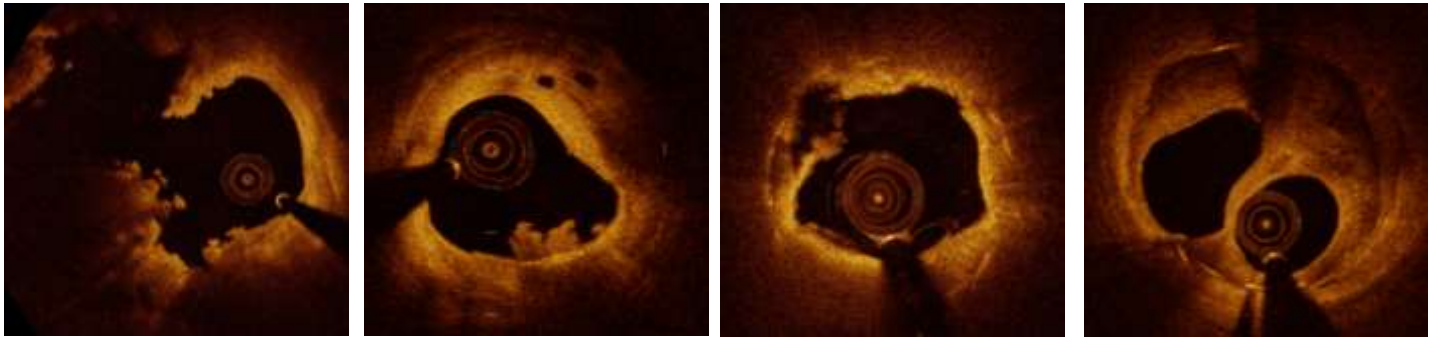
Assessment of Stent Failure

Giulio Guagliumi, MD, FESC
Ospedale Papa Giovanni XXIII, Bergamo- ITALY



- SPEAKER NAME: GIULIO GUAGLIUMI, MD

  I have the potential conflicts of interest to report

- CONSULTANT: BOSTON SCIENTIFIC, S JUDE MEDICAL
- RESEARCH GRANT: ABBOTT VASCULAR, BOSTON SCIENTIFIC, S JUDE MEDICAL
- EDUCATIONAL GRANT: ABBOTT VASCULAR

2014 ESC Guidelines on Myocardial Revascularization

Recommendations for the clinical value of intracoronary diagnostic techniques

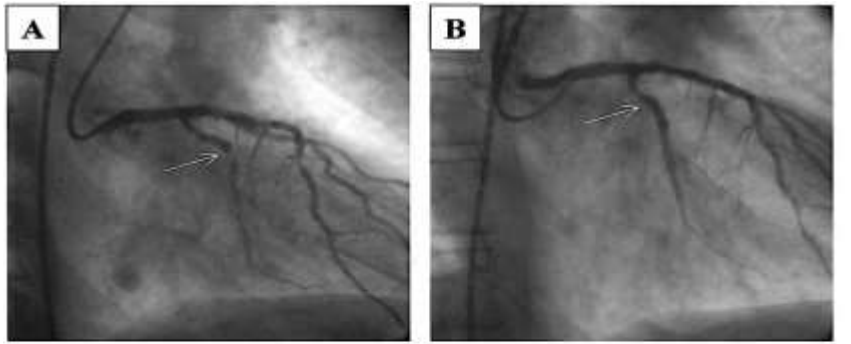
Recommendations	Class[a]	Level[b]	Ref.[c]
FFR to identify haemodynamically relevant coronary lesion(s) in stable patients when evidence of ischaemia is not available.	I	A	50,51,713
FFR-guided PCI in patients with multivessel disease.	IIa	B	54
IVUS in selected patients to optimize stent implantation.	IIa	B	702,703,706
IVUS to assess severity and optimize treatment of unprotected left main lesions.	IIa	B	705
IVUS or OCT to assess mechanisms of stent failure.	IIa	C	
OCT in selected patients to optimize stent implantation.	IIb	C	

Circulation February 17, 2004

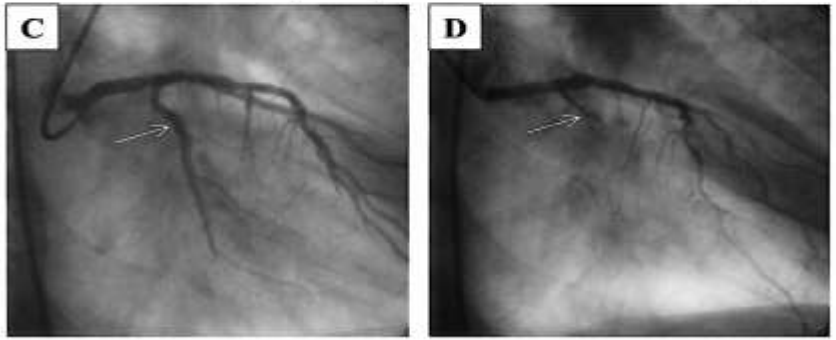
Localized Hypersensitivity and Late Coronary Thrombosis Secondary to a Sirolimus-Eluting Stent

Should We Be Cautious?

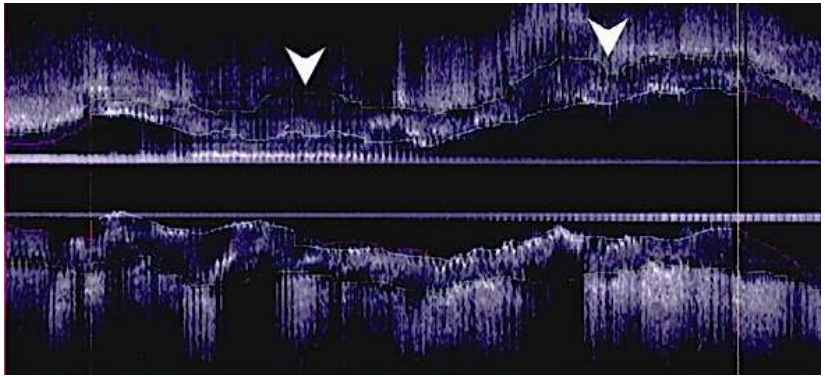
Renu Virmani, MD; Giulio Guagliumi, MD; Andrew Farb, MD; Giuseppe Musumeci, MD;

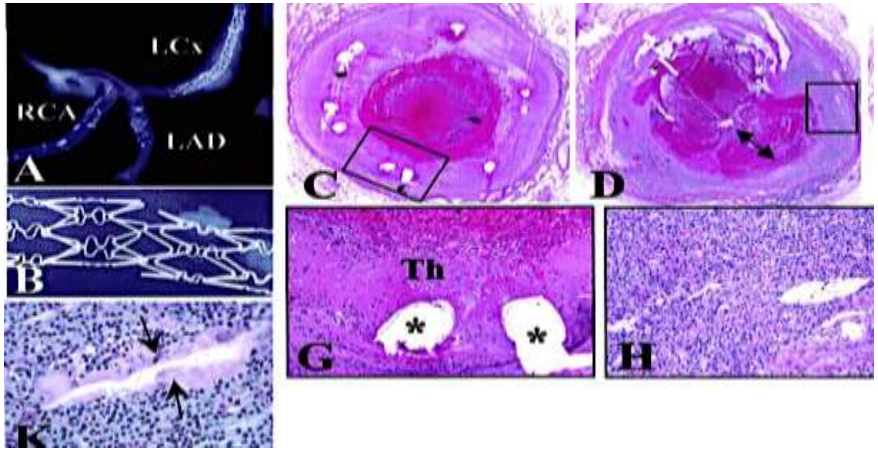


Baseline Lesion (LCx) CYPHER™ Stent Implants

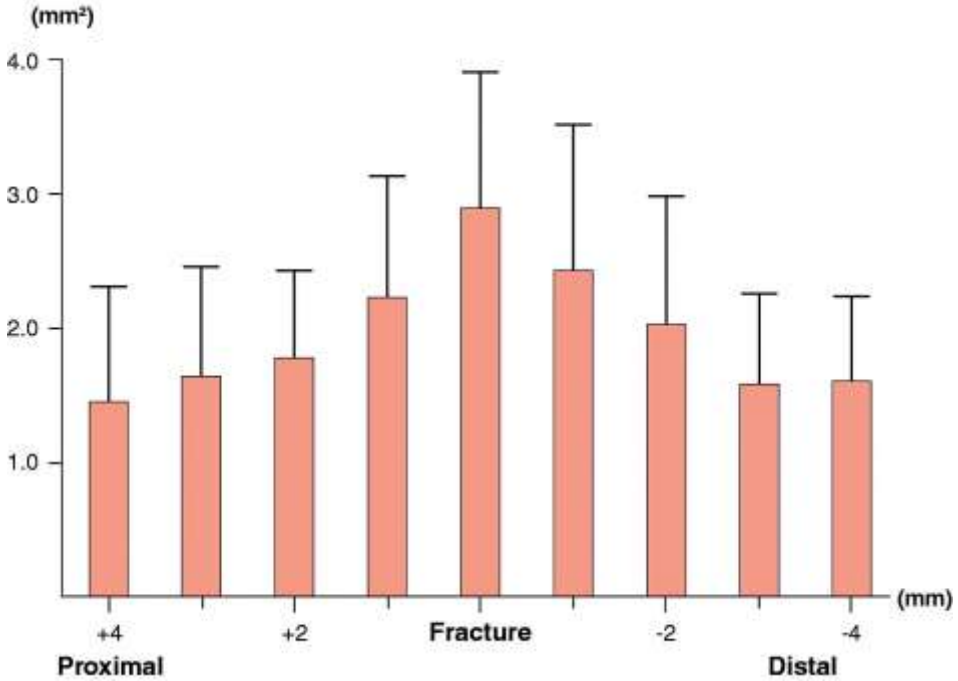


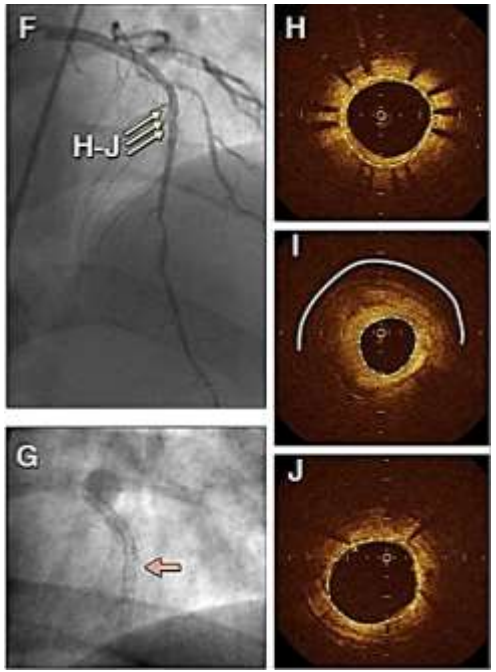
Follow-up (8 Months) Follow-up (18 Months)





