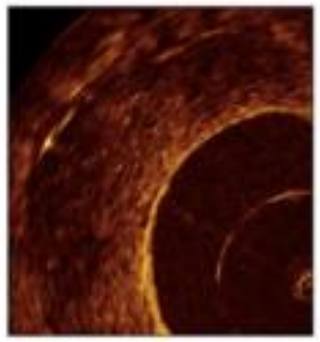
OCT pattern of Stent Restenosis
Gonzalo et al. AHJ, 2009.

Stent Restenosis

Restenotic tissue backscatter

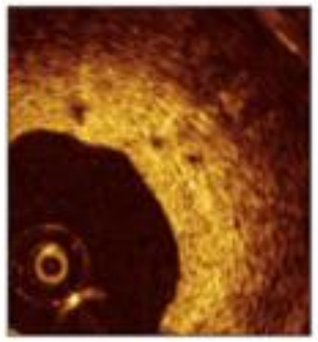


High: the majority of the tissue shows high backscatter and appears bright

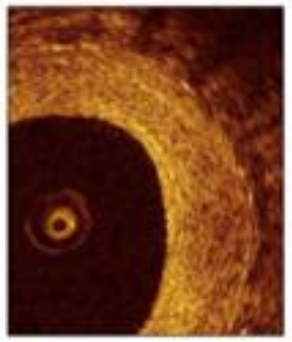


Low: the majority of the tissue shows low backscatter and appears dark or black

Microvessels visible

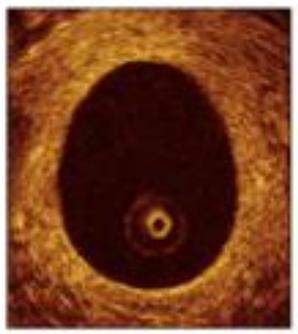


Yes: microvessels appear as well delineated low backscattering structures less than 200 micron in diameter that show a trajectory within the vessel

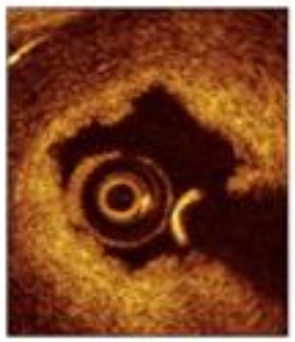


No

Lumen shape



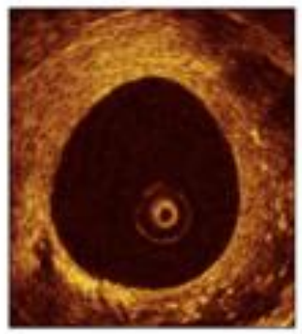
Regular: lumen border is sharpy delineated, smooth and circular



Irregular: lumen border irregular with tissue protrusions from the vessel wall into the lumen

Presence of intraluminal material

Yes: there is visible material inside the vessel lumen.



No

OCT pattern of Stent Restenosis
Gonzalo et al. AHJ, 2009.

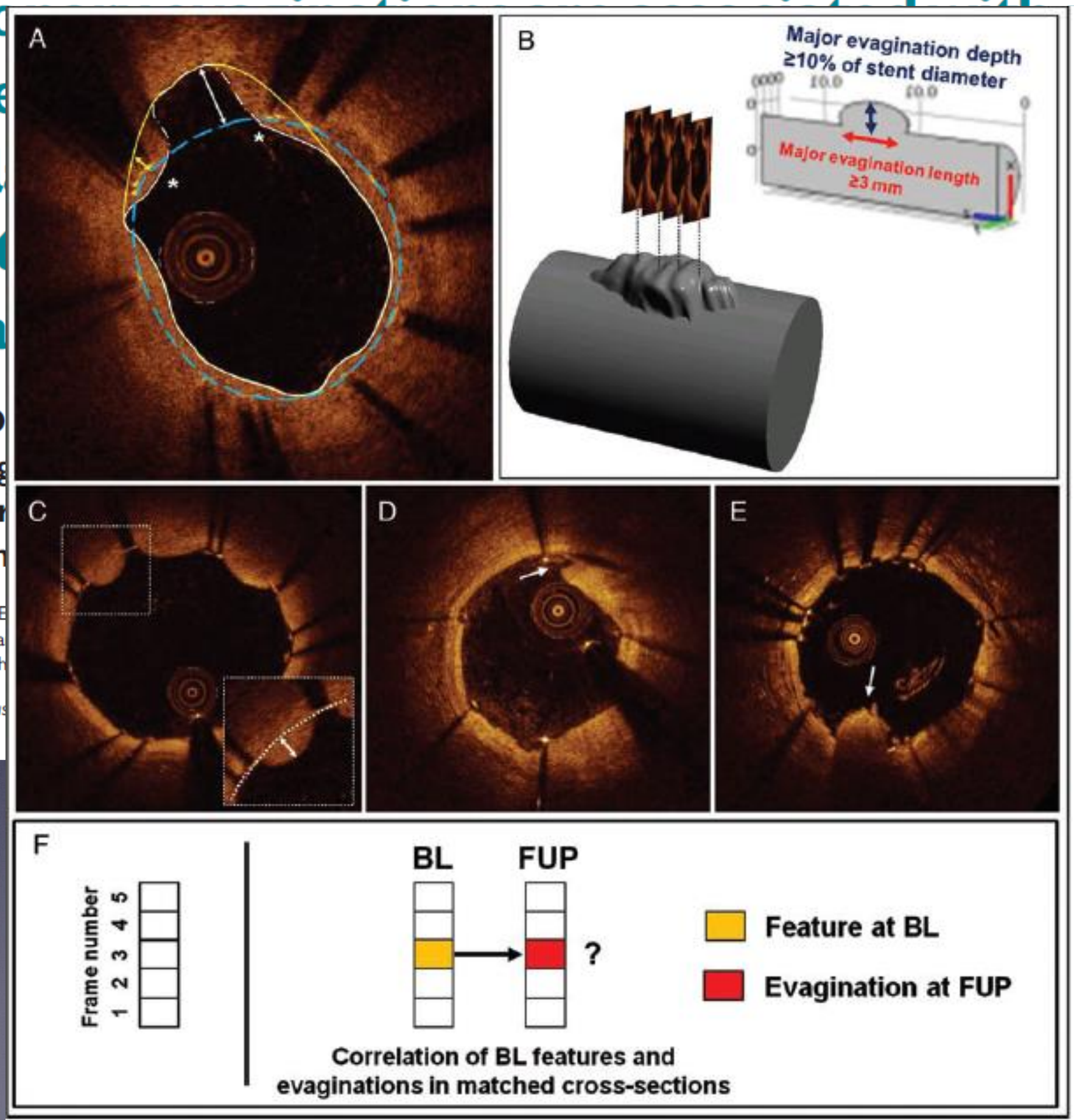
Coro positive vesse llowing impl ting stent nd intra

