

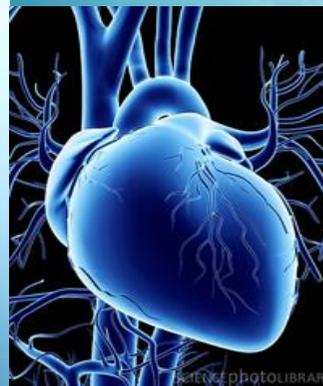
JCR  
2018. 12. 8

# Intravascular Imaging to Evaluate Stent Thrombosis and Restenosis



전남대학교병원

홍영준  
전남의대 순환기내과



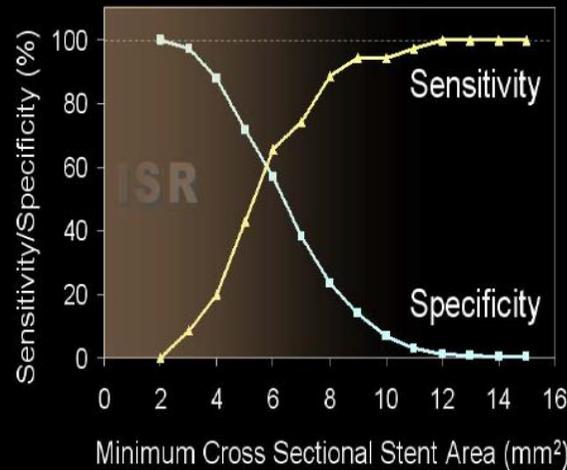
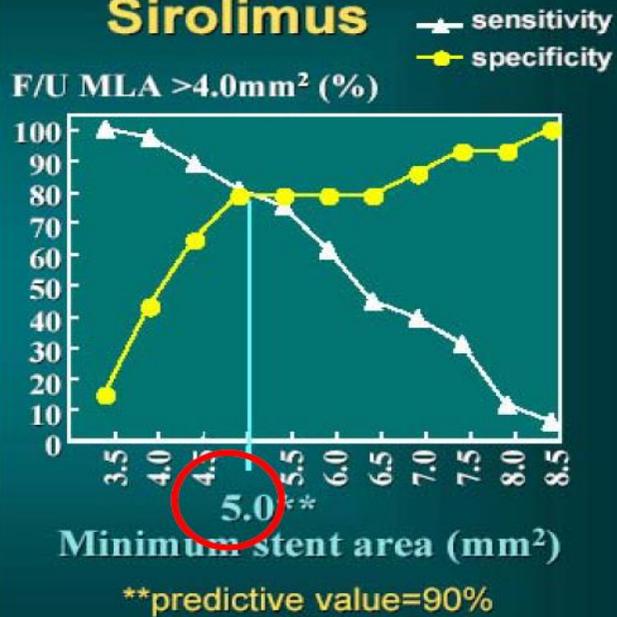
# **Final Stent CSA (Stent Underexpansion)?**

**In-stent restenosis** 

**Stent thrombosis** 

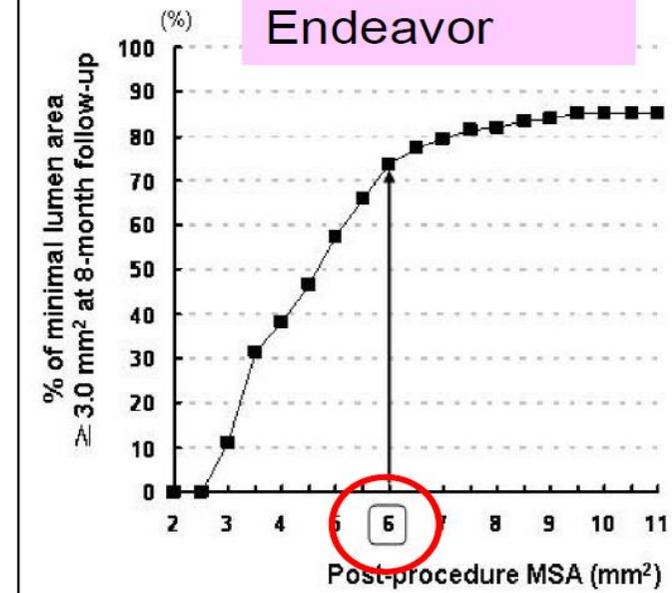
# Optimal Stent Area (IVUS) and Restenosis in DES