Neointimal Hyperplasia Increase at Fracture Site in DES

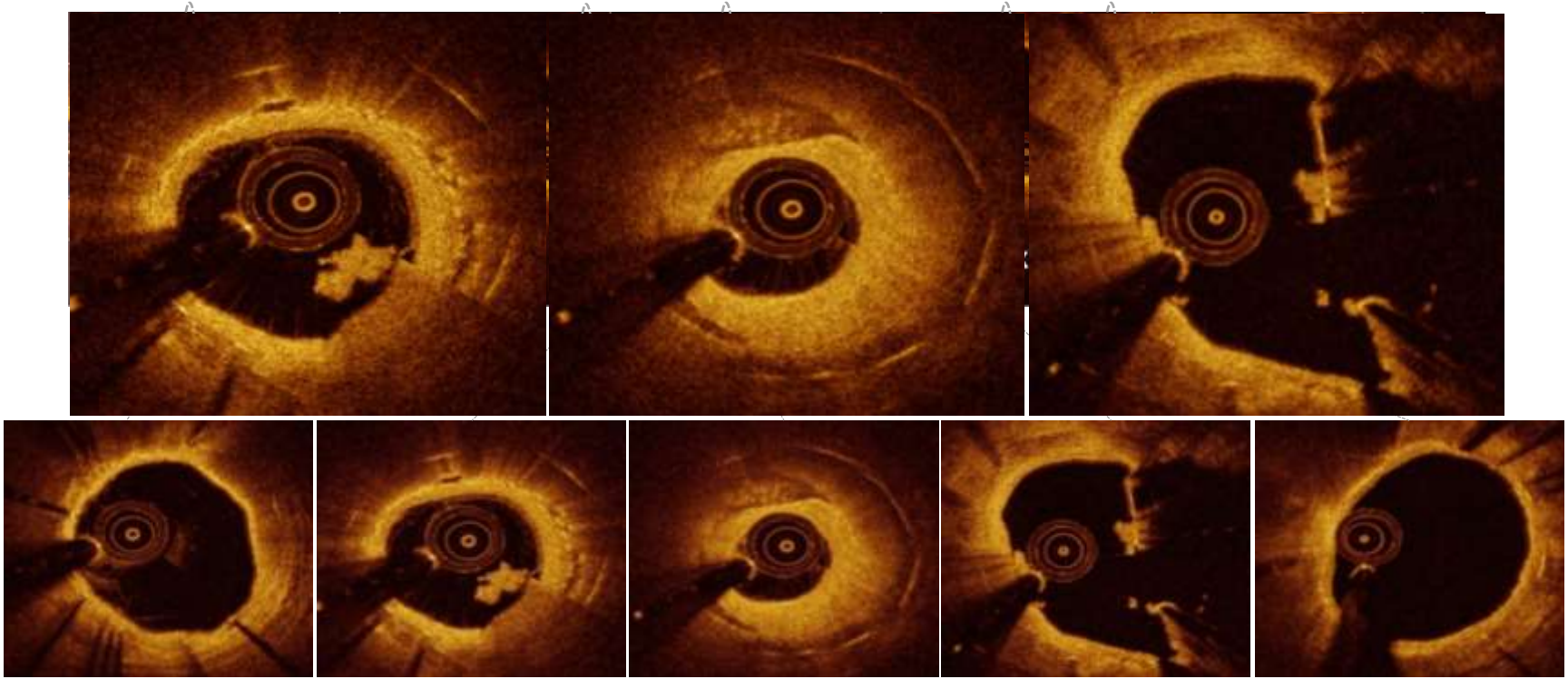




Kashiwagi M et al. JACC 2012, 5(2): 232-3

To Understand Causes of Stent Failure –Thrombosis vs Restenosis

Stent Underexpansion, Malapposition, Lipid Laden Neointima, Restenosis



Azienda Ospedaliera Papa Giovanni XXIII Bergamo

Sistema Sanitario Regione Lombardia

G. Guagliumi et al JACC Intv Jan 2012; 5:12-20

JACC: CARDIOVASCULAR INTERVENTIONS

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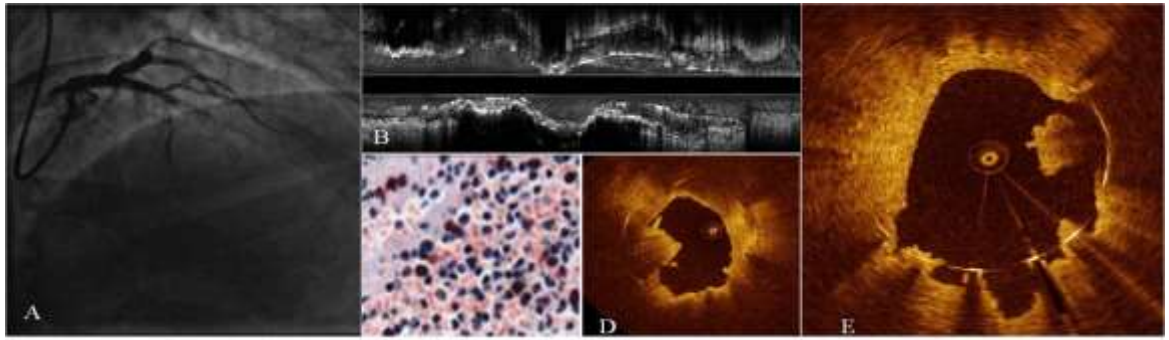
EDITORIAL COMMENT

Do We Know What Causes Very Late Drug-Eluting Stent Thrombosis?*

Gary S. Mintz, MD, Akiko Maehara, MD

New York, New York



JACC: CARDIOVASCULAR INTERVENTIONS
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VOL. 5, NO. 1, 2012
ISSN 1936-8798/$36.00
DOI: 10.1016/j.jcin.2011.09.018

CLINICAL RESEARCH

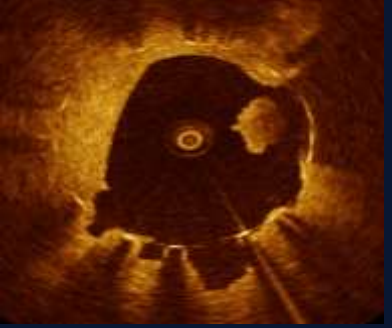
CME

Examination of the In Vivo Mechanisms of Late Drug-Eluting Stent Thrombosis

Findings From Optical Coherence Tomography and Intravascular Ultrasound Imaging

Giulio Guagliumi, MD,* Vasile Sirbu, MD,* Giuseppe Musumeci, MD,* Robert Gerber, MD,† Giuseppe Biondi-Zoccai, MD,* Hideyuki Ikejima, MD,* Elena Ladich, MD,‡ Nikoloz Lortkipanidze, MD,* Aleksandre Matiashvili, MD,* Orazio Valsecchi, MD,* Renu Virmani, MD,‡ Gregg W. Stone, MD§

Bergamo, Italy; London, United Kingdom; Gaithersburg, Maryland; and New York, New York



1st Gen DES with Definite LST: Thr Asp +OCT +IVUS

Median time to presentation 615 days (1-3 Q 394-1186)

Multivariate Predictors of Late Stent Thrombosis in DES

Variable	OR [95% CI] per 0.01 increase	P
Length of segments with uncovered struts, mm (OCT)	2.46 [1.29-9.78]	0.008
Remodeling index (IVUS)	1.06 [1.03-1.19]	0.003

Matched for: stent type, similar EEM CSA (p= 0.49) and LCSA (p=0.96) of the IVUS reference segment

G. Guagliumi et al. JACC Intv 2012; 5:12-20

Journal of the American College of Cardiology
© 2005 by the American College of Cardiology Foundation
Published by Elsevier Inc.

Vol. 45, No. 7, 2005
ISSN 0735-1097/05/$30.00
doi:10.1016/j.jacc.2004.12.066

Stent Underexpansion and Residual Reference Segment Stenosis Are Related to Stent Thrombosis After Sirolimus-Eluting Stent Implantation

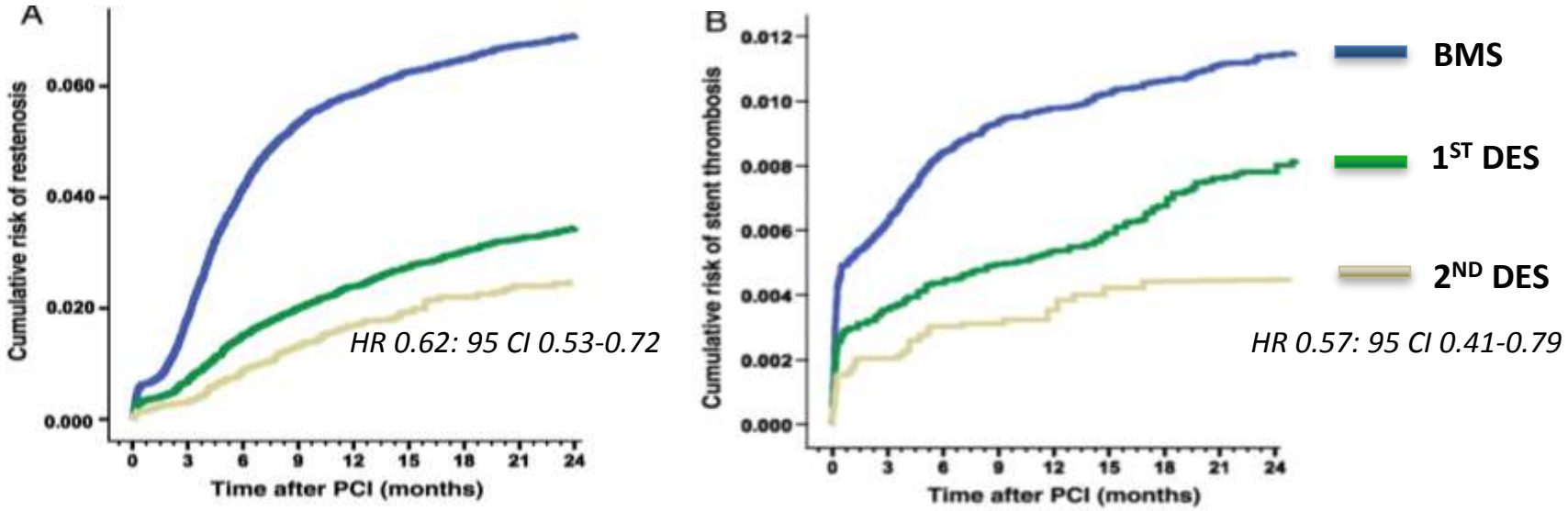
An Intravascular Ultrasound Study

Kenichi Fujii, MD, Stéphane G. Carlier, MD, PhD, Gary S. Mintz, MD, Yi-ming Yang, MD,

	Stent Thrombosis (n=15)	Matched Control Group (n=45)	*P*
• IVUS analyses			
Plaque burden	62 ± 13	46 ± 9	<0.001
Significant residual stenosis	10(67%)	4(9%)	<0.001
• Stent segment			
Minimum stent CSA (mm^2)	4.3 ± 1.6	6.2 ± 1.9	<0.001
Stent expansion	0.65 ± 0.18	0.85 ± 0.14	<0.001
Malapposition	2(13%)	7(16%)	0.8

Lower risk of restenosis and stent thrombosis with unrestricted use of "new-generation" drug-eluting stents: SCAAR Registry

94.384 consecutive stent (Nov 2006 to Oct 2010)

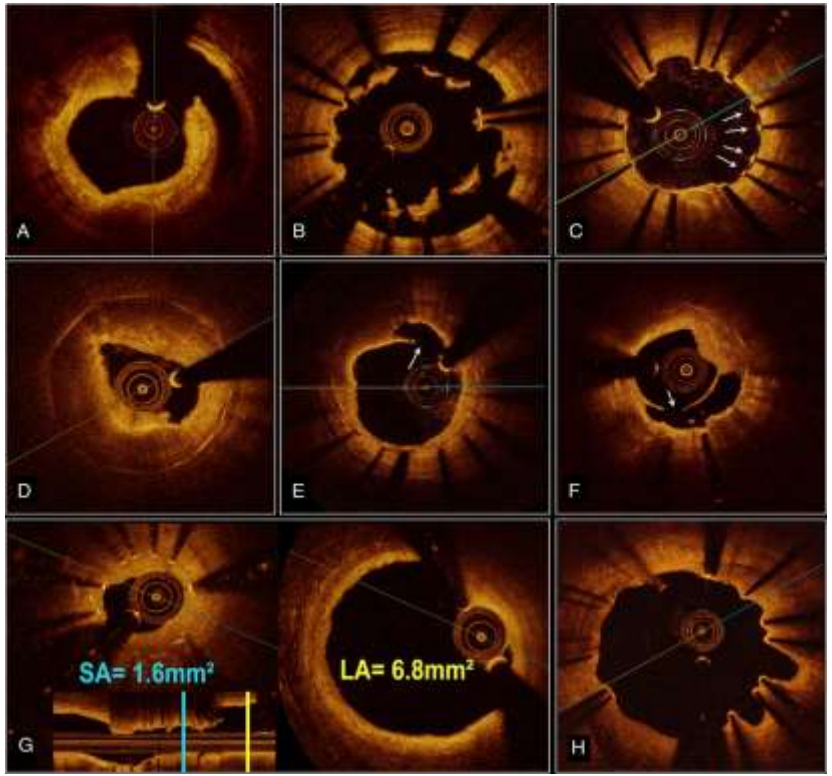


Sarno G. Eur Heart J. 2012, 33(6) 606-13

Mechanisms of stent thrombosis: the National PESTO French Registry (N=120)