Maria D ,
Henning Farooq[1],
Salvator mäki[2],
Stephan

[1]Thoraxcenter, E
Denmark; [3]Depa
Rotterdam, Neth

y Hospital, Copenhagen,
rland; and [5]Cardialysis BV,

Received 16 Augus

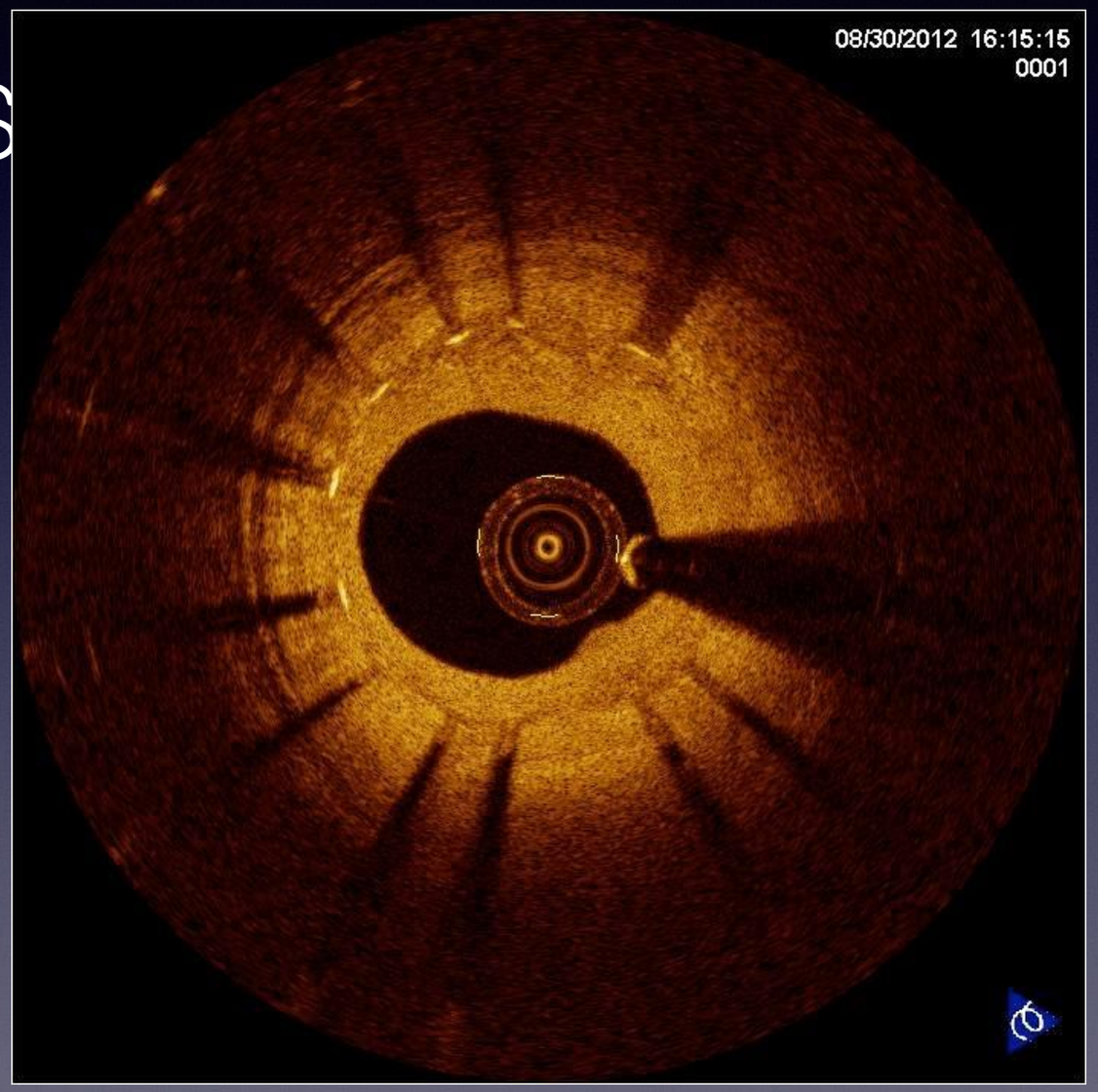


Stent Restenosis

57 YO Male

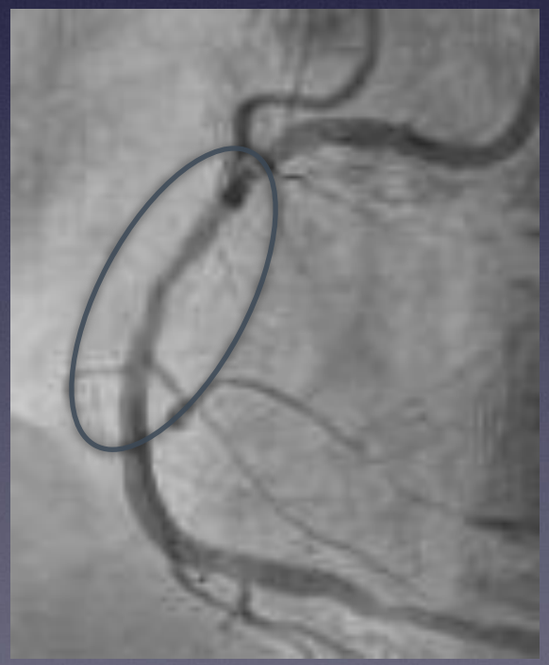
EPC capture stent d/t S

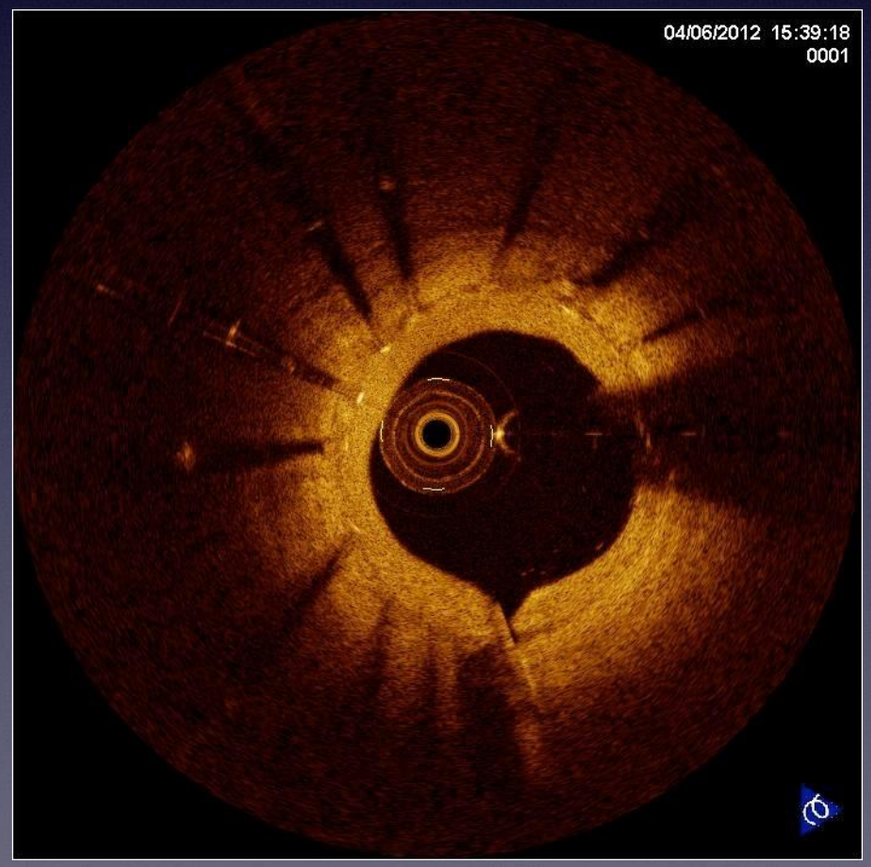
24 months FU

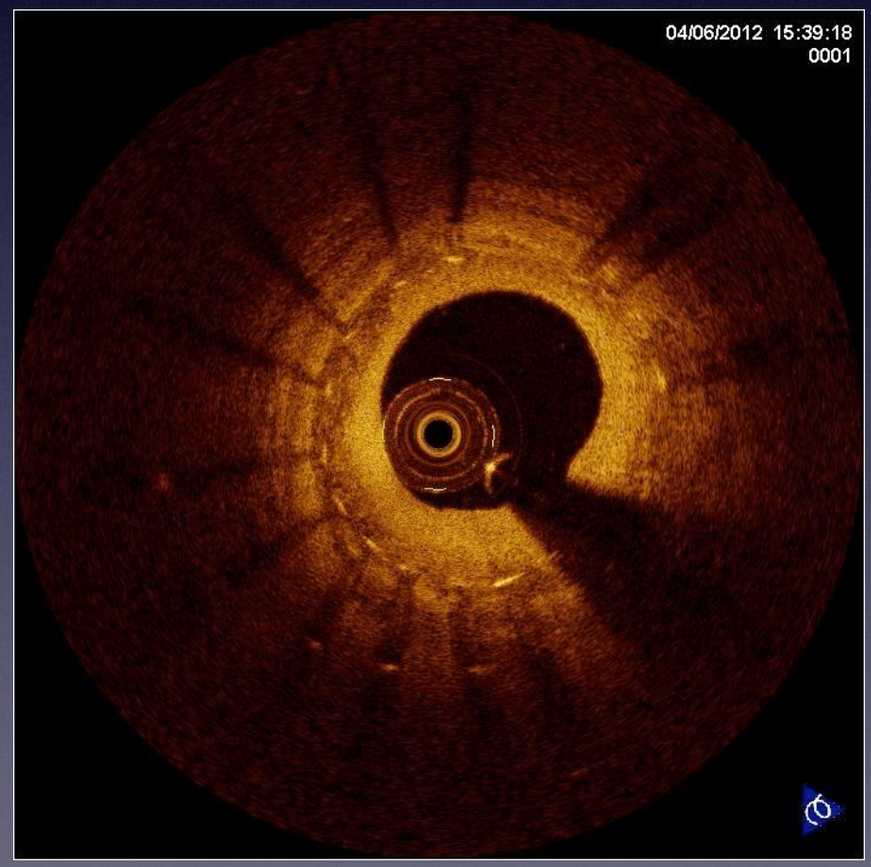


Stent Restenosis

71 yrs Female
EPC capture stent d/t
STEMI 22 months FU





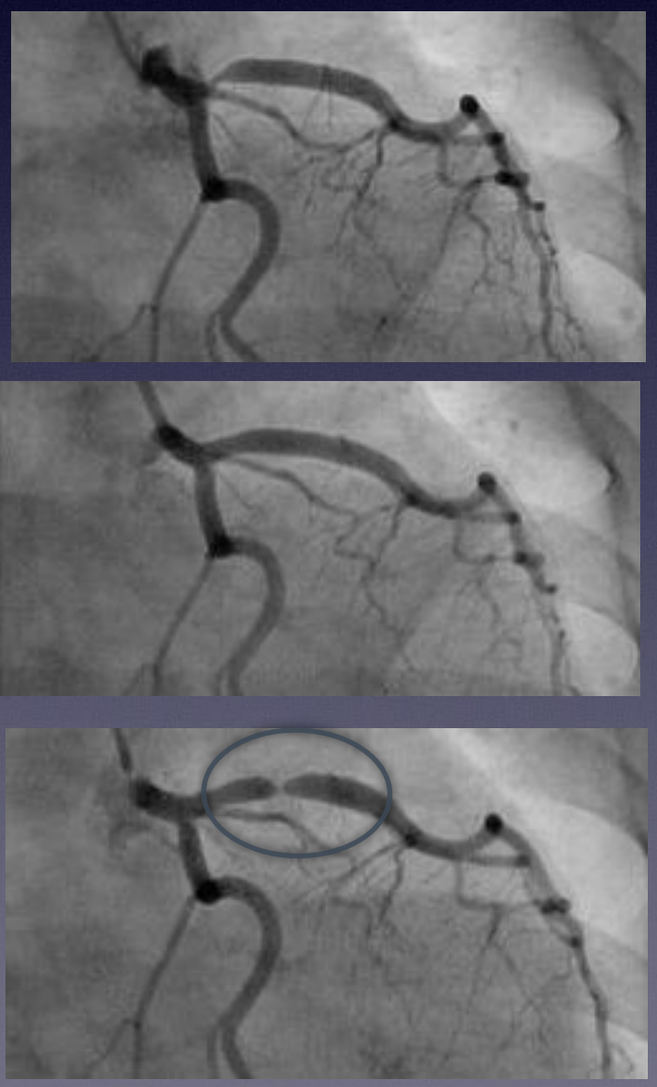