## Sirolimus

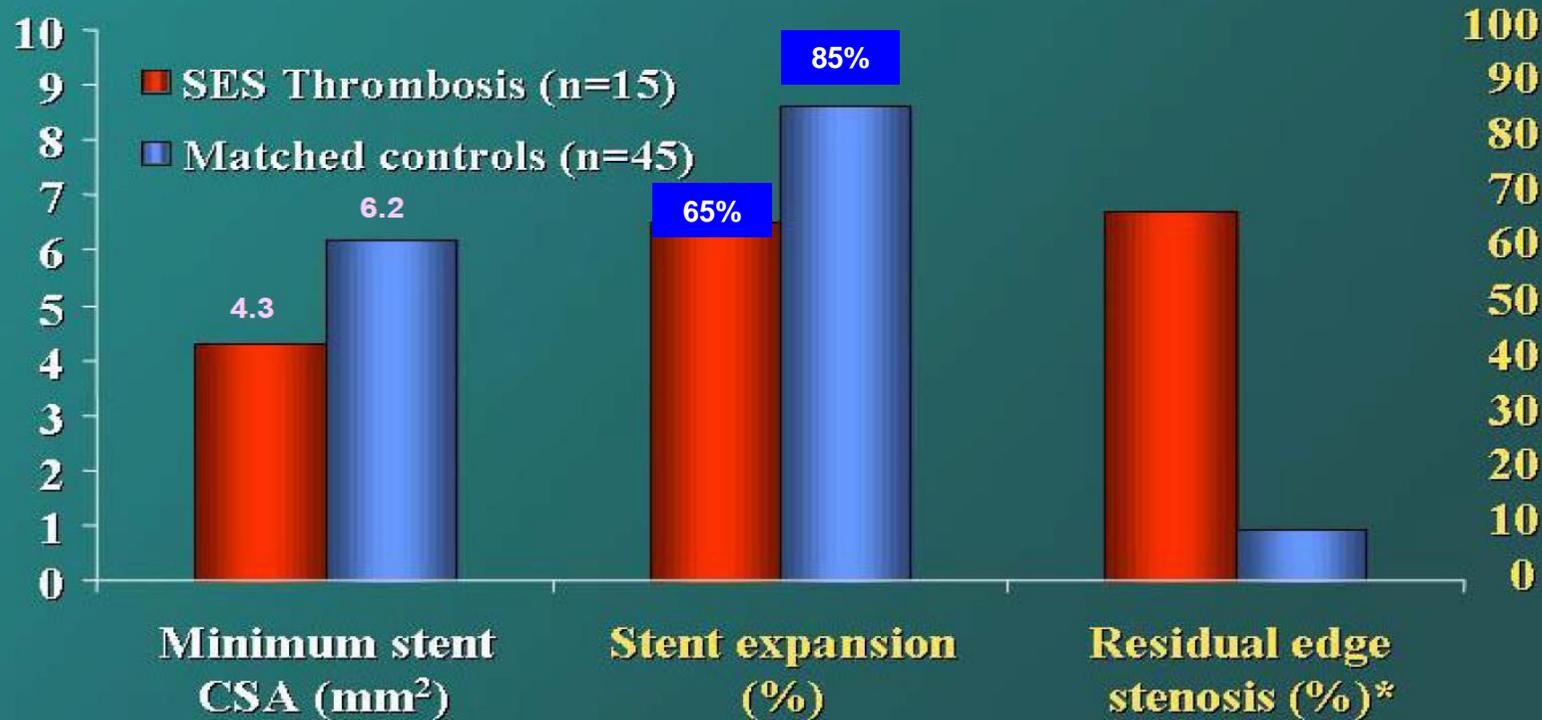


ex. 5.5 mm<sup>2</sup> → 94% Neg. Predictive Value