- 69% deferred OCT procedure, 4 days (2-7) after vessel de-occlusion (Thrombus asp +- IIb/IIIa inhibit

Mechanism of ST`	Angio (n=13)	Post-OCT (n=14)	P
Completely identified	12 %	43 %	0, 001
Unidentified	48 %	13%	0,001
Probably identified	40%	46%	NS
Unique abnormality		77.5%	
Multiple abnormalities		22.5%	

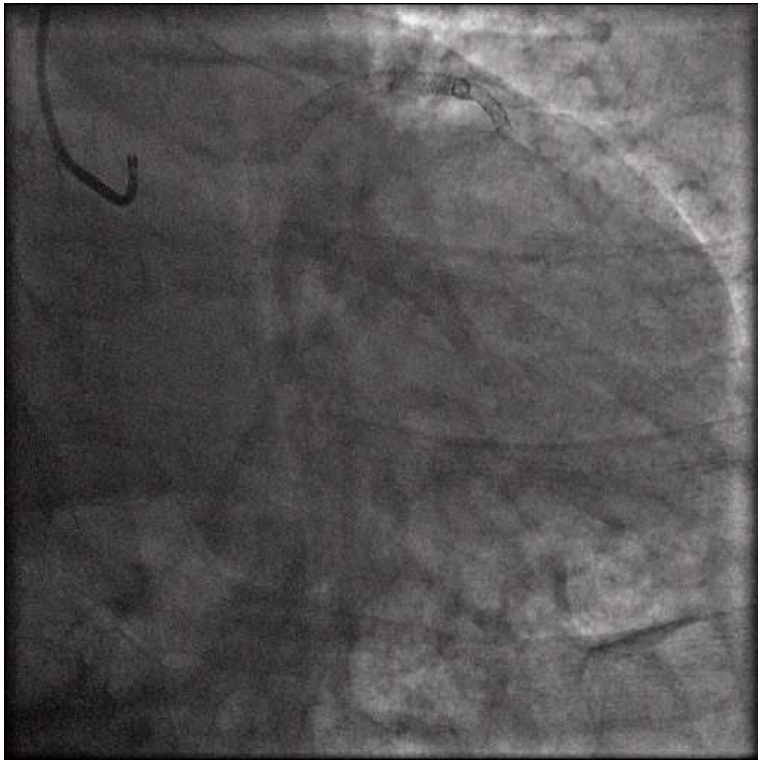


Geraud Souteyrand et al. Eur Heart J 2016;37:1208-1216

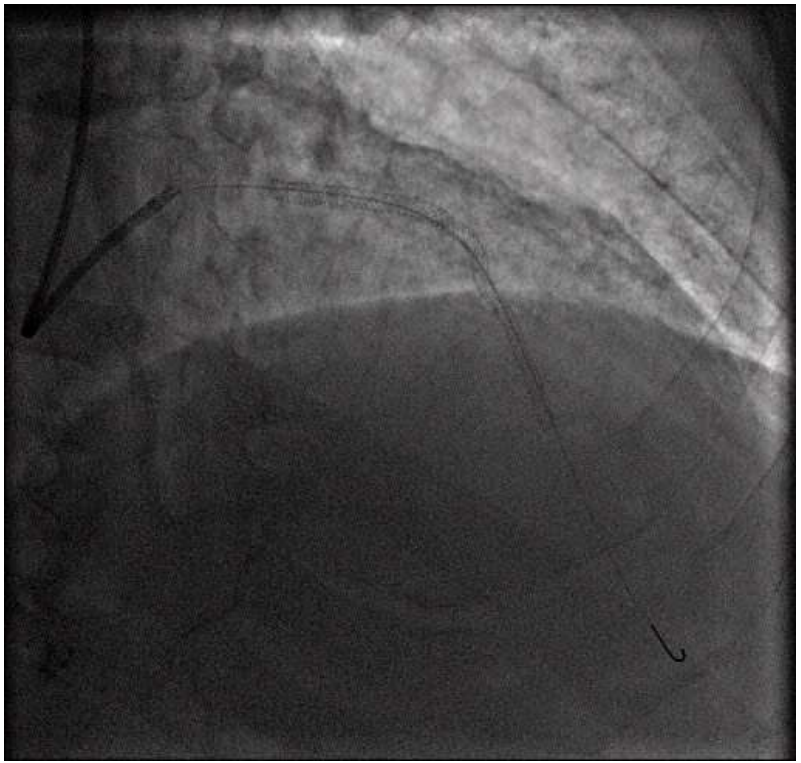
European Heart Journal

VLST 4 years after EES

only on aspirin since 2 yrs: ASPI test 211 (normal 390-780)