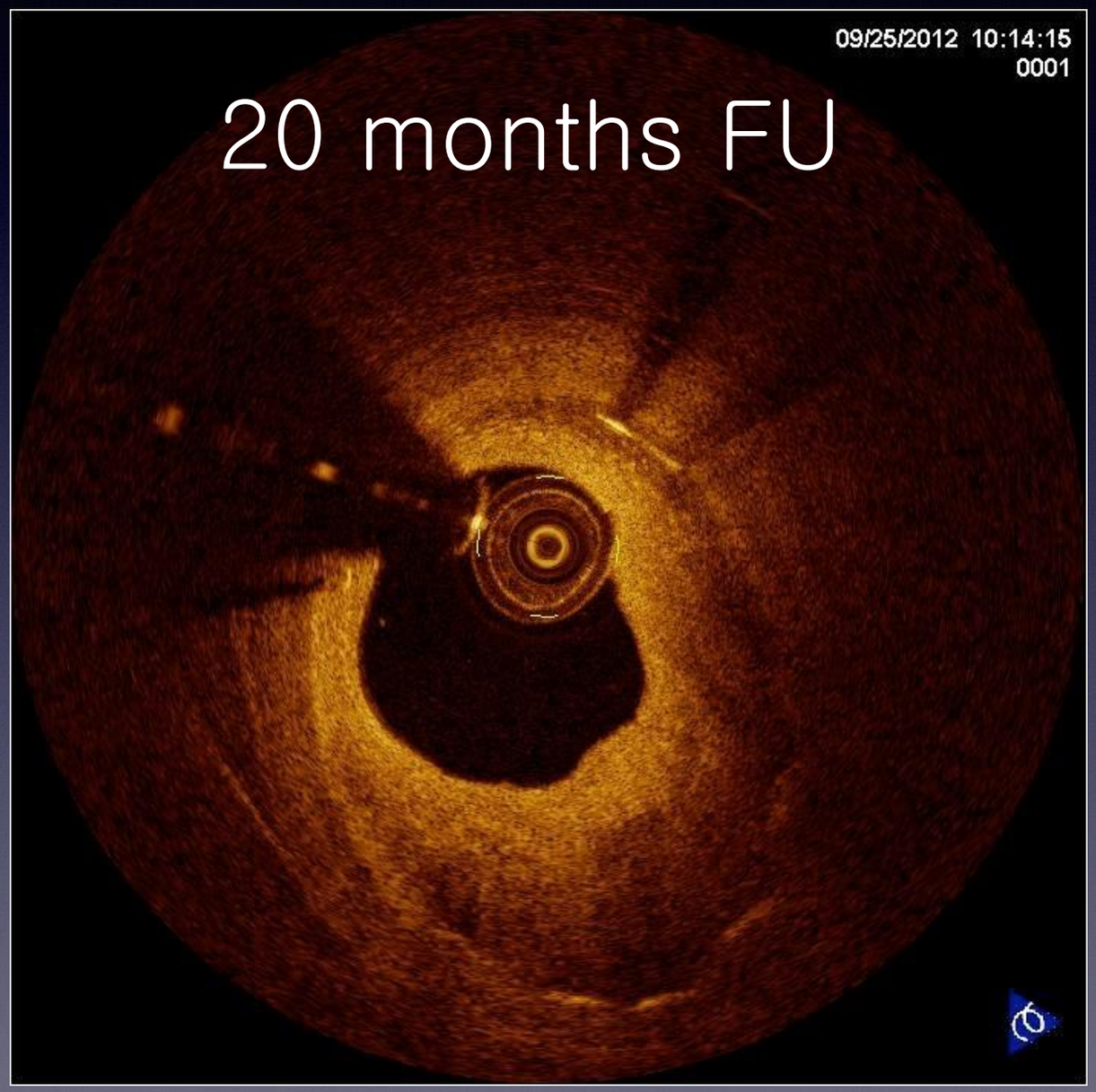
Keimyung Univ. OCT Registry

Stent Restenosis

59 YO Female

EES d/t SA



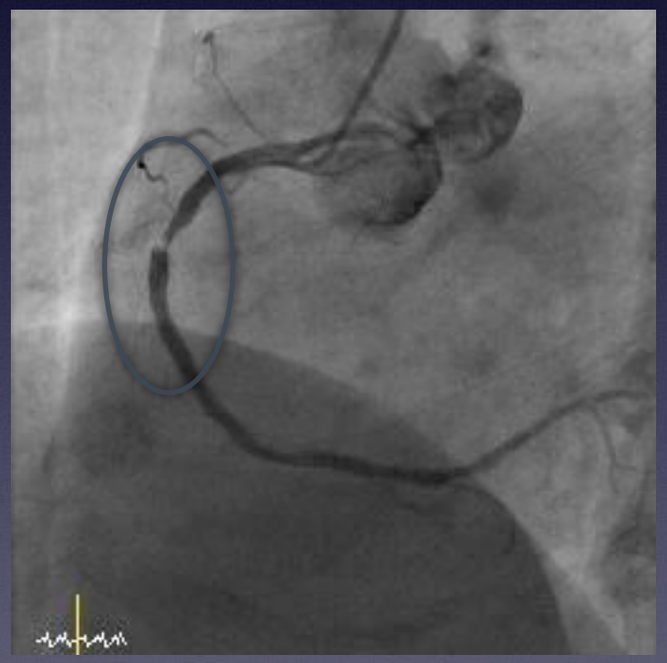


Keimyung Univ. OCT Registry

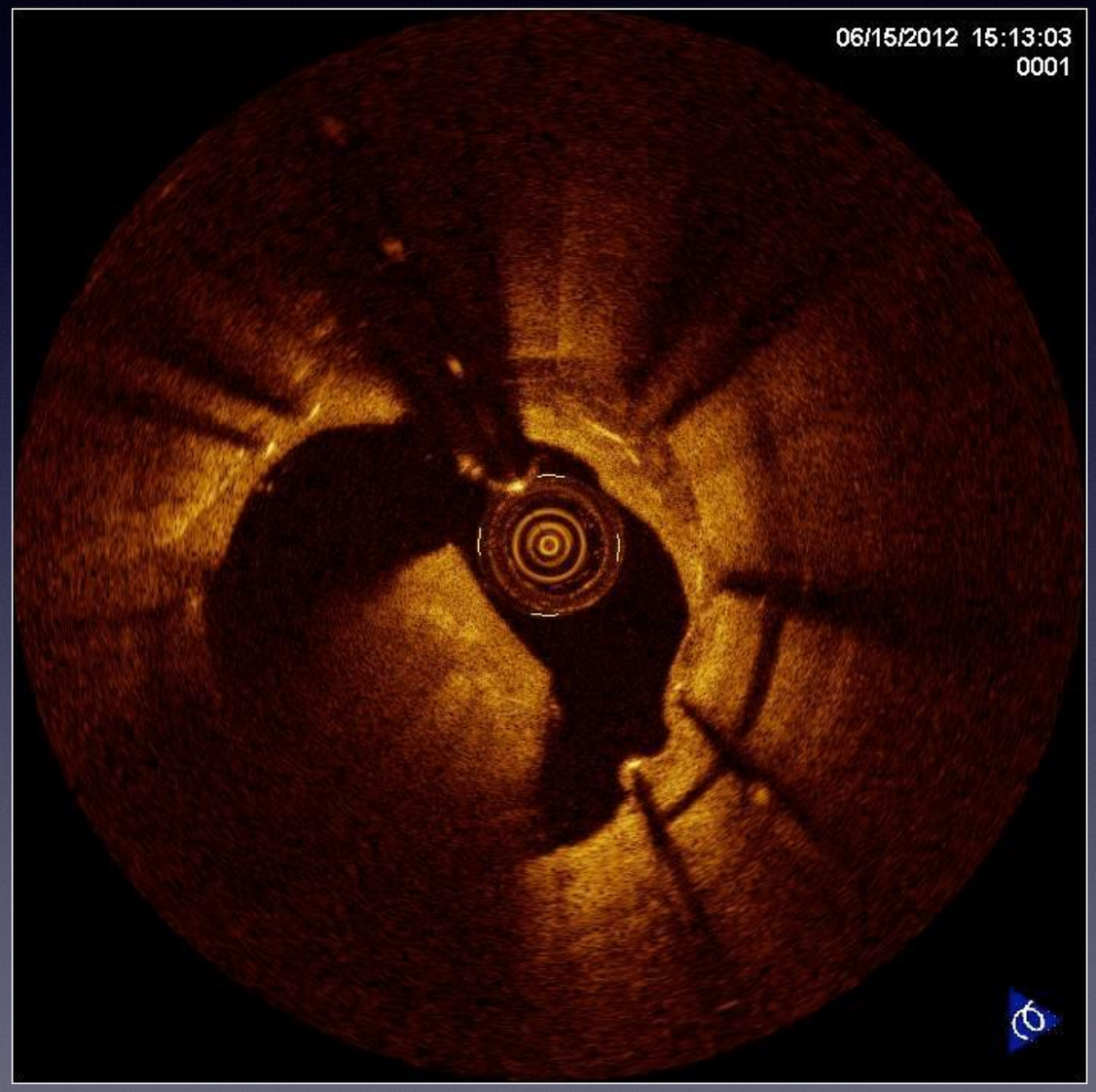
Stent Restenosis

55 YO Male

PES d/t STEMI



34 months FU

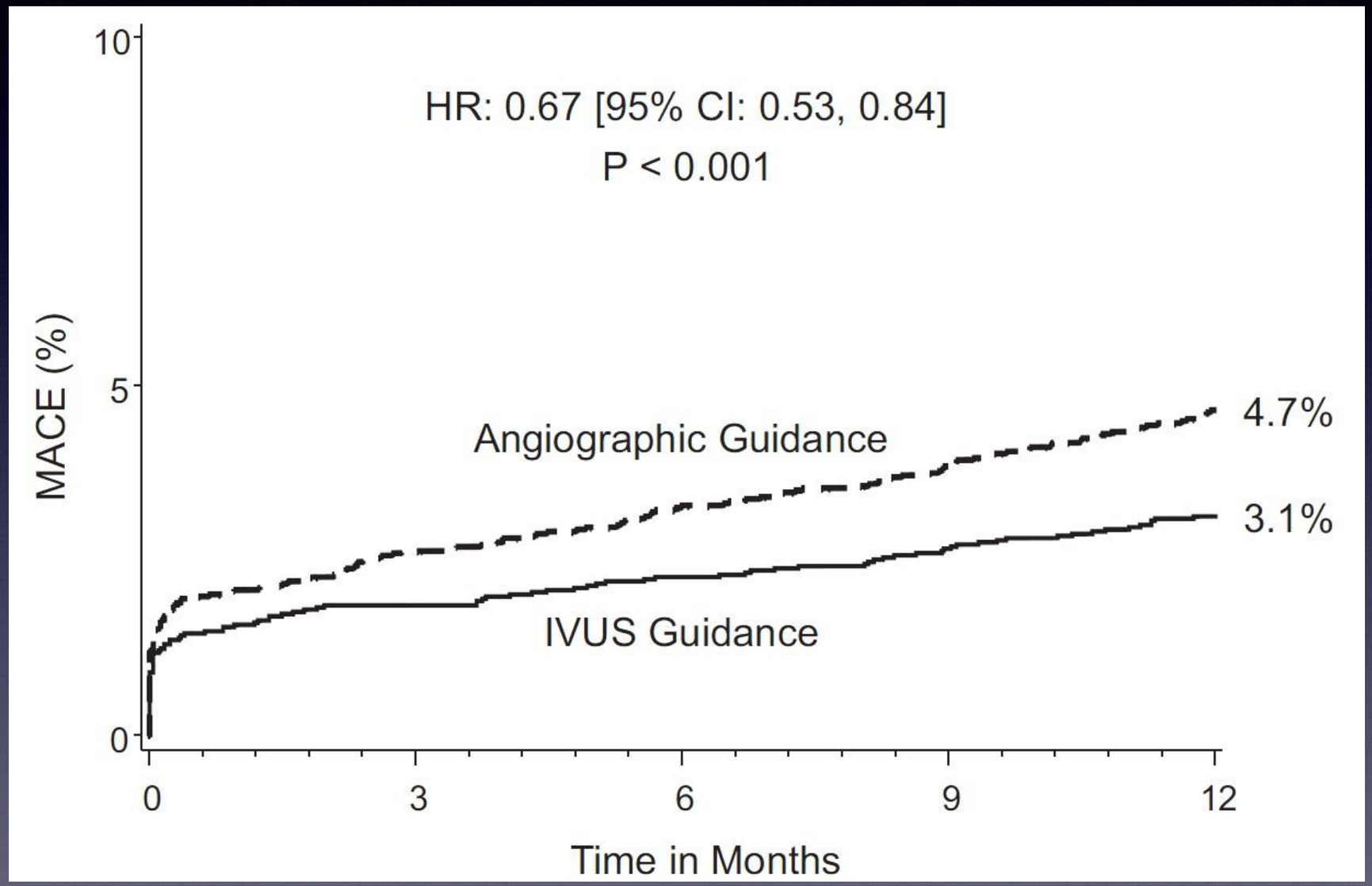


Keimyung Univ. OCT Registry

Evidence of Clinical Relevance

IVUS- vs. angio-guided PCI with DES

Results from Assessment of Dual Antiplatelet Therapy With Drug-Eluting Stents (ADAPT-DES)