## Endeavor

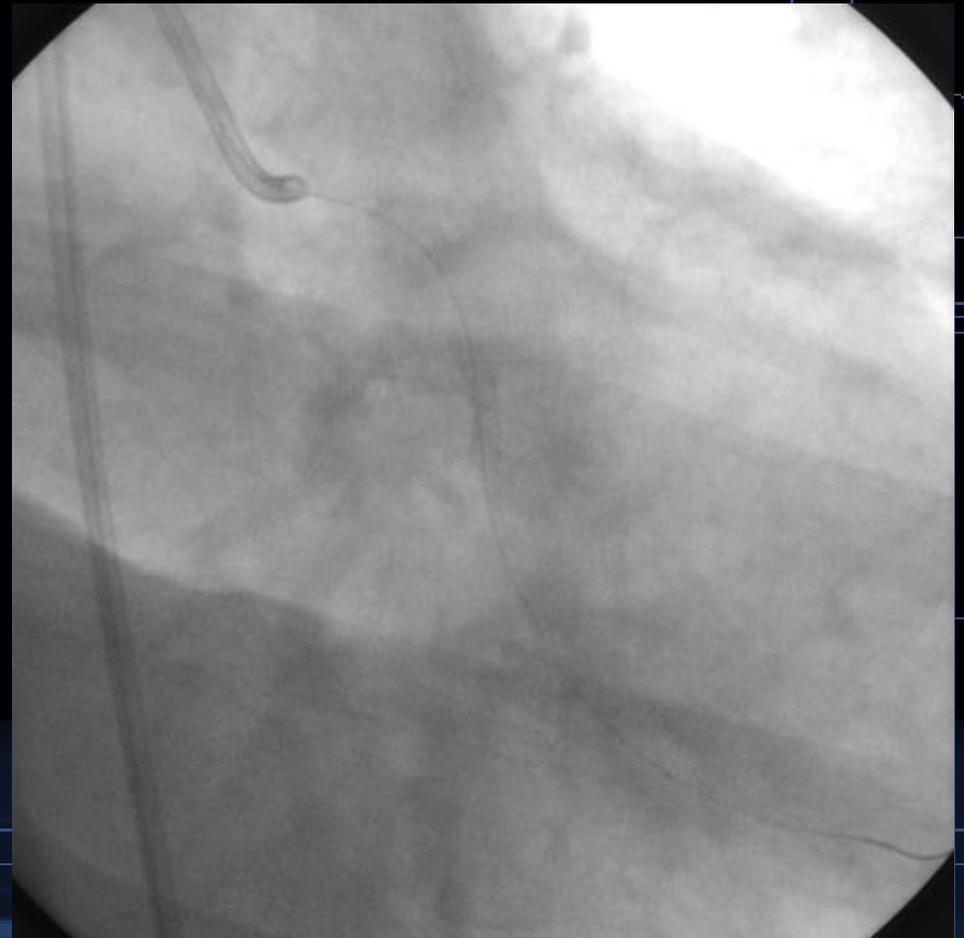
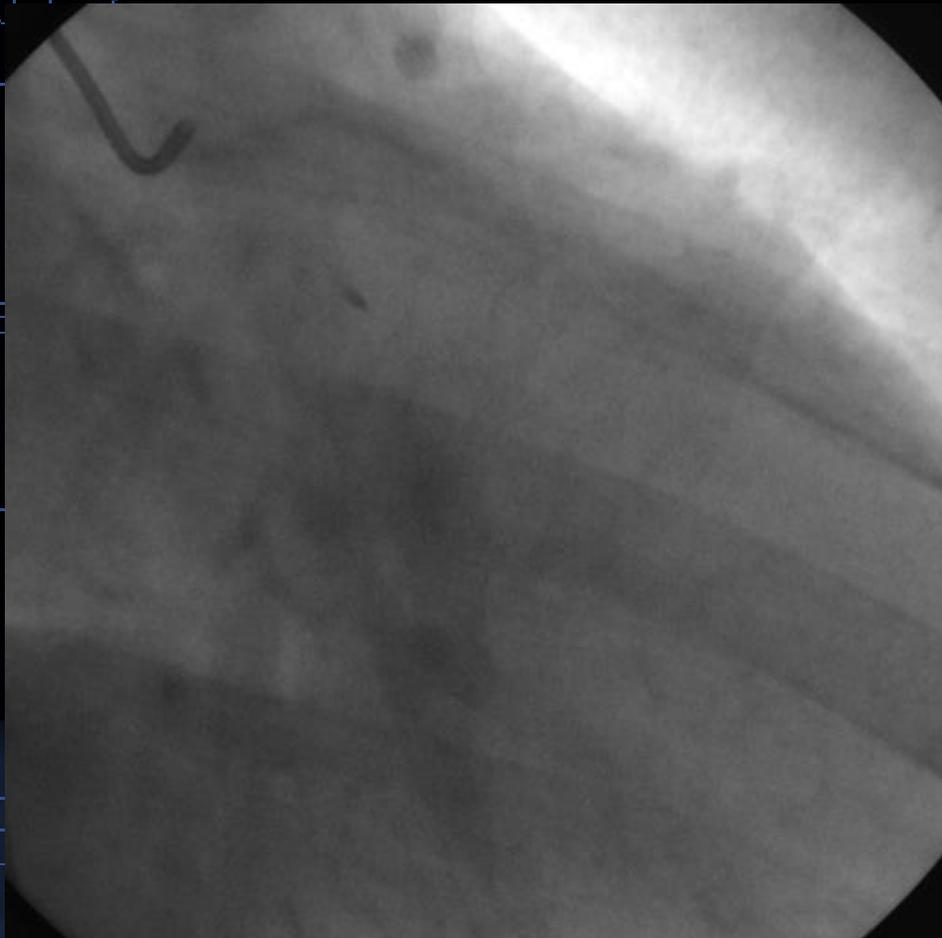