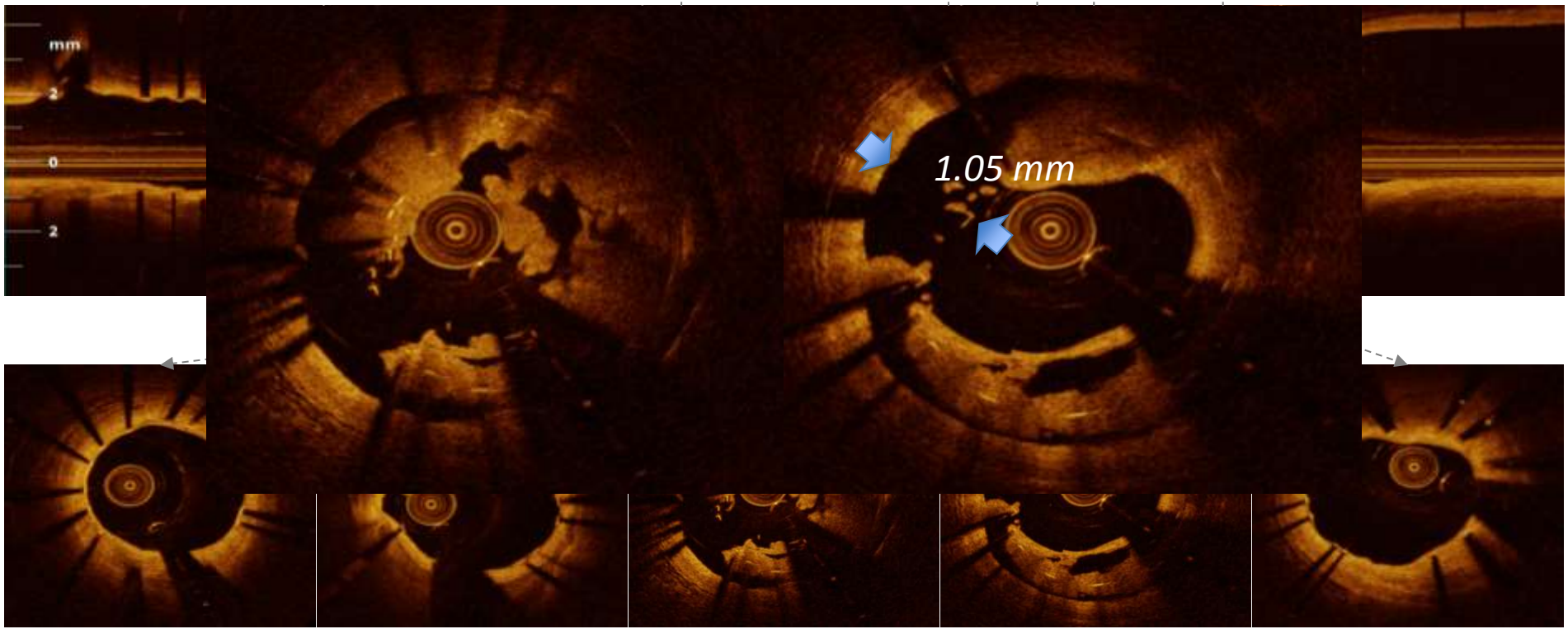


March 04, 2014



After thrombus aspiration

Large segmental malapposition with uncovered struts



SA 7.02 mm²

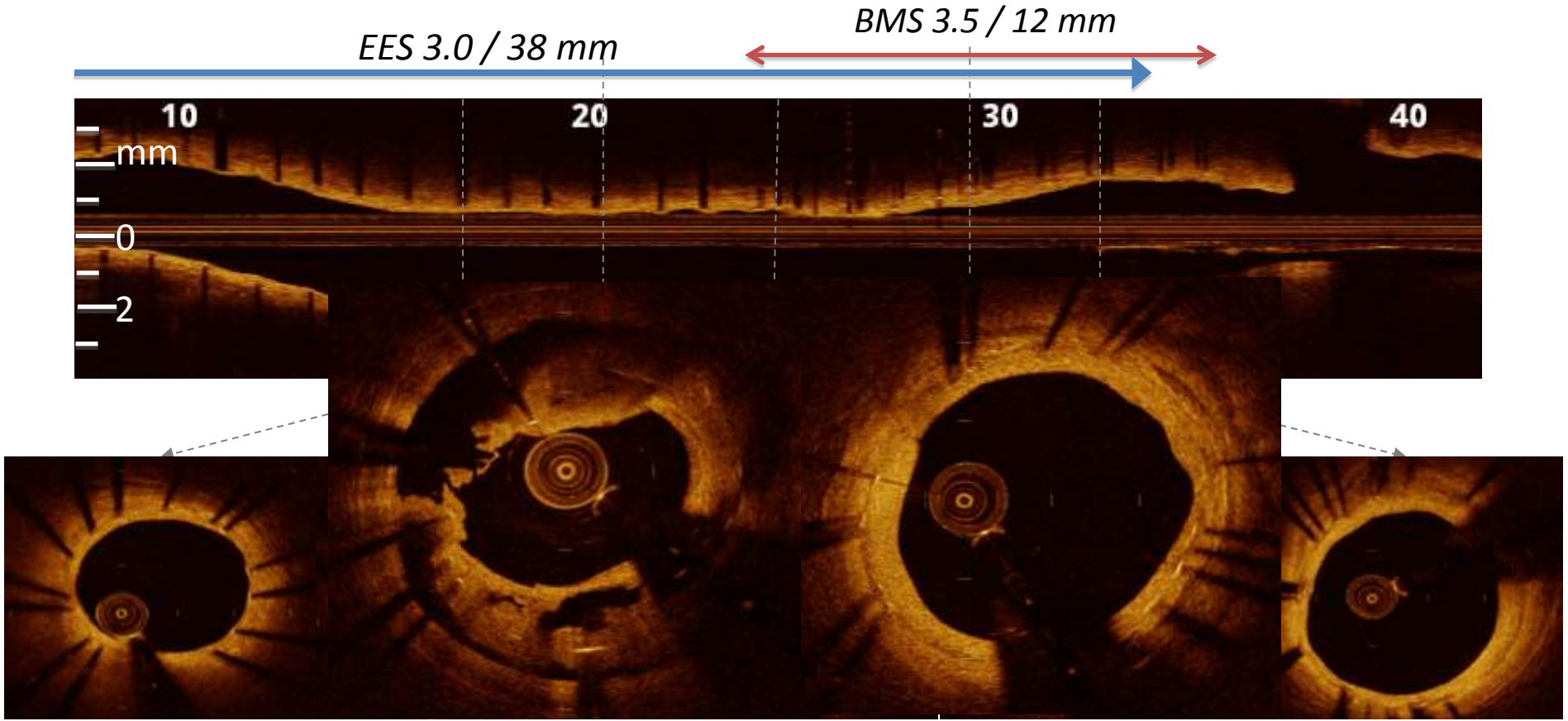
SA 8.12 mm²

SA 9.10 mm²
LA 16.47 mm²

SA 8.12 mm²
LA 14.08 mm²

SA 7.94 mm²

6-month follow-up after BMS Focal Implantation



VLST

6-month follow-up

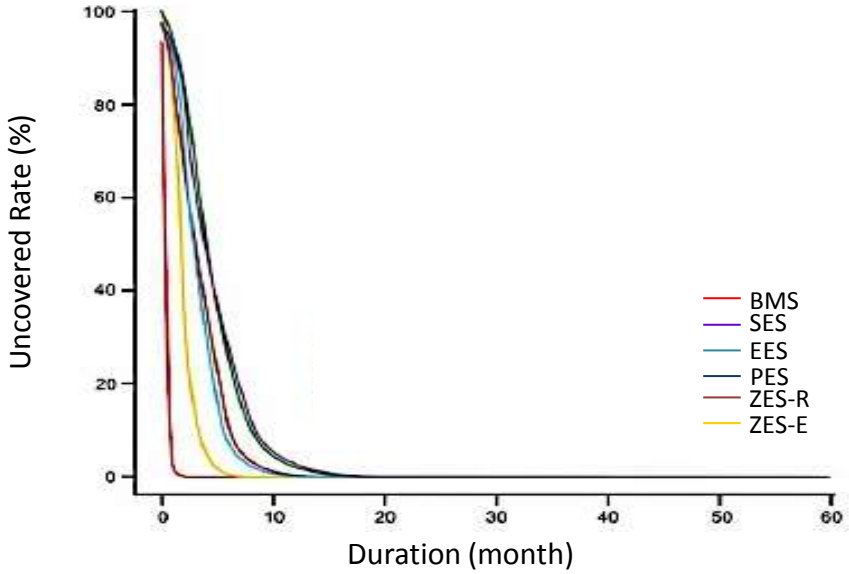
Catheterization and Cardiovascular Interventions 00:00–00 (2015)

Original Studies

Temporal Trends in Strut-Level Optical Coherence Tomography Evaluation of Coronary Stent Coverage: A Systematic Review and Meta-Analysis

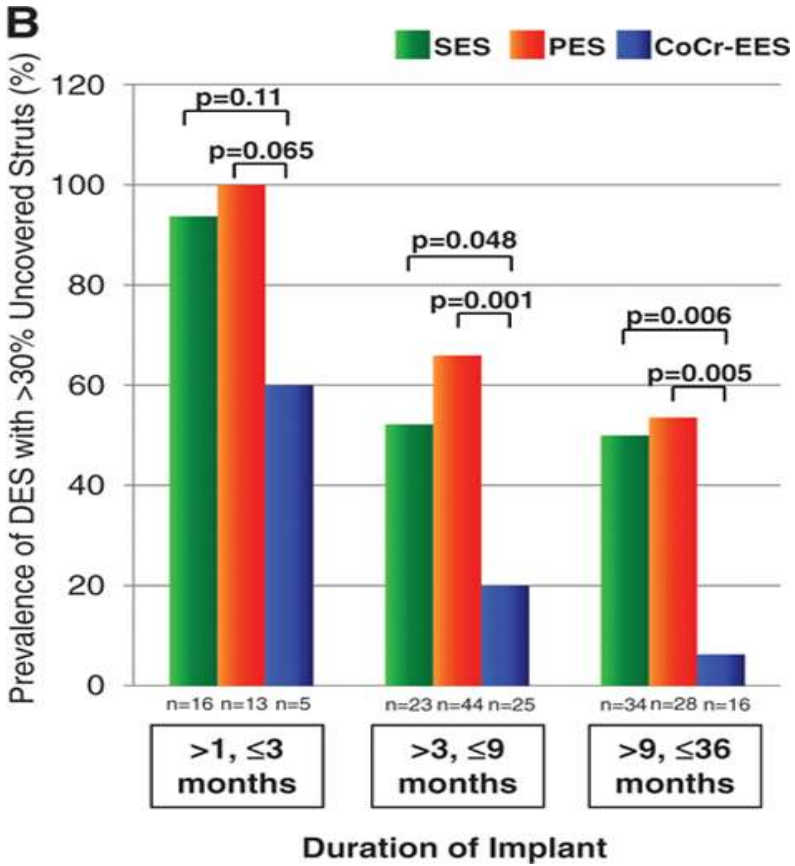
Kwan S Lee,[1*] MD, Justin Z Lee,[1] MD, Chiu-Hsieh Hsu,[1] PhD, Muhammad Husnain,[1] MD,

81 studies included in meta-analysis



Comparison of strut coverage rate

1° Generation vs current DES



Otsuka F. et al. Circulation 2014

Interventional Cardiology

Mechanisms of Very Late Drug-Eluting Stent Thrombosis Assessed by Optical Coherence Tomography

Masanori Taniwaki, MD; Maria D. Radu, MD, PhD; Serge Zaugg, MSc;

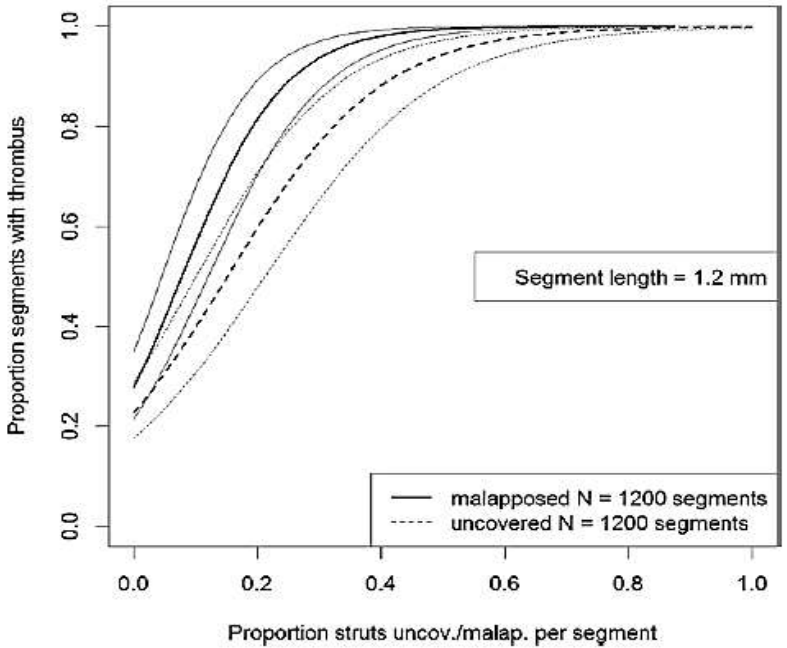
(*Circulation*. 2016;133:650-660. DOI: 10.1161/CIRCULATIONAHA.115.019071.)

N=64 patients

Malapposition and uncovered struts strongly associated with the presence of thrombus

	Thrombus region *median (95% CI)*	**Control region** *median (95% CI)*	**Ratio of percentages (Thrombus/Control)** *median (95% CI)*	**P**
Percentage of struts				
Uncovered, apposed (%)	10.59 (6.67 - 16.21)	1.28 (0.78 - 2.03)	8.26 (6.82 - 10.04)	<0.001
Malapposed, (%)	3.73 (3.24 - 5.81)	0.29 (0.17 - 0.46)	13.03 (10.13 - 16.93)	<0.001
Percentage of frames with				<0.001
≥30% uncovered, apposed struts (%)	16.15 (10.4 -23.16)	1.83 (1.07 - 2.92)	8.82 (6.43 - 12.31)	<0.001
≥30% malapposed struts (%)	5.51 (3.04 - 9.41)	0.2 (0.09 - 0.42)	27.06 (16.23 - 46.88)	<0.001

Proportion of Segments with Thrombus and the Proportion of Malapposition or Uncoverage in 1.2-mm-Long Segments



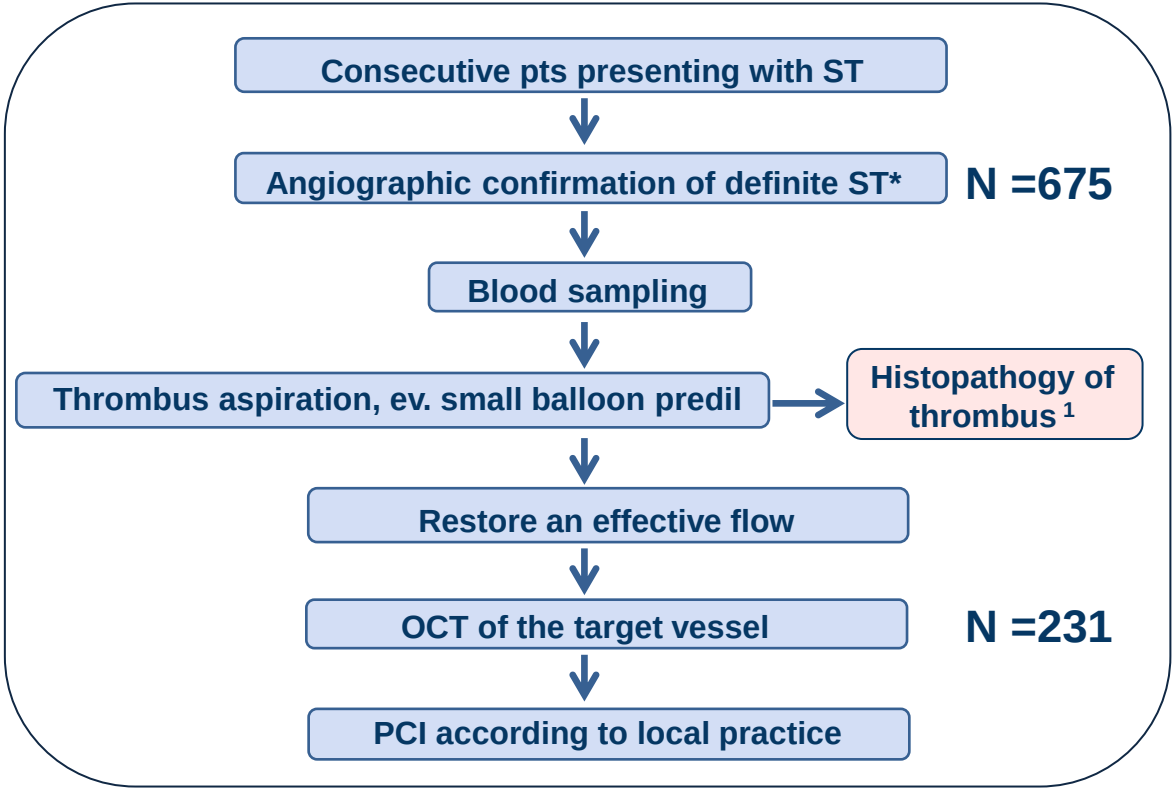
Taniwaki M et al. Circ 2016, 133:650-660

Longitudinal Extension: most important correlate of thrombus formation

	Thrombus region *mean (95% CI)*	**Control region** *mean (95% CI)*	**Difference** *mean (95% CI)*	***P***
Minimal stent area (mm^2)	5.18 (4.63 - 5.73)	5.55 (4.97-o 6.13)	-0.37 (-0.71 - -0.04)	0.030
Maximal ISA distance (mm)	0.44 (0.3 - 0.58)	0.42 (0.29 - 0.55)	0.02 (-0.08 - 0.13)	0.696
Maximal neointimal thickness (mm)	0.69 (0.59 - 0.78)	0.74 (0.65 - 0.84)	-0.06 (-0.17 - 0.05)	0.291
Maximal length with consecutive				
Uncoverage (mm)	2.24 (1.63 - 2.85)	0.99 (0.64 - 1.34)	1.25 (0.58 - 1.92)	<0.001
Malapposition (ISA) (mm)	3.4 (2.55 - 4.25)	1.29 (0.81 - 1.77)	2.11 (1.23 - 3)	<0.001