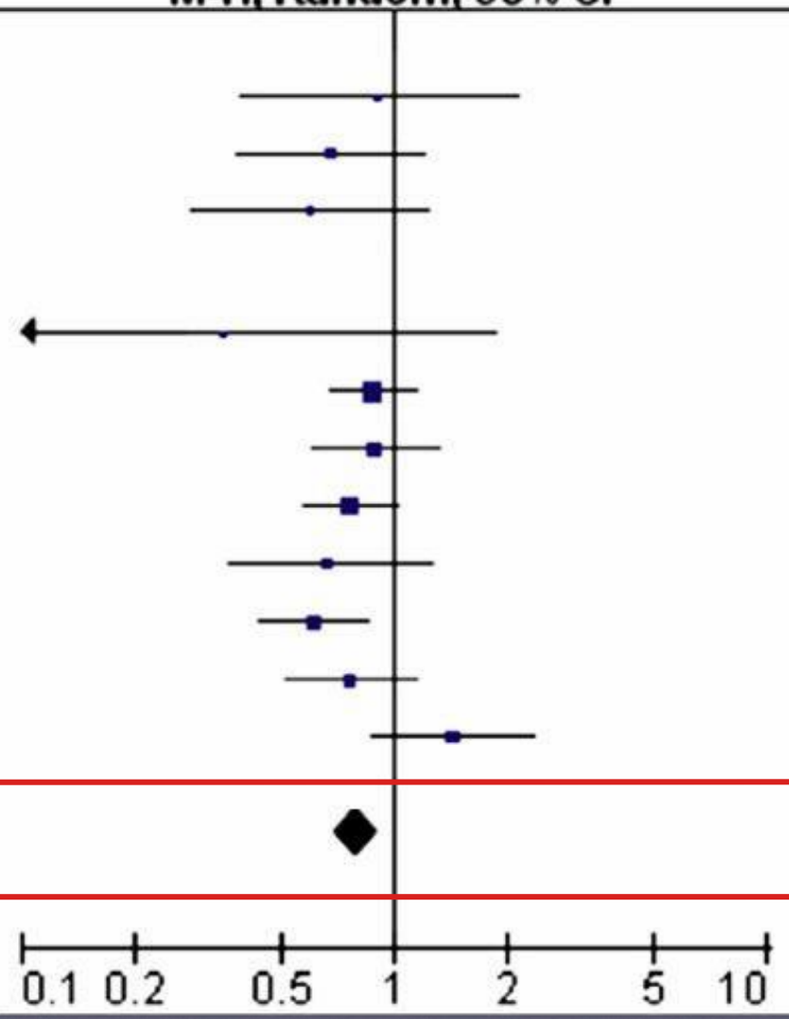
IVUS guidance was associated with a reduction in stent thrombosis, MI, and MACE within 1 year after DES implantation.

Witzenbichler, et al., Circulation. 2014;129:463-470

IVUS- vs. angio-guided PCI with DES

A meta-analysis of randomized trials and observational studies

MACE	IVUS		Angiography		Odds Ratio	Odds Ratio
Study or Subgroup	Events	Total	Events	Total	, Random, 95% CI	M-H, Random, 95% CI
1.1.1 Randomized studies						
HOME DES IVUS	11	105	12	105	0.91 [0.38, 2.16]	
AVIO	24	142	33	142	0.67 [0.37, 1.21]	
RESET	12	269	20	274	0.59 [0.28, 1.24]	
1.1.2 Non-randomized studies						
Agostoni	2	24	7	34	0.35 [0.07, 1.86]	
Roy	128	884	143	884	0.88 [0.68, 1.14]	
COBIS	53	487	59	487	0.89 [0.60, 1.31]	
MATRIX	85	631	148	873	0.76 [0.57, 1.02]	
Youn	16	125	39	216	0.67 [0.36, 1.25]	
IRIS-DES	54	1616	88	1628	0.60 [0.43, 0.86]	
Chen	51	324	60	304	0.76 [0.50, 1.15]	
EXCELLENT	34	619	31	802	1.45 [0.88, 2.38]	
Total (95% CI)		**5226**		**5749**	**0.79 [0.69, 0.91]**	



IVUS-guided DES implantation is associated with significantly lower rates of adverse clinical events compared with angiography guidance.

Jang JS, et al., JACC interv 2014; 7:233–43

OCT- vs. angio-guided PCI with DES or BMS

The retrospective Centro per la Lotta contro l'Infarto-Optimisation of Percutaneous Coronary Intervention (CLI-OPCI) study

Events at 1-year follow-up	Angiographic guidance group (n=335)	Angiographic plus OCT guidance group (n=335)	*p*-value
Death	23 (6.9%)	11 (3.3%)	0.035
Cardiac death	15 (4.5%)	4 (1.2%)	0.010
Myocardial infarction	29 (8.7%)	18 (5.4%)	0.096
Target lesion repeat revascularisation	11 (3.3%)	11 (3.3%)	1.0
Definite stent thrombosis	2 (0.6%)	1 (0.3%)	1.0
Cardiac death or myocardial infarction	43 (13.0%)	22 (6.6%)	0.006
Cardiac death, myocardial infarction, or repeat revascularisation	50 (15.1%)	32 (9.6%)	0.034

The use of OCT can improve clinical outcomes of patients undergoing PCI.

Prati F, et al., EuroIntervention 2012;8:823-829

OCT guided vs. IVUS guided

N = 70
Non-ACS, De Novo CAD
Randomized OCT or IVUS guidance

Smaller stent expansion & frequent residual stenosis when using OCT than IVUS.

Impact of FD OCT in PCI. Habara et al.
Circulation: Cardiovasc Interven2012; 5: 193-201

IVUS/OCT in ESC guideline 2014

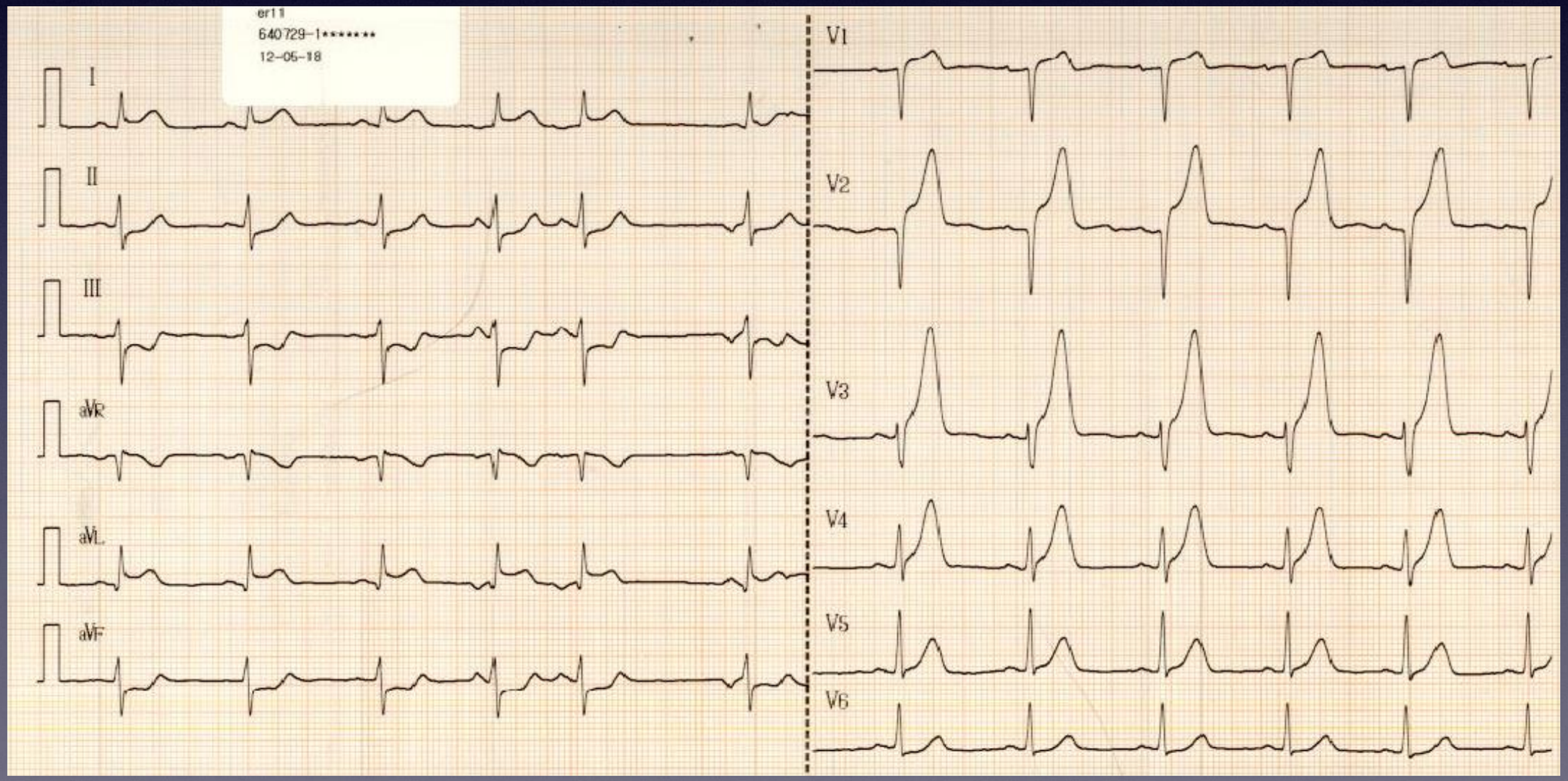
Recommendations	Class	Level
IVUS in selected patients to optimize stent implantation.	IIa	B
OCT in selected patients to optimize stent implantation.	IIb	C