# IVUS Predictors of SAT



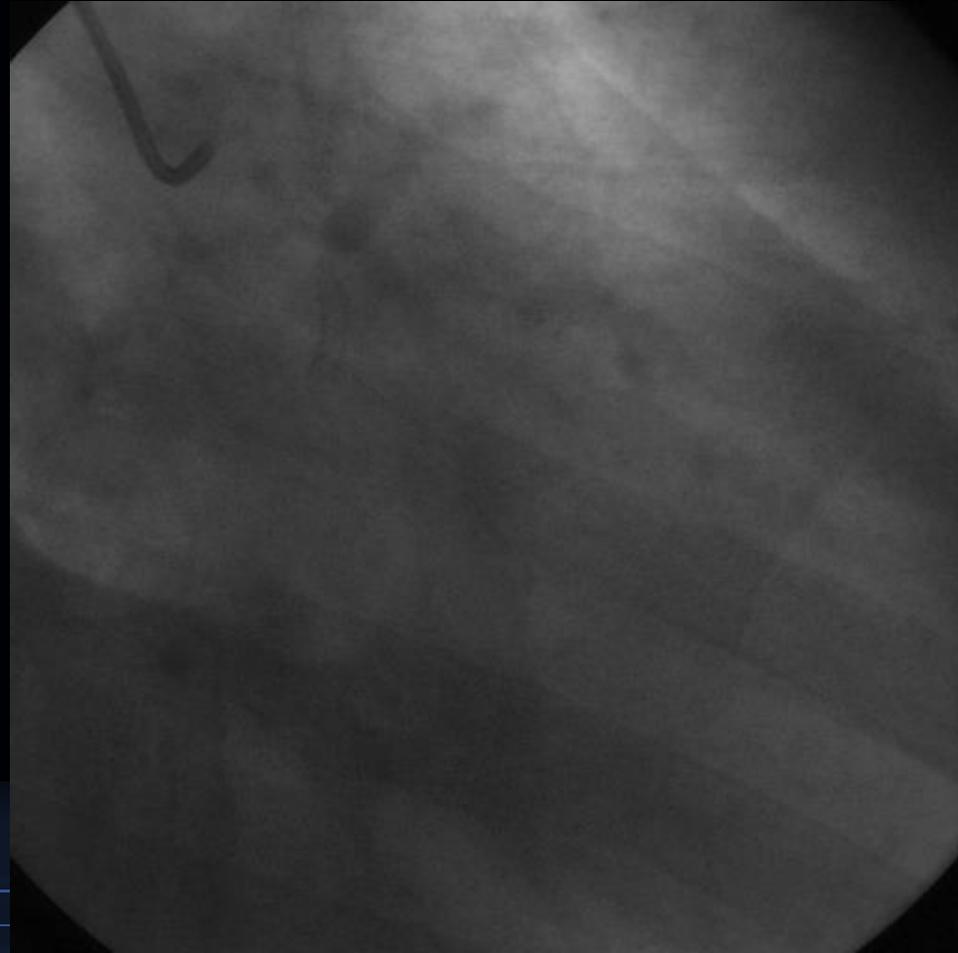
- 2,575 patients were treated with 4,722 Cypher stents.
- 21 (0.8%) had stent thrombosis of whom 15 had IVUS
- 12/15 SES thrombosis lesions has stent CSA <5.0mm<sup>2</sup> (vs 13/45 controls)