Taniwaki M et al. Circ 2016, 133:650-660

PRESTIGE – Stent Thrombosis



OCT substudy

- **29 Centers** with OCT capability
- Pts **prospectively enrolled** using a **centralized telephone** registration system
- Data collected according to a **standardized protocol**
- **OCT before interventions** (**recommended**)
- OCT immediately after emergent PCI (suggested)

- **217 patients comprised the primary study cohort for the current analysis (333 stent, ≅ 50% current generation DES)**

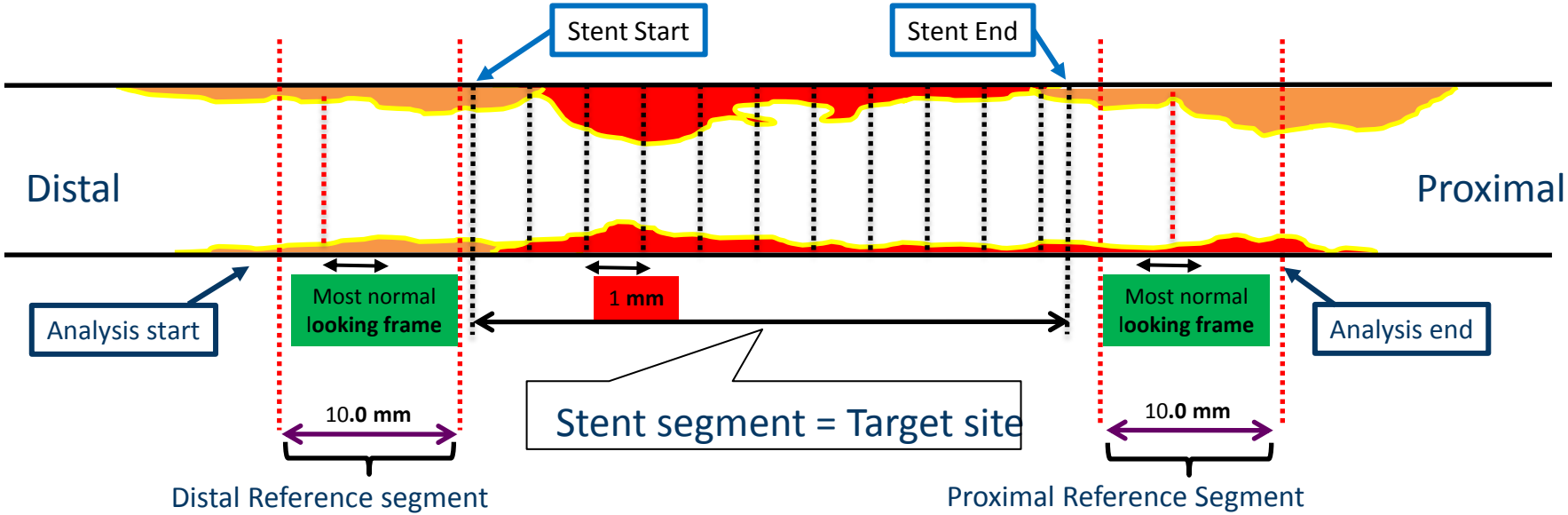
** according to Academic Research Consortium (ARC) criteria.*

[1] J. Riegger et al Eur H J 2015:ESC FASTTRACK

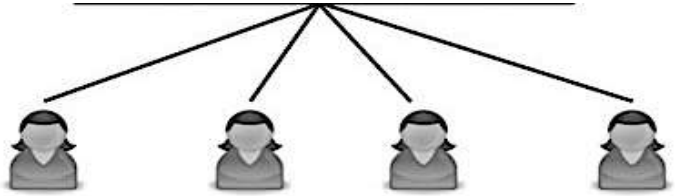
Core Lab OCT Qualitative and Quantitative Analysis

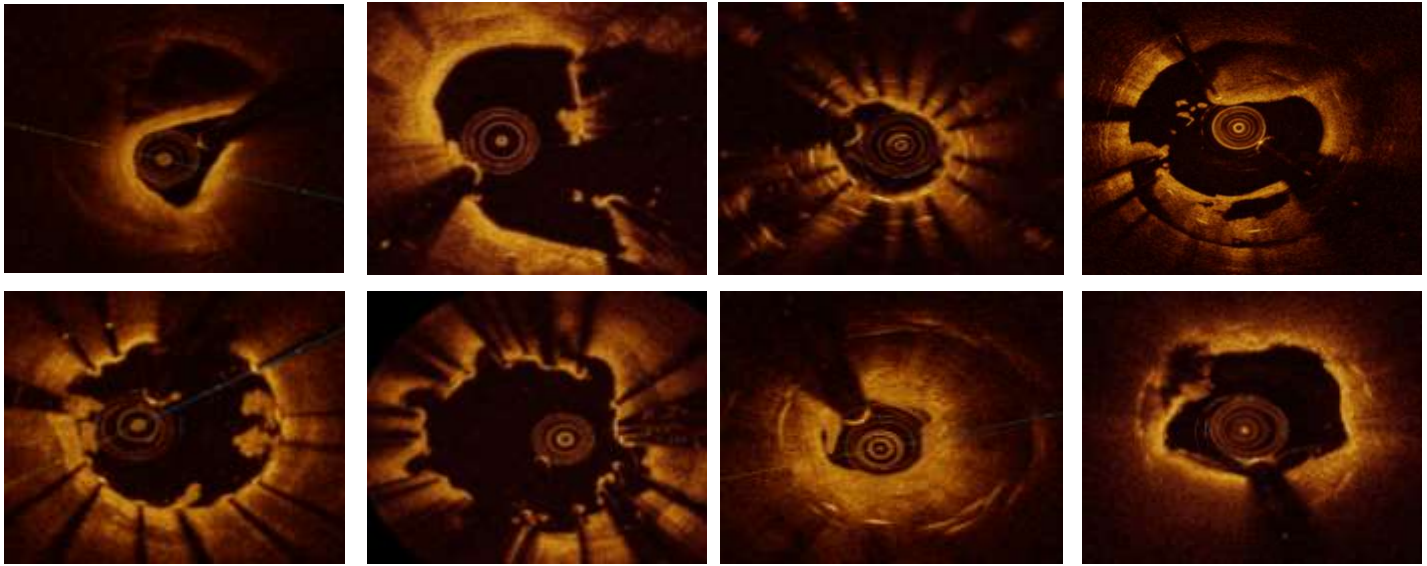
Expert readers blind to patients characteristics and time of ST

- Quality screening: 14/231 not sufficient quality
- Morphometric Analysis
- Qualitative/quantitative analysis