Eur Heart J. 2014;35:2541-2619

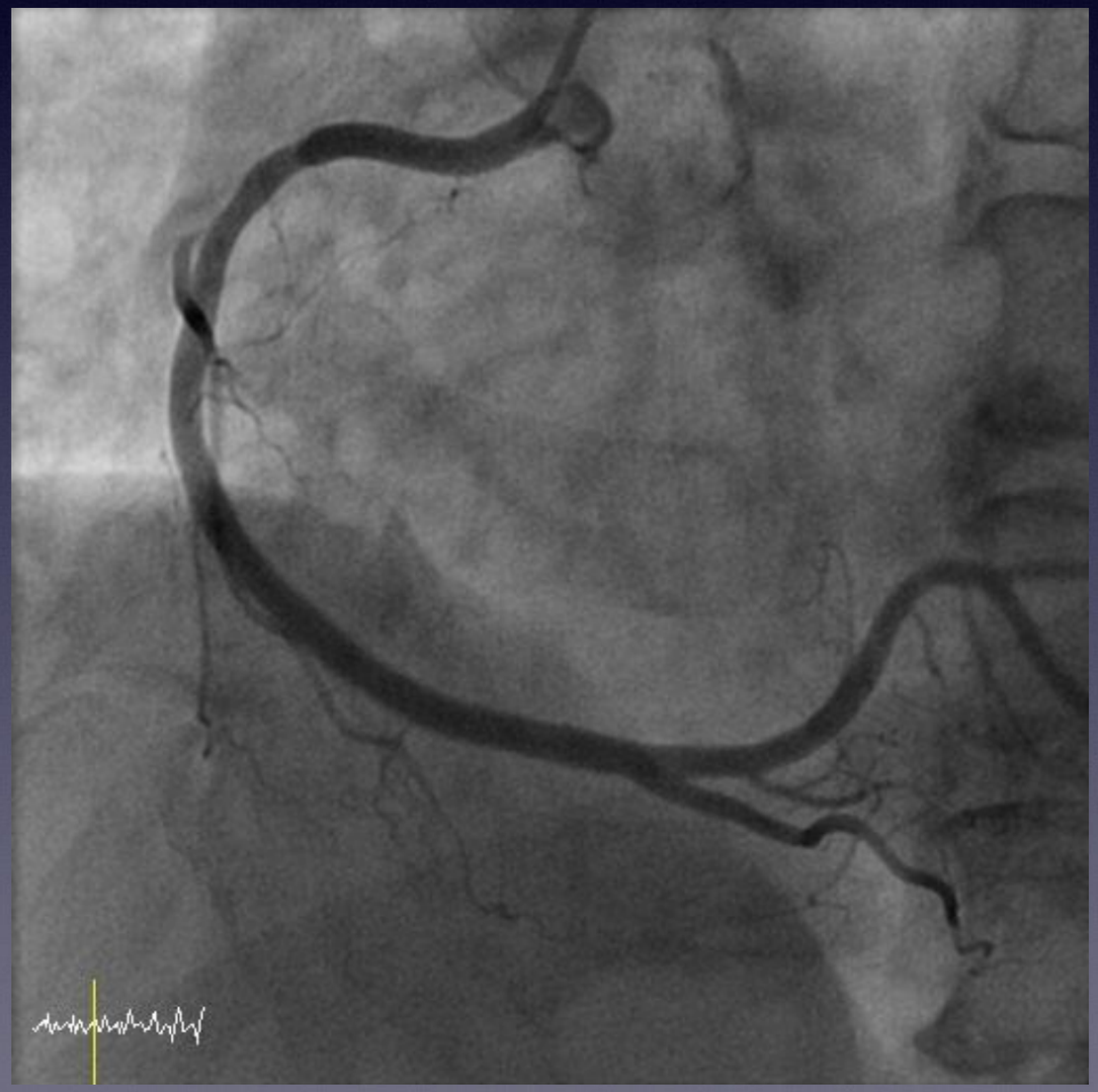
- The resolution of OCT is 10 times higher than that of IVUS.
- OCT is capable of providing accurate coronary measurements.
- OCT is more accurate than IVUS in detecting subtle stent morphologies including malapposition, residual thrombus, plaque prolapse, and residual dissections.
- Further studies are needed to define the clinical value of OCT.