# 51/M STEMI



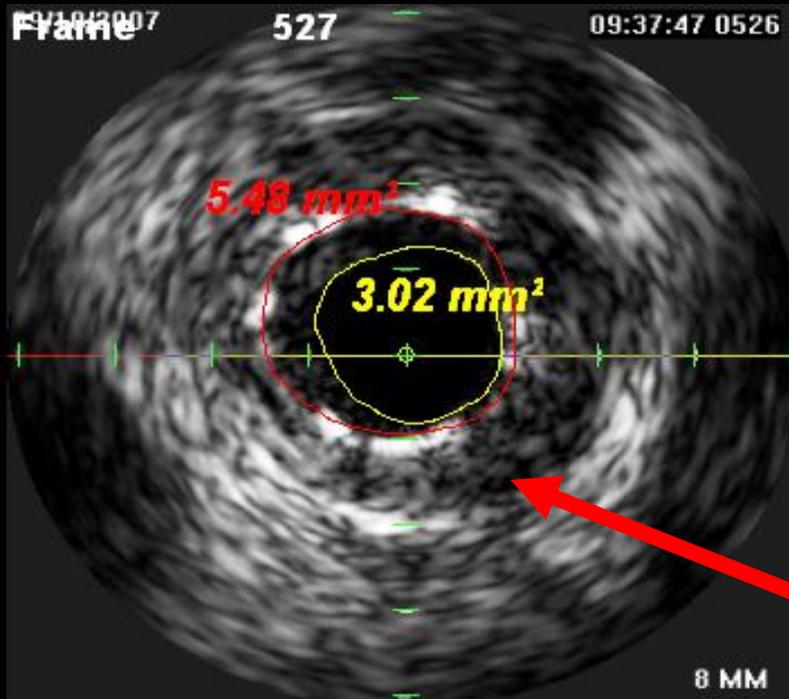
3.0\*19mm stent at 8 atm

# STEMI (7 days after stenting)



Subacute stent thrombosis

# Minimum Stent Area Site



... Patient Gender: M

Study

- Study Name: IVUS
- Study ID: 20070910-95213
- Study Date & Time: 2007-09-10 9:52:1
- Referring Physician:

Series

- Series Number:0
- Series Date & Time: N/A
- Series:
- Modality: US
- Performing Physician: LCx-STENT