Expert Group* to adjudicate causative factors

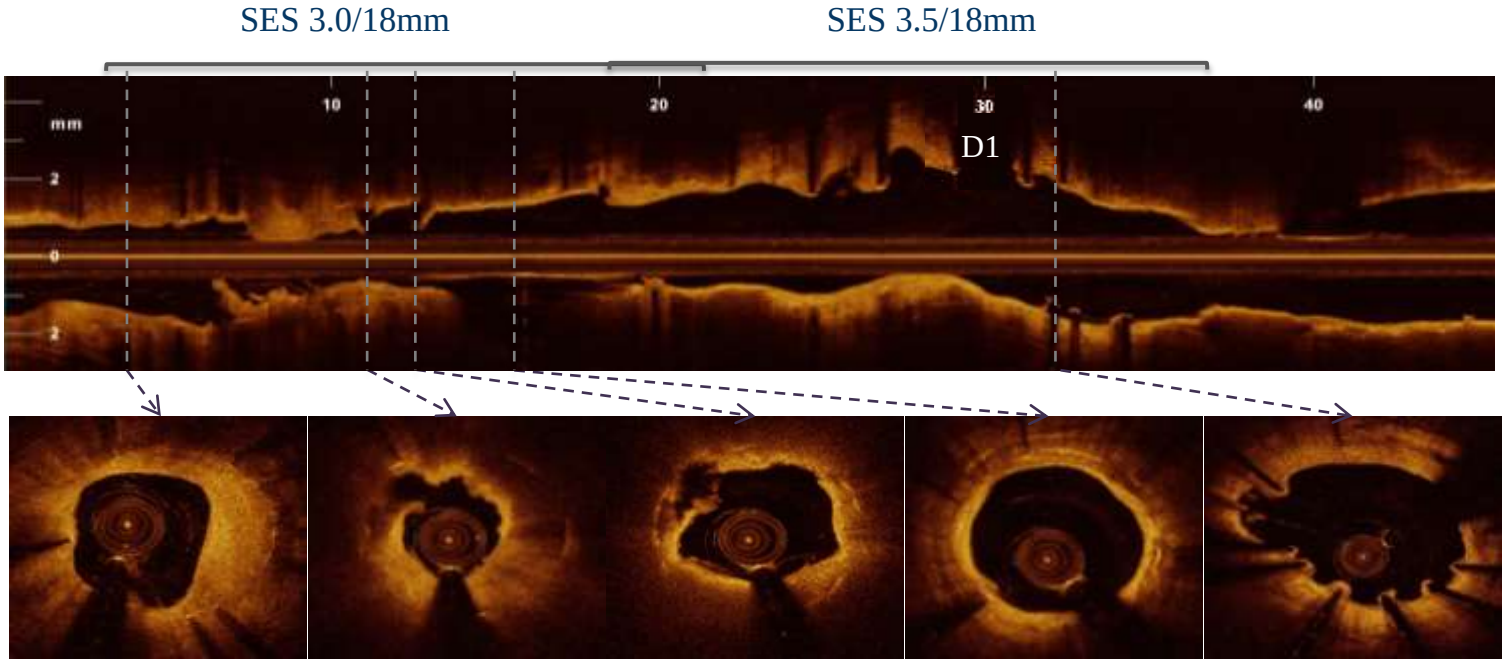




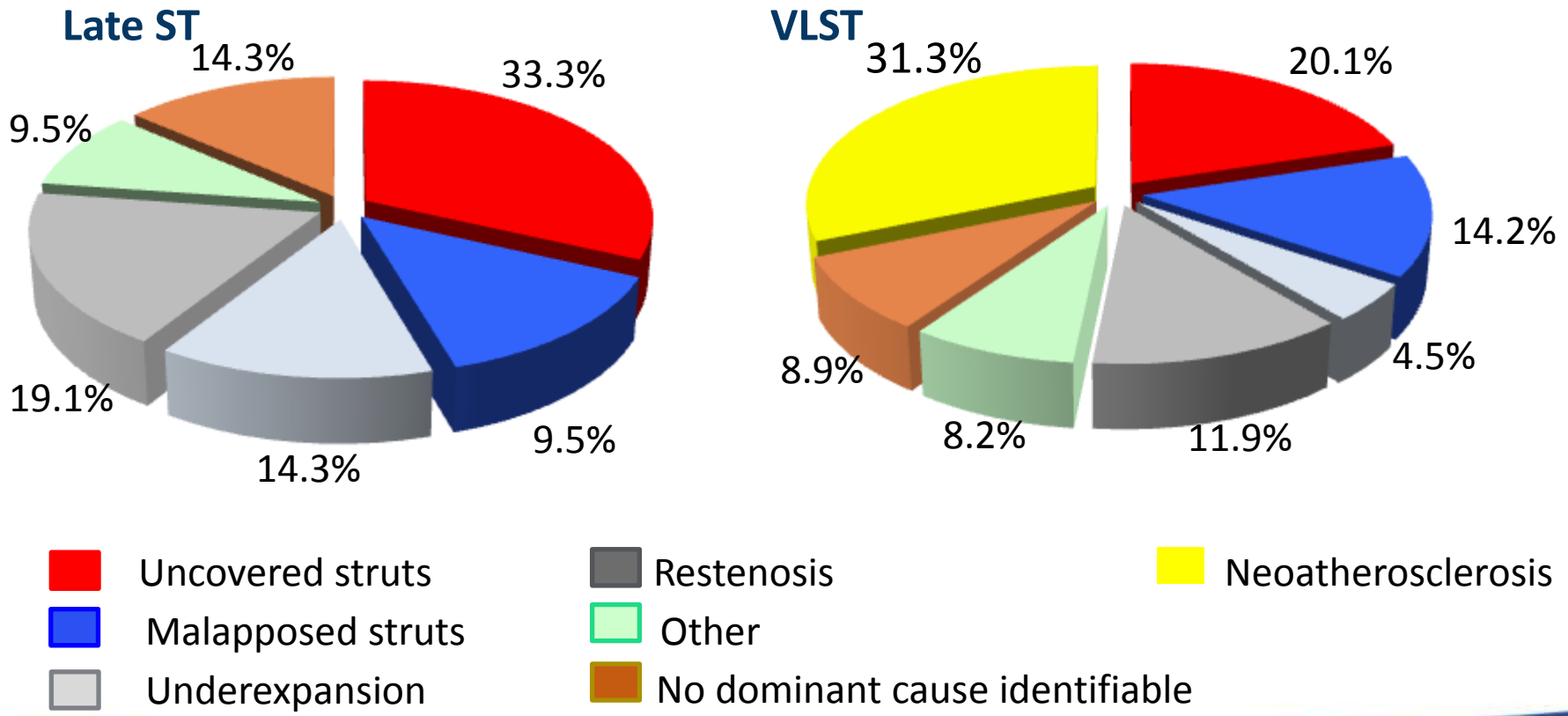
* Interventional cardiologists (TA, TkA, FA, RB, GG, VS) and a pathologist (MJ) with documented expertise in clinical/non-clinical use of OCT for evaluating coronary stent procedures and differential vascular responses

Dominant mechanism and contributing factors

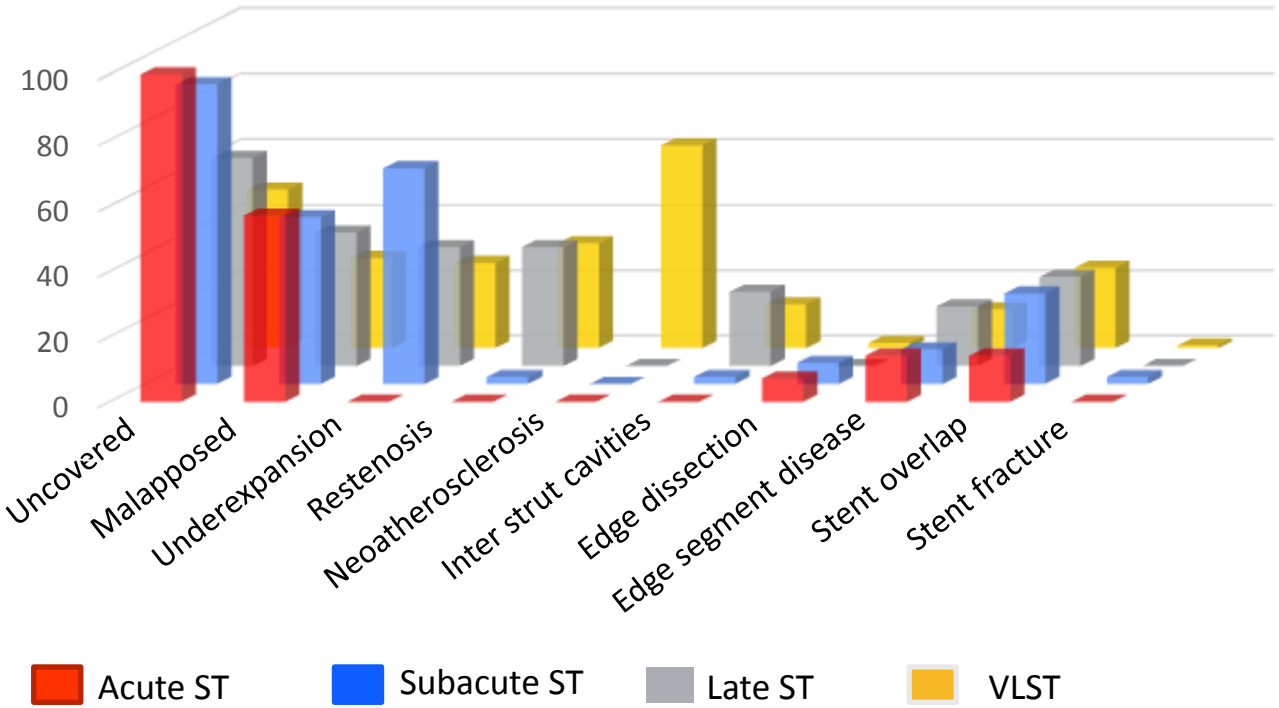
- Unaware from patient/stent characteristics and timing of ST
- Review of all acquired and analyzable pullbacks
- Dominant and possibly contributing imaging factors identified by consensus



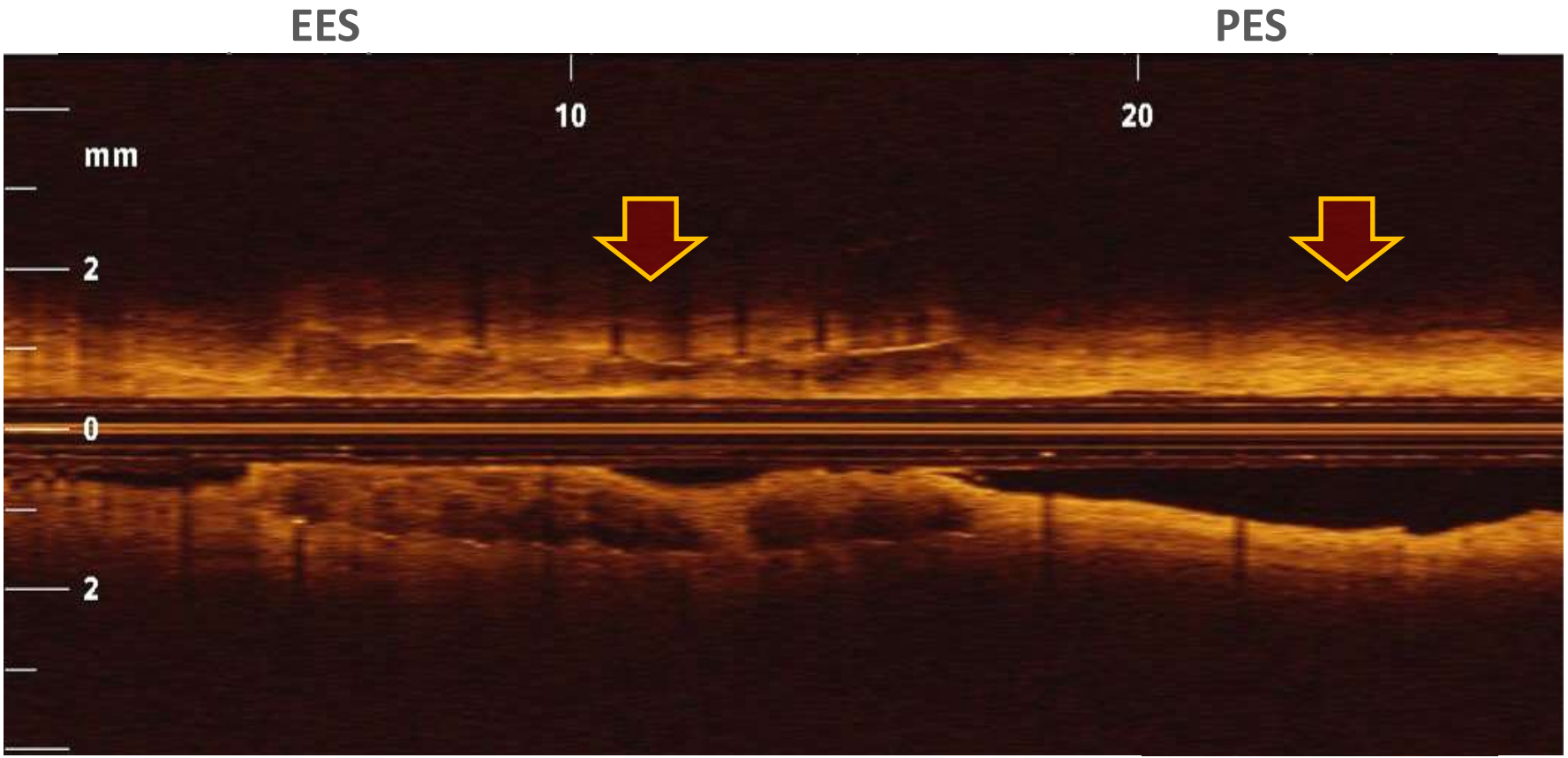
Dominant Imaging Findings of ST as adjudicated by Expert Group



Possibly Contributing Imaging Factors identified by the Expert Group

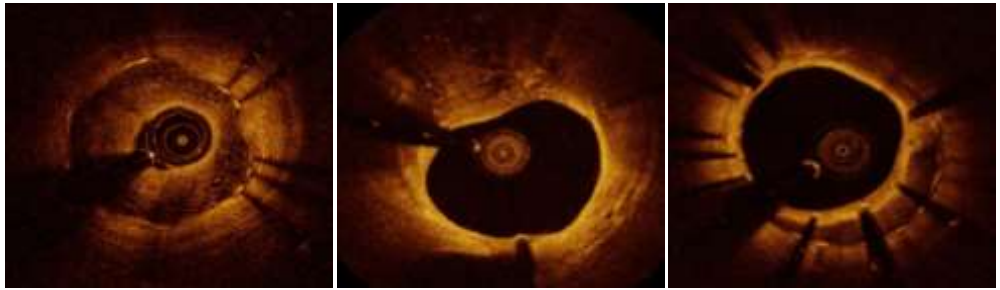


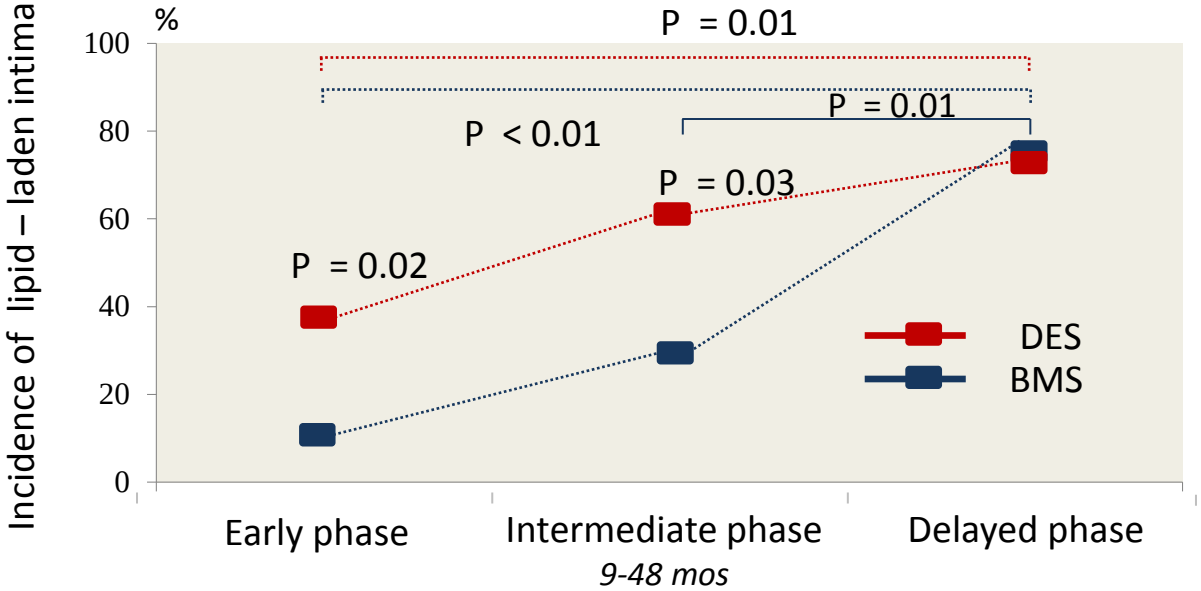
Accelerated neoatherosclerosis in first and current generation DES