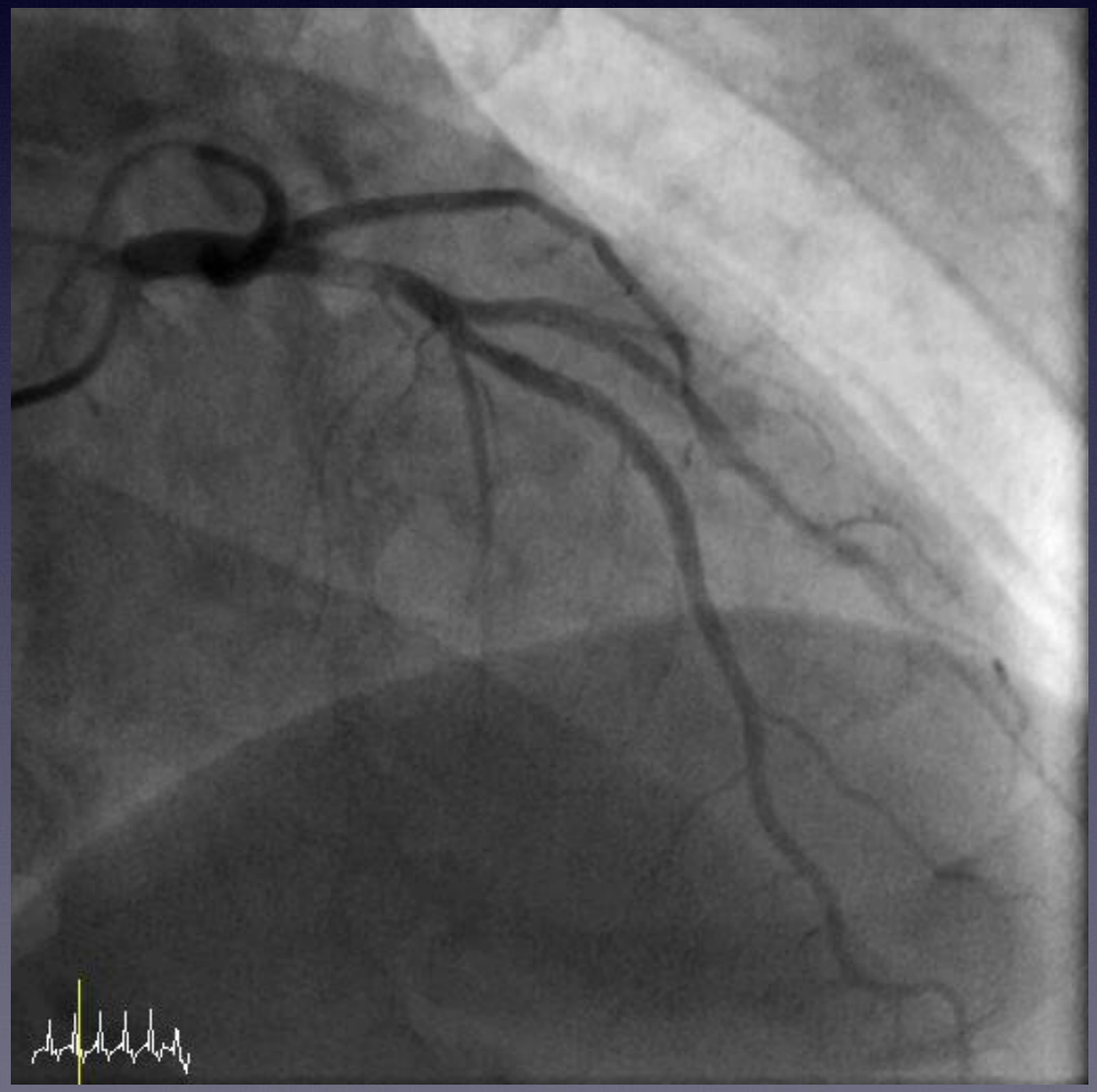
STEMI

E C G

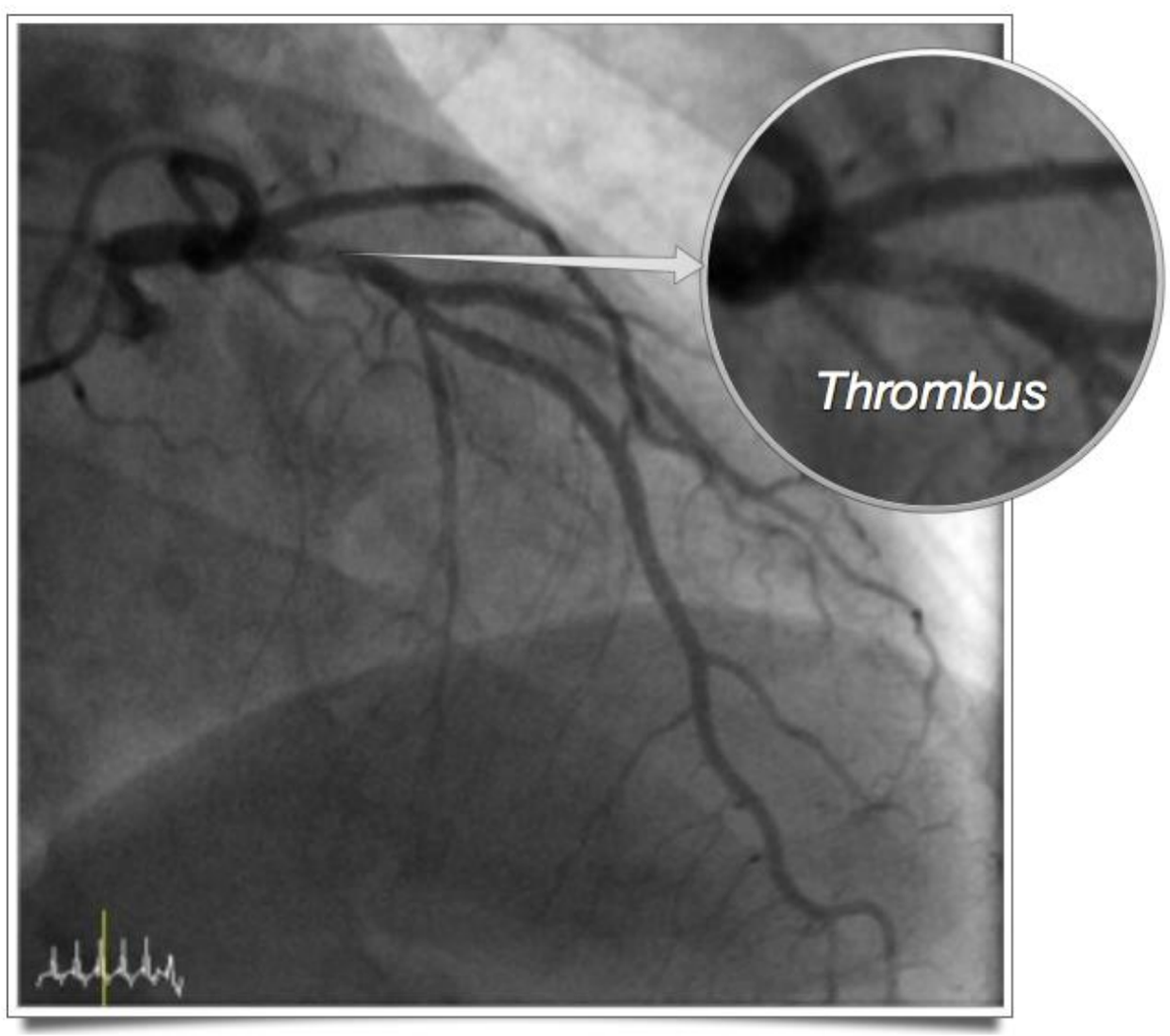


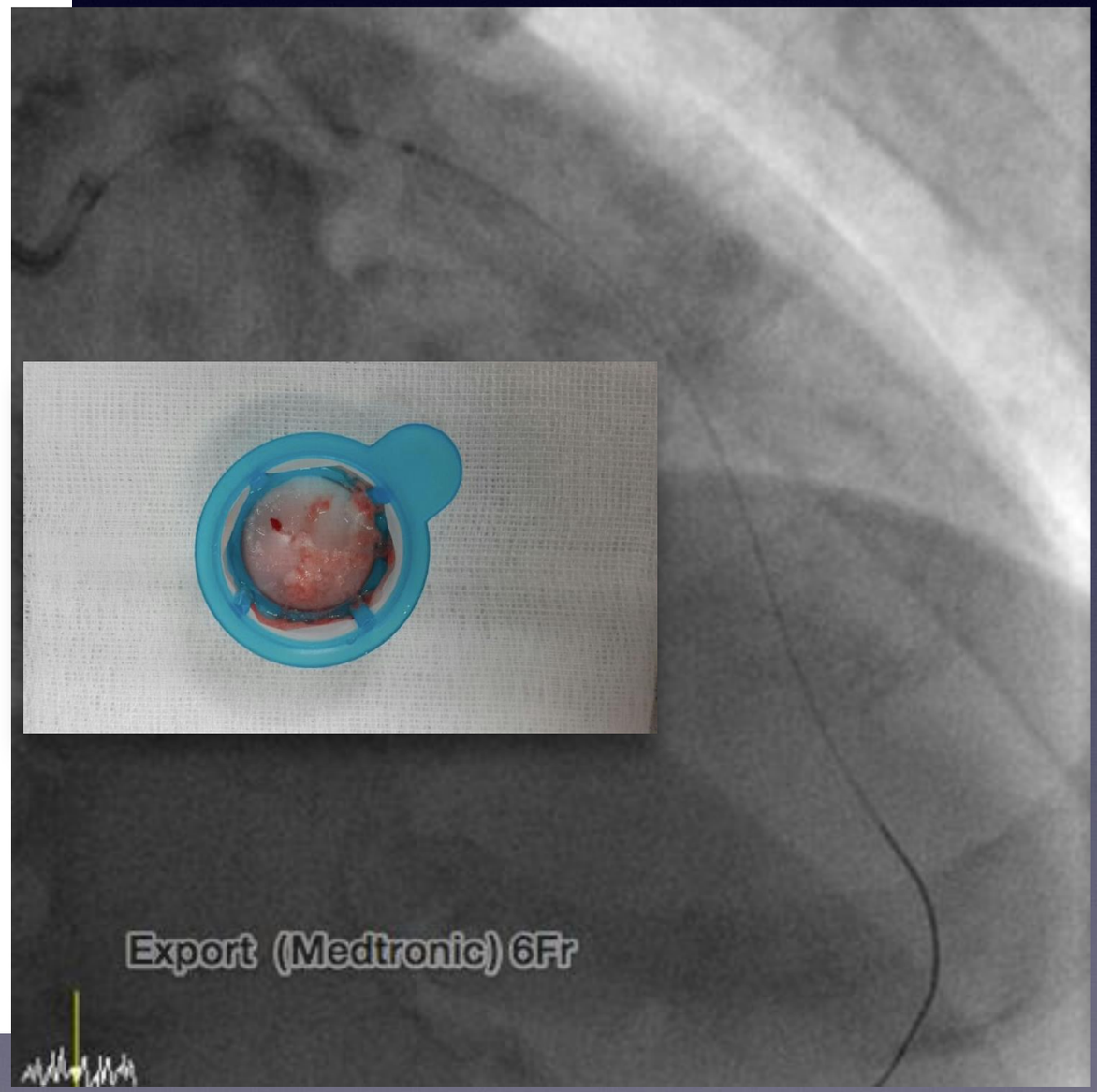
Primary PCI





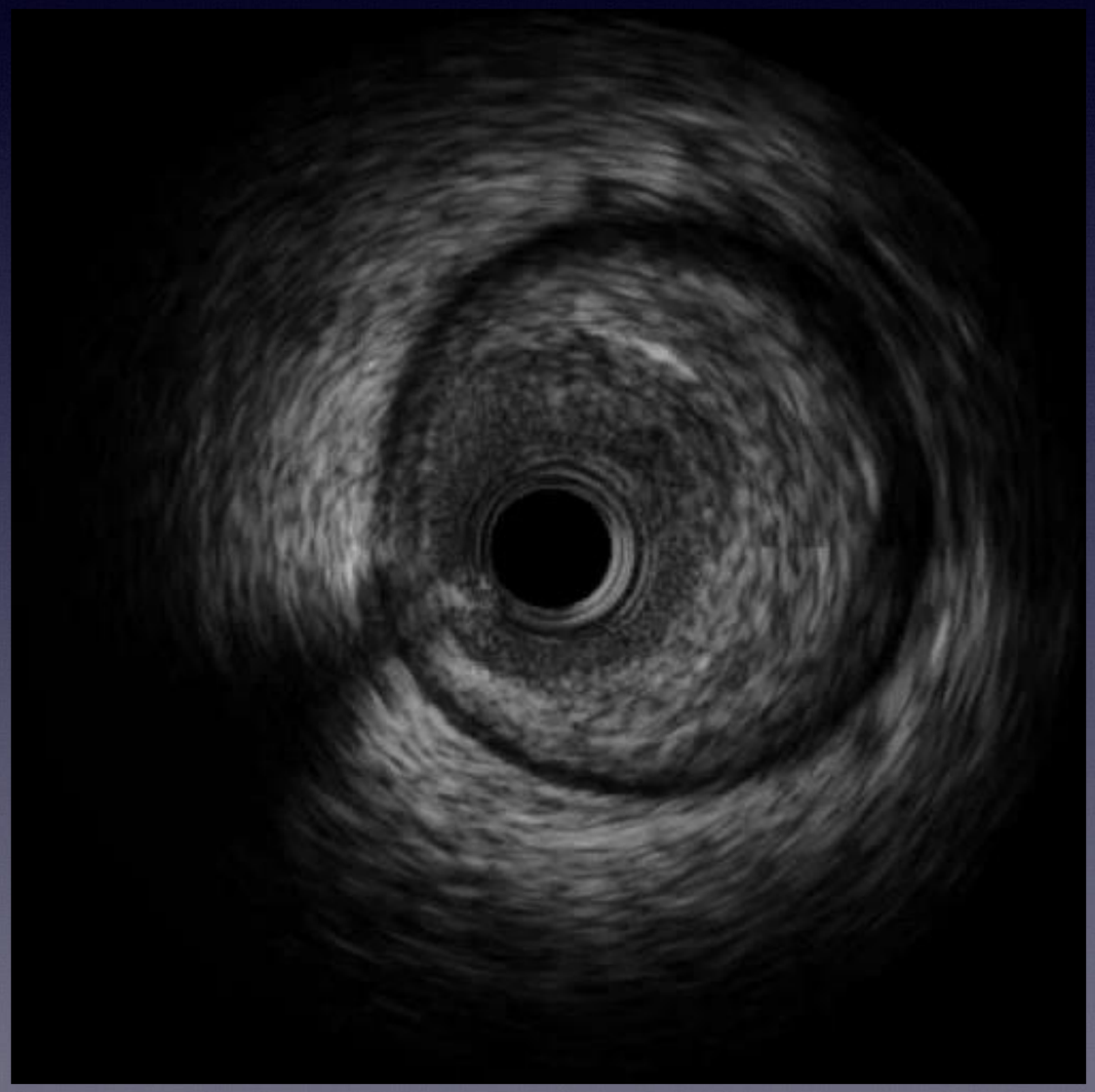
Primary PCI