Institute: C.N.U.H-JMH

Equipment: JOMED

Acquisition Date & Time: N/A

Manufacturers Model Name: IN-VISION

Rollback rate: 0.50 mm/s

Acquisition rate: 10.0 frames/s

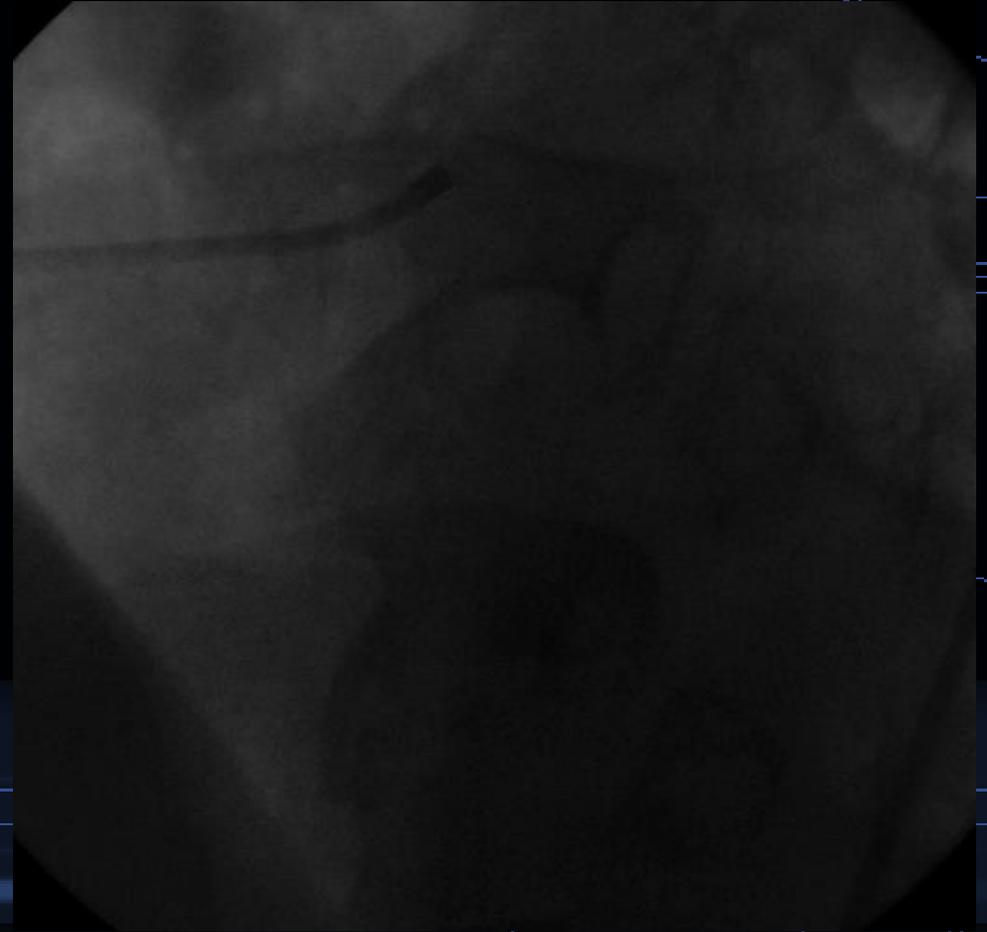
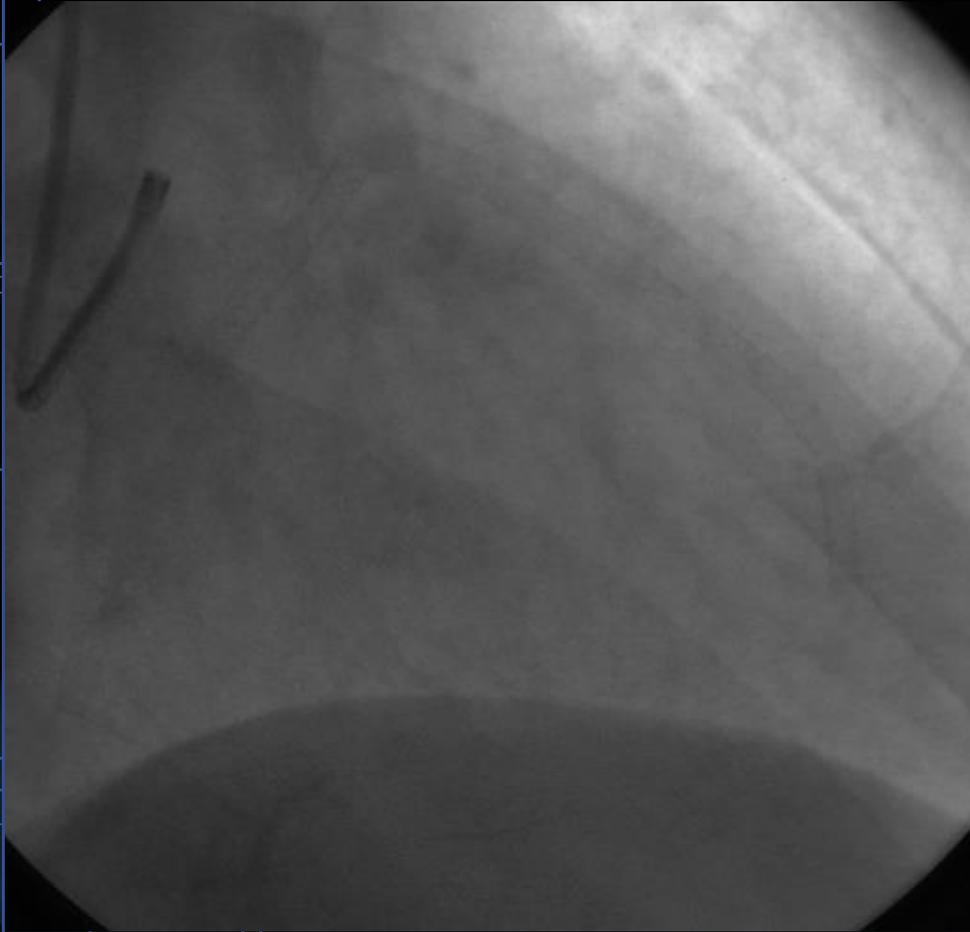
Indexed frames 327 through 986 steppir