Komukai K. Guagliumi G et al, Eurointervention 2015, November

Incidence and time course of neoatherosclerosis between BMS and DES

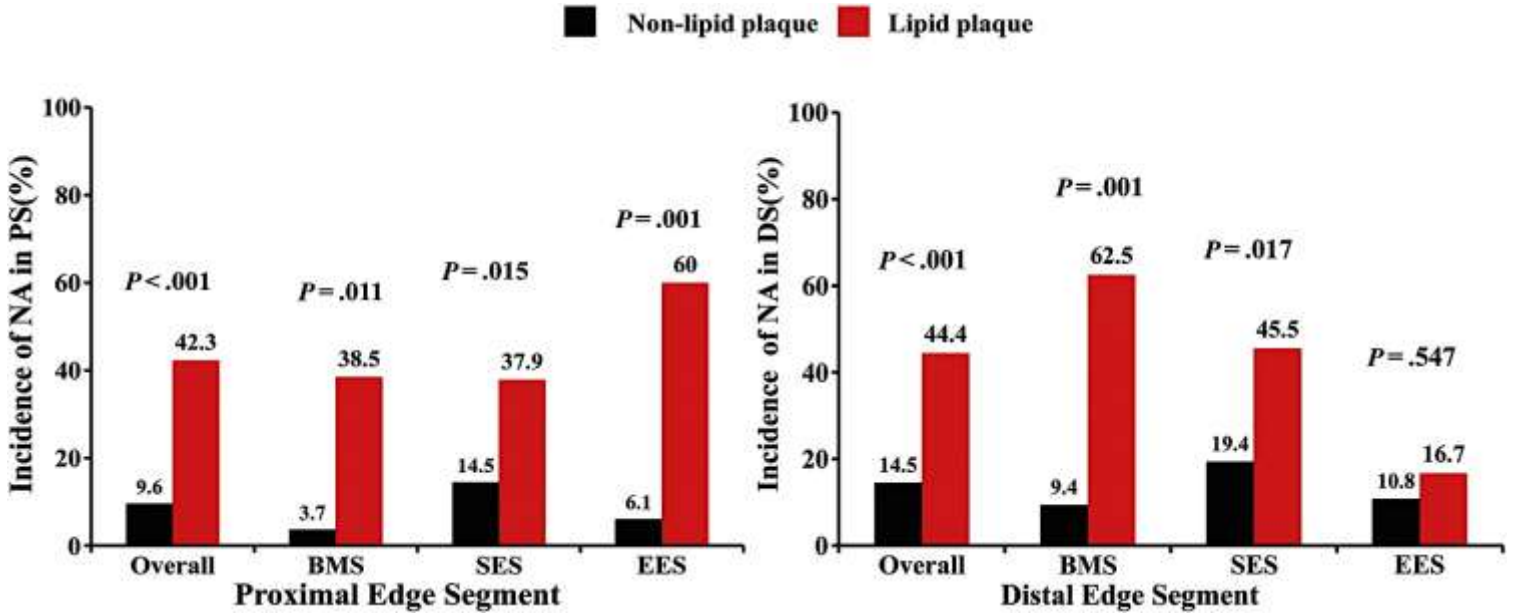




Implication for patient care: **Earlier onset of neoatherosclerosis in DESs than in BMSs**

Yonetsu T et al Am J Cardiol 2012; 110: 933-39

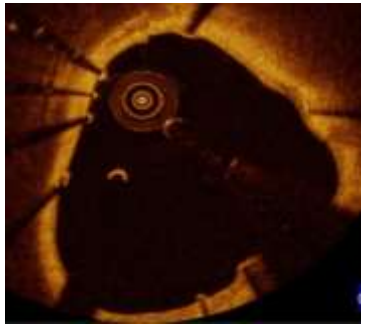
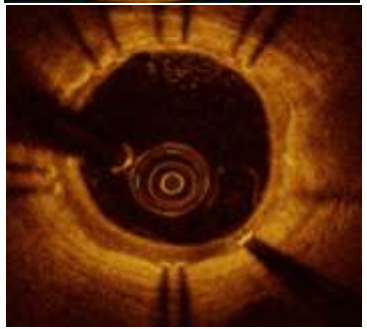
Incidence of Neoatherosclerosis in Relation to Adjacent Plaque

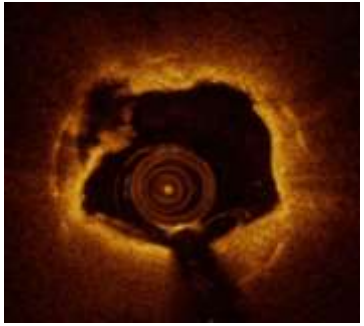
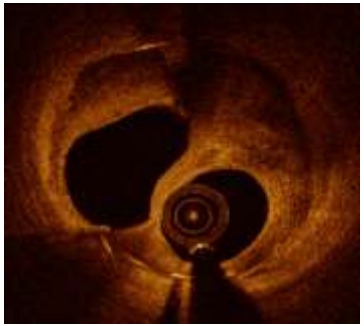


J. Tian et al. Am Heart J 2014; 167:884 - 892.e2

TRANSFORM-OCT

Prospective, randomized, controlled, single blind study comparing **biodegradable abluminal polymer** EES (SYNERGY™) **vs conformal durable polymer** ZES (RESOLUTE Integrity™)

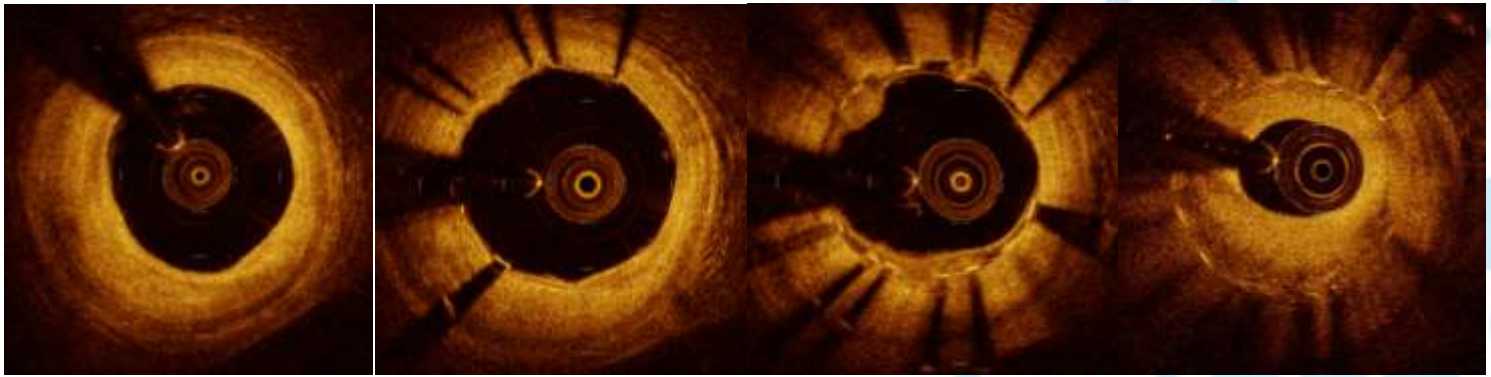



Azienda Ospedaliera Papa Giovanni XXIII Bergamo

Sistema Sanitario Regione Lombardia

ClinicalTrial.gov identifier NCT01972022

Study Endpoints



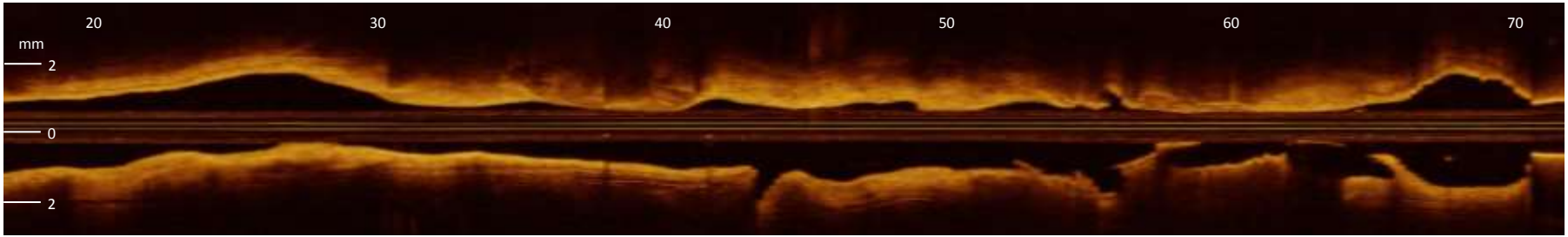
- Max length of consecutive frames with uncovered struts in the two stent arms at 3 and 18 month (**3 month primary end-point and 18 months co-primary end-points**)
- OCT finding of neoatherosclerosis, (***18 month primary end-point***)

- **3 months (powered non inferiority SINERGY vs RESOLUTE)***
- **18 months (powered superiority for SINERGY)**

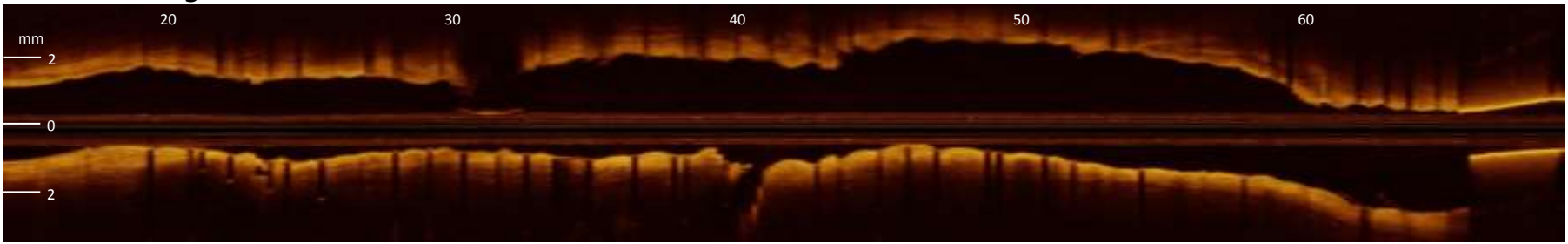
** Selected for presentation at **LBT Hot Line Session EuroPCR 2016***

Does neoatherosclerosis correspond to the site of the culprit plaques?