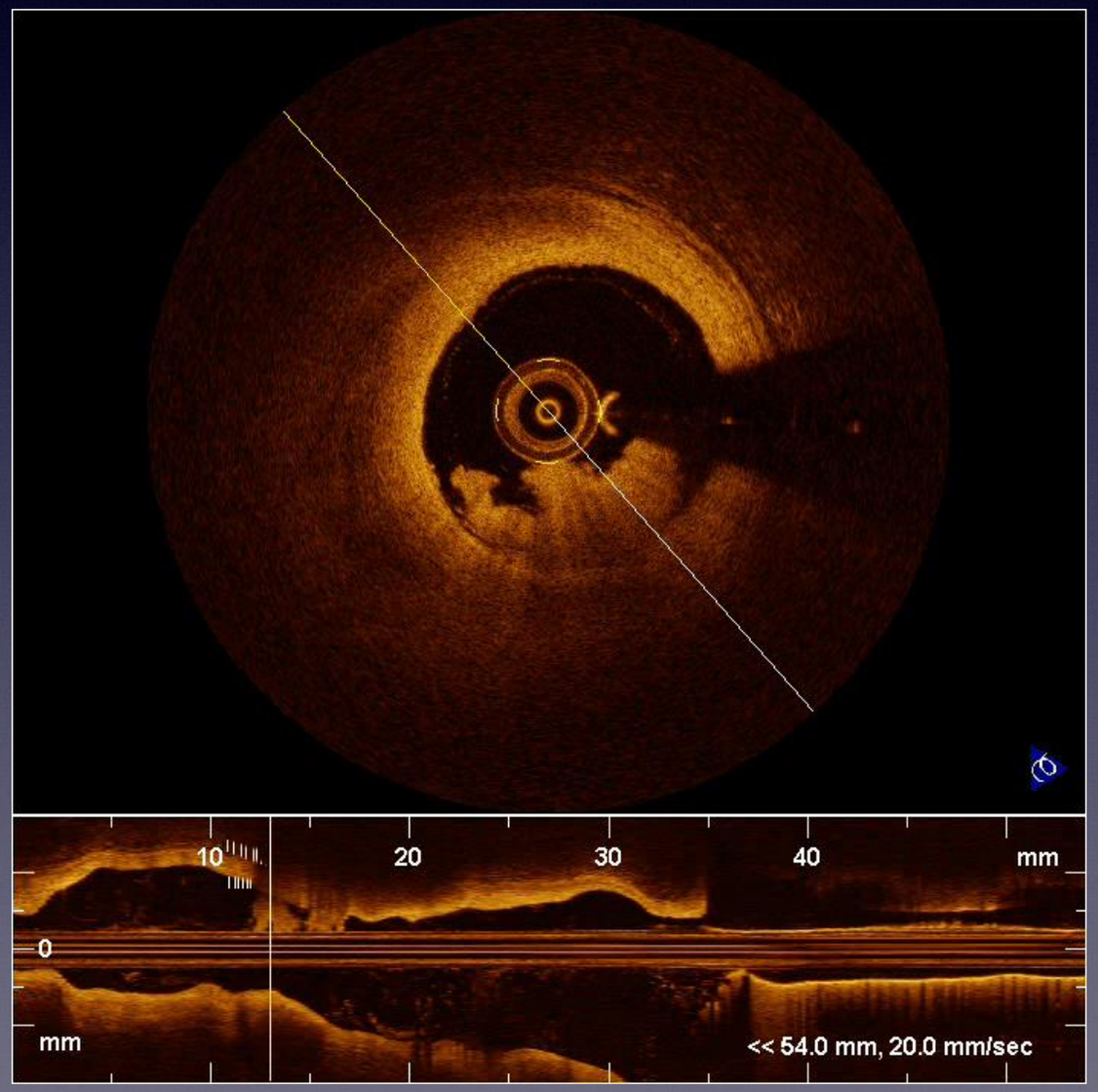




IVUS & OCT

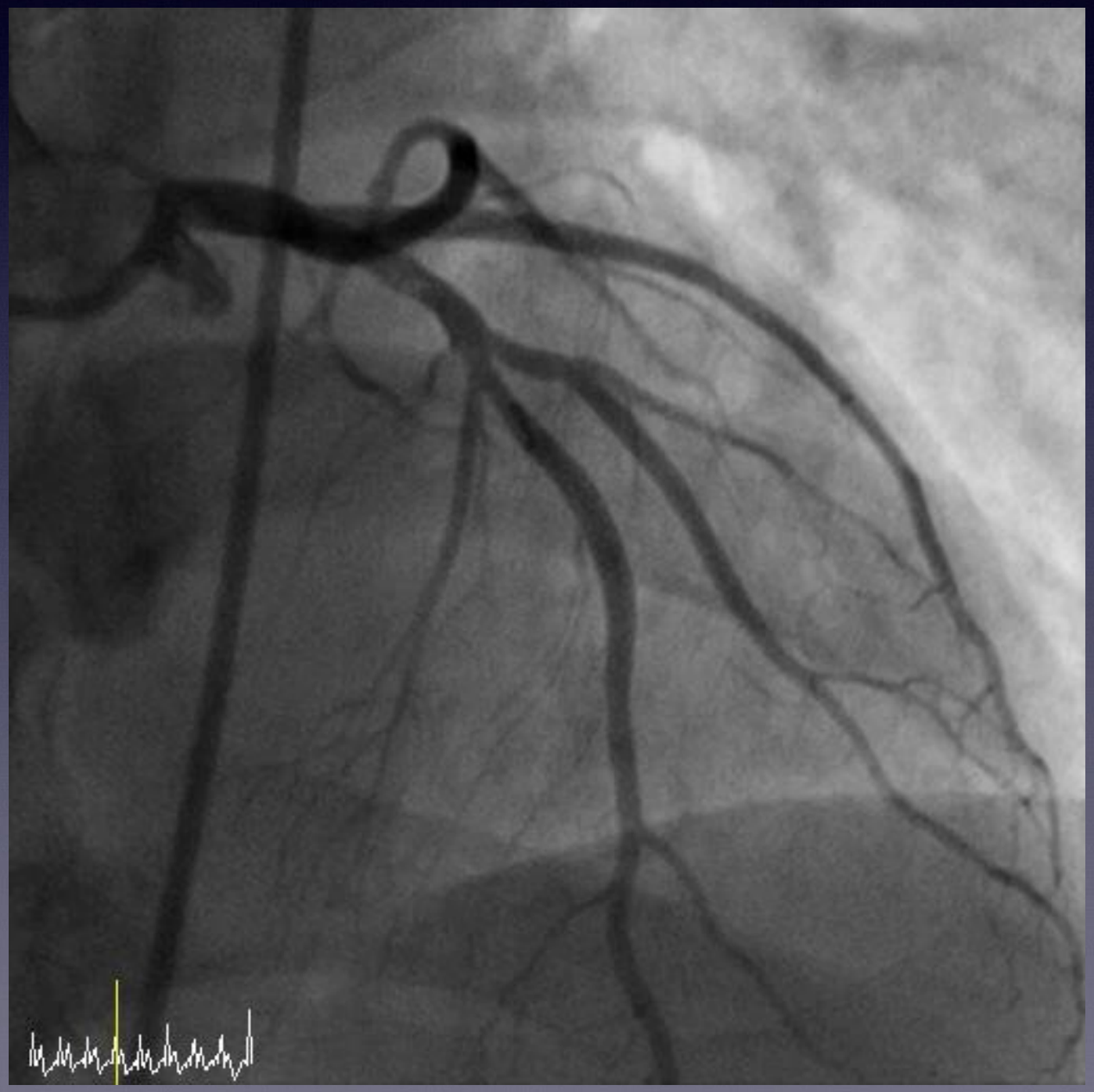
Case 2

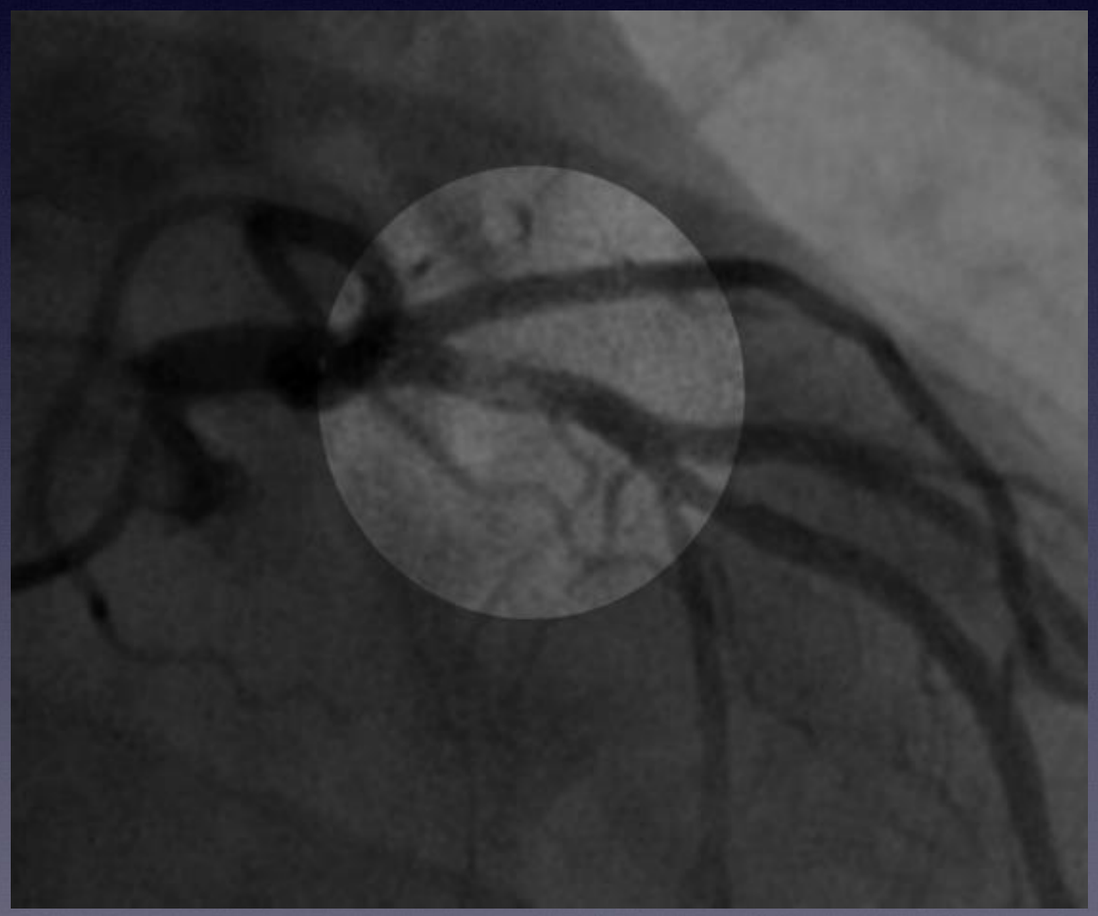




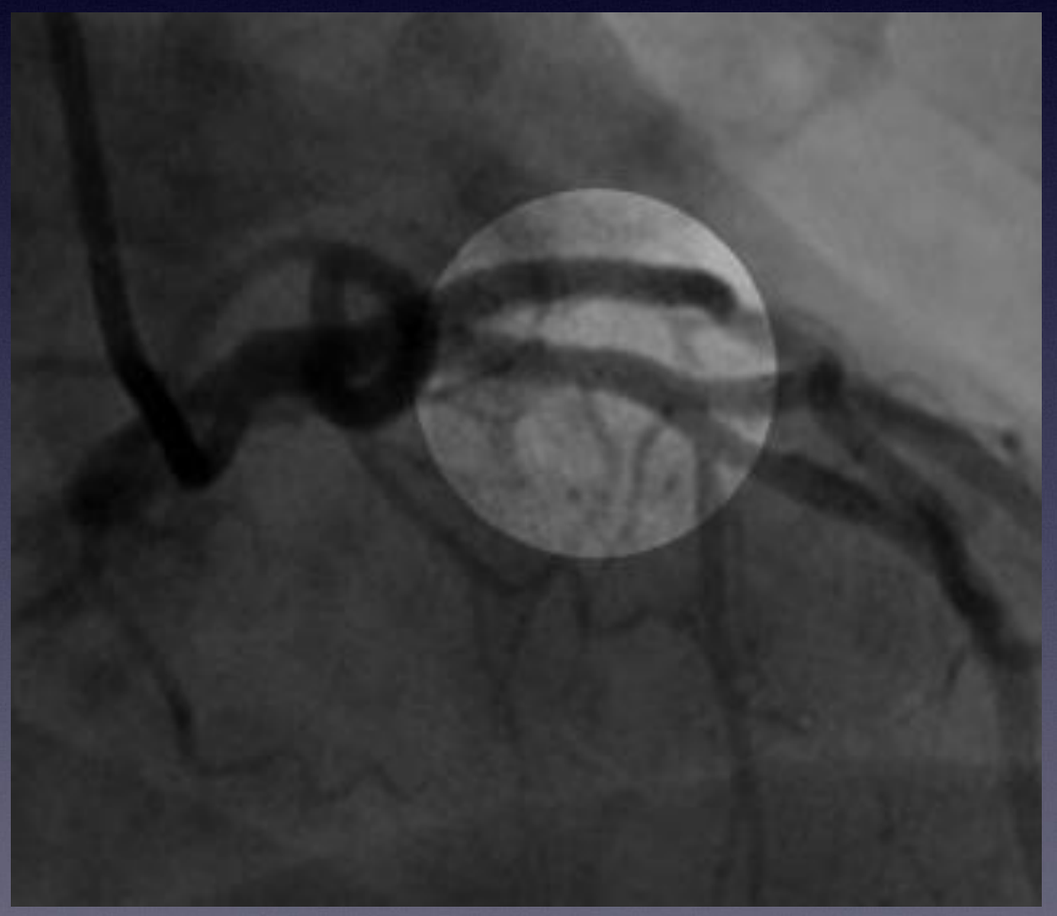
Thrombus over the plaque in proximal LAD