Key Frames

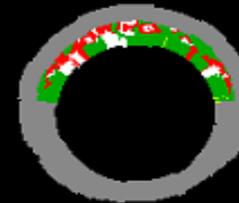
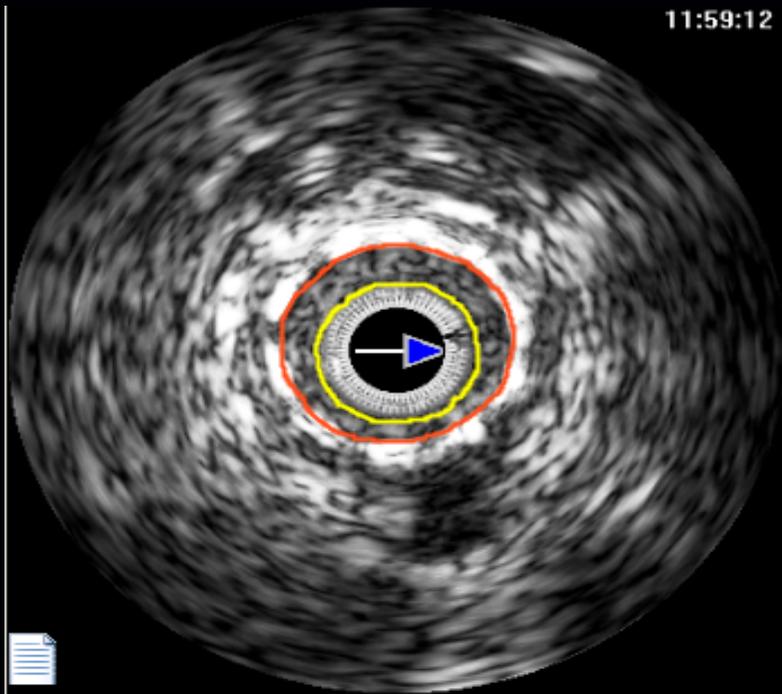
- 527

**Stent underexpansion (70%)**

# 9-Month FU CAG after Two DES Overlapping

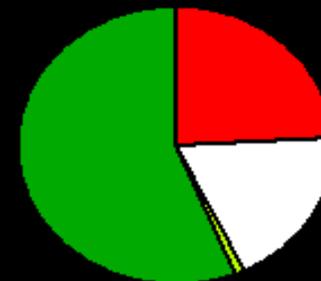


# VH-IVUS at Maximum IH Site

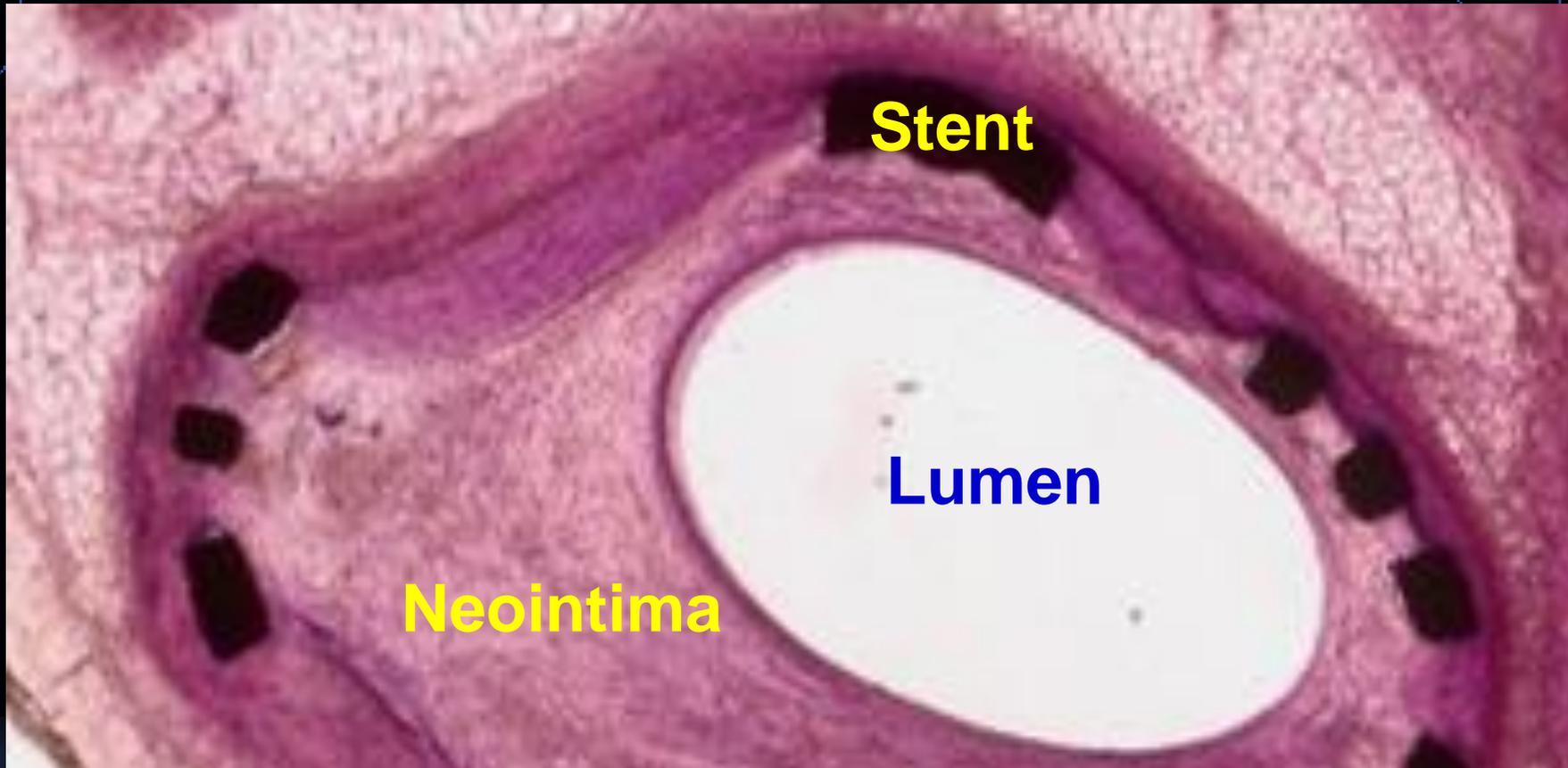


Lumen Area	3.3 mm	
Vessel Area	7.0 mm	
Plaque Area	3.7 mm	
% Plaque Burden	53 %	
FI Green Area	0.6 mm	56 %
FF Light Green Area	0.0 mm	1 %
DC White Area	0.2 mm	19 %
NC Red Area	0.3 mm	24 %

More ...



# In-Stent Restenosis



**Tissue characteristics in neointima?**

# Tissue Characterization of In-Stent Neointima Using Intravascular Ultrasound Radiofrequency Data Analysis