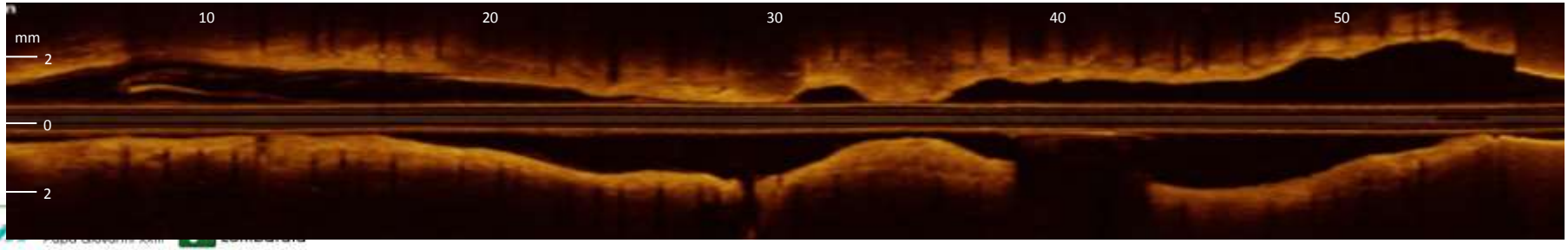
Pre-PCI



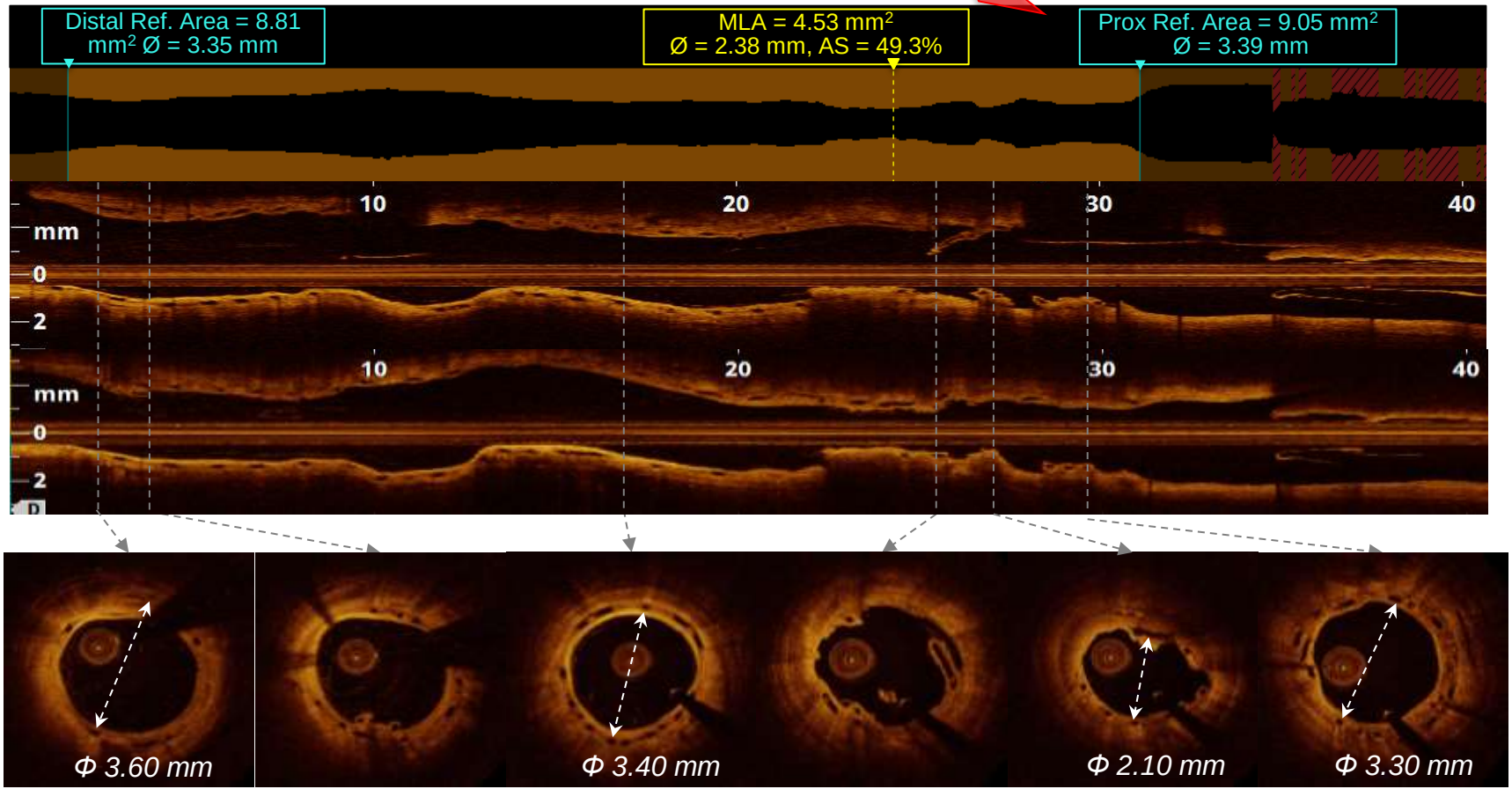
Post-stenting



11 Months: ACS and neoatherosclerosis

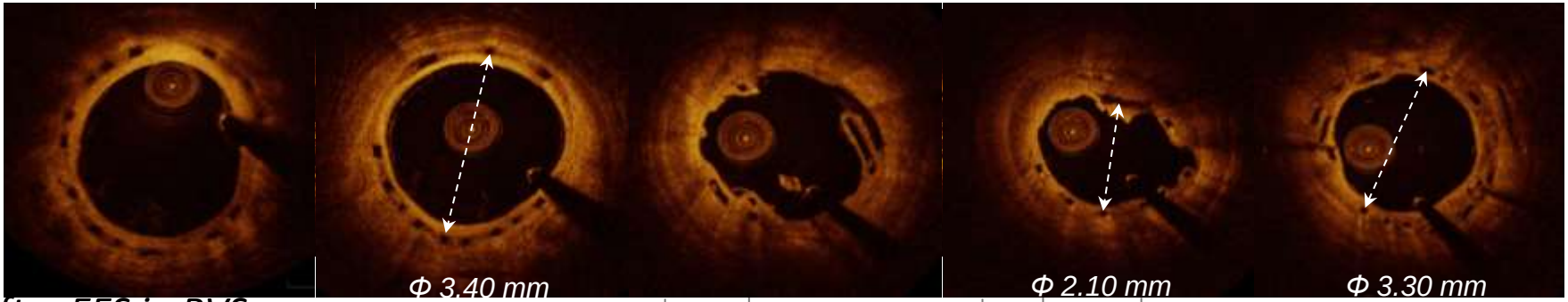


VL Scaffold Thrombosis: role of underexpansion and dismantling

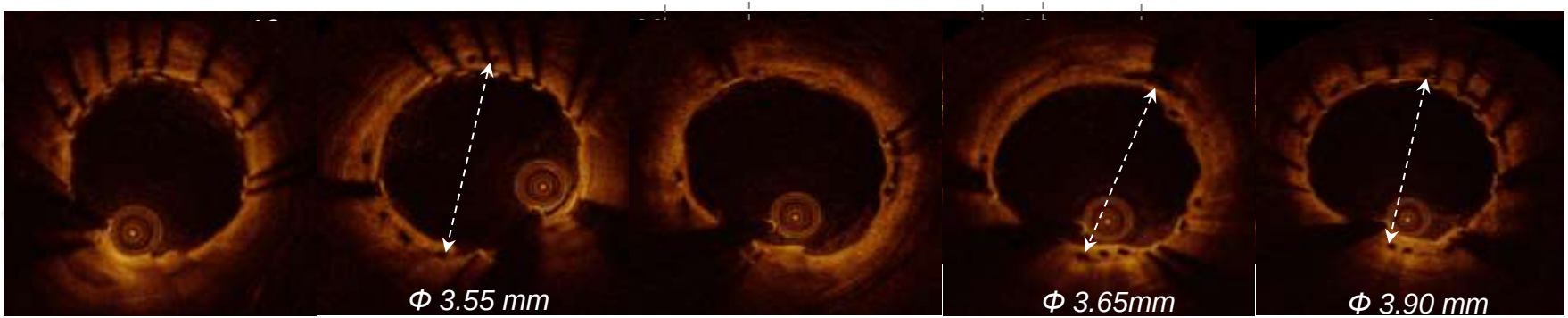


EES expansion in BVS

BVS Thrombosis

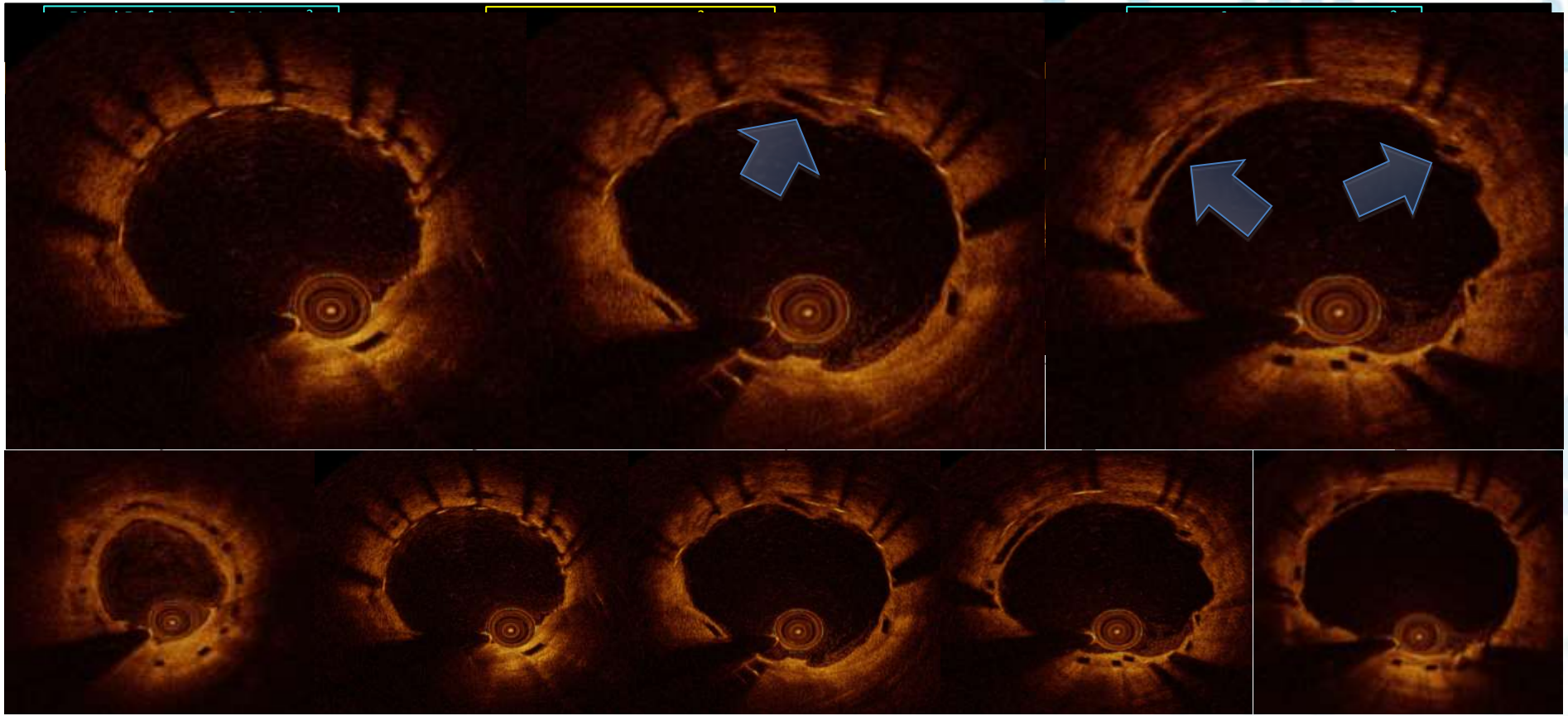


After EES in BVS



EES implantation in BVS

EES 3.5/32 mm + postdil NC balloon Φ4.5 mm



Intracoronary Imaging in Assessing Stent Failure

- Use of Intracoronary imaging, after culprit vessel patency restoration, identify the underlying mechanisms (dominant and contributing) of ST in almost all cases (97% with OCT, $p < 0.001$ vs angio)
- OCT is highly sensitive for thrombus, lack of coverage, malapposition, neoatherosclerosis all possible causes for stent failure. IVUS has unique capabilities in measuring underexpansion and detecting positive vessel remodeling
- Uncovered/malapposed stent struts (longitudinal extension!), underexpansion and severe restenosis were predominant factors within the first year. In-stent neoatherosclerosis is an important factor beyond 1 year.
- OCT and IVUS are both useful to guide appropriate intervention based on specific causes of ST and to assess the following vessel response.