Post Aspiration CAG

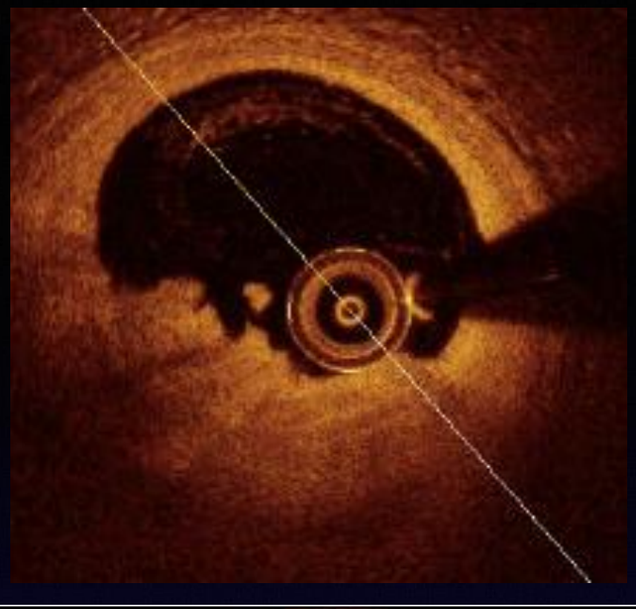


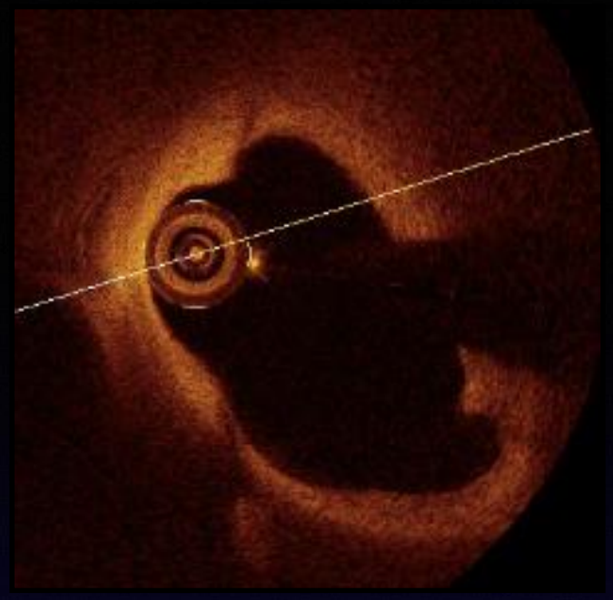


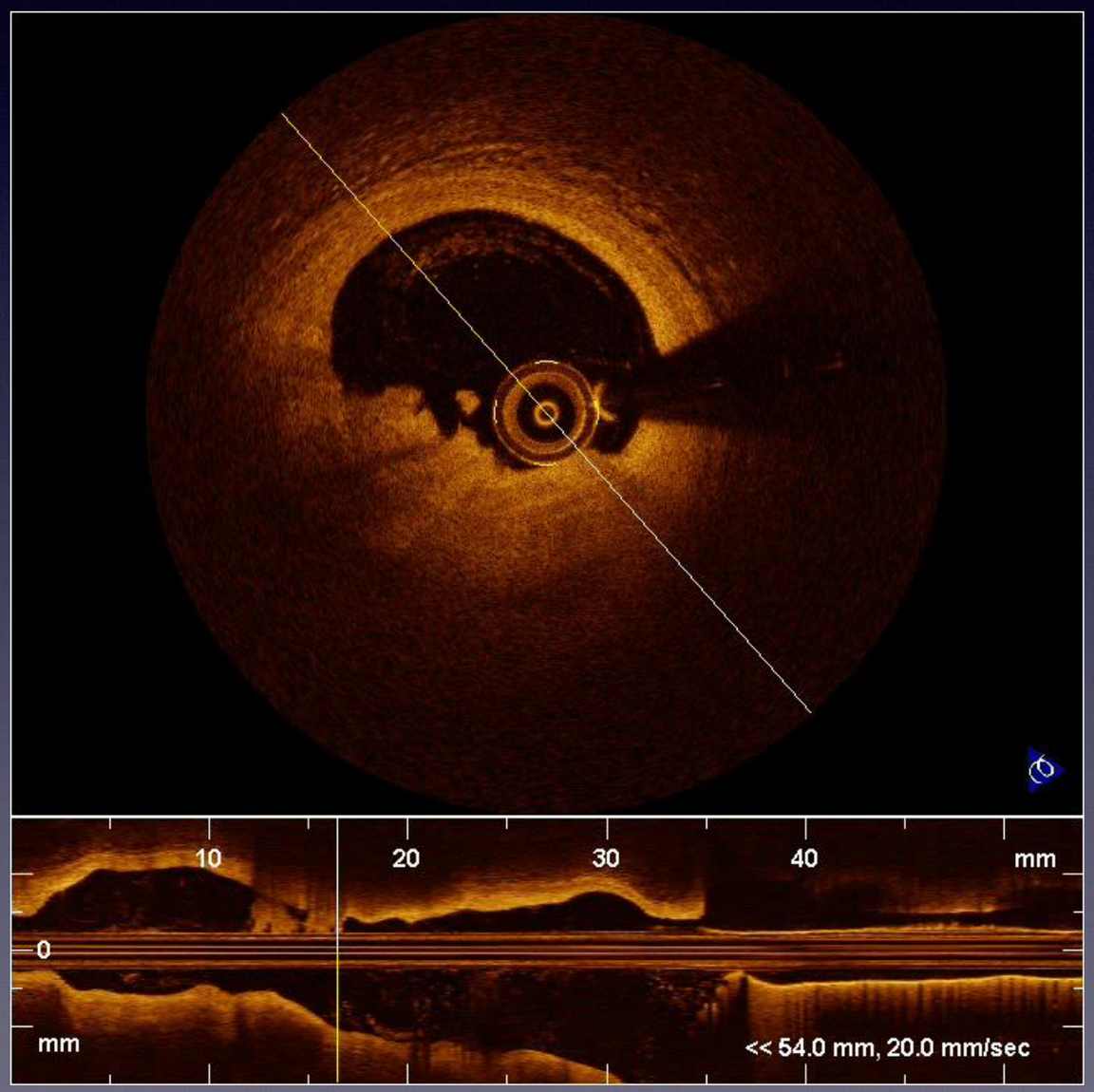
Initial

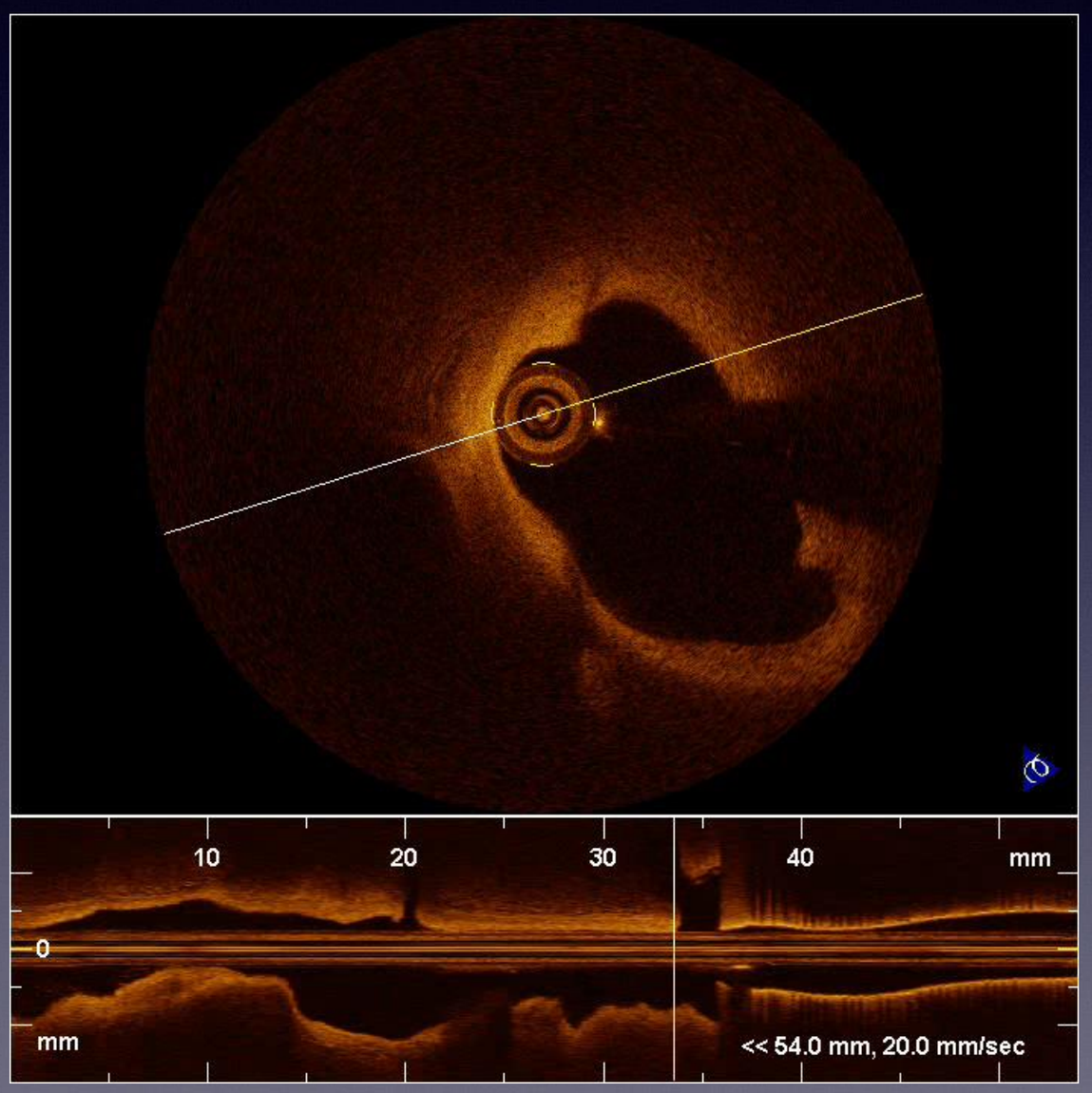


3days later









Initial

3days later

Conclusion

OCT is useful…

- To identify accurate lesion characteristics
- To detect vulnerable plaque
- To reveal pathologic character of ambiguous lesion
- To determine adequate therapeutic strategy
- To determine response to therapy

Summary

- OCT provide us enormous imaging data during PCI.
- An enormous amount of work is still required to validate the clinical relevance of the various OCT applications.

Thank you for attention!!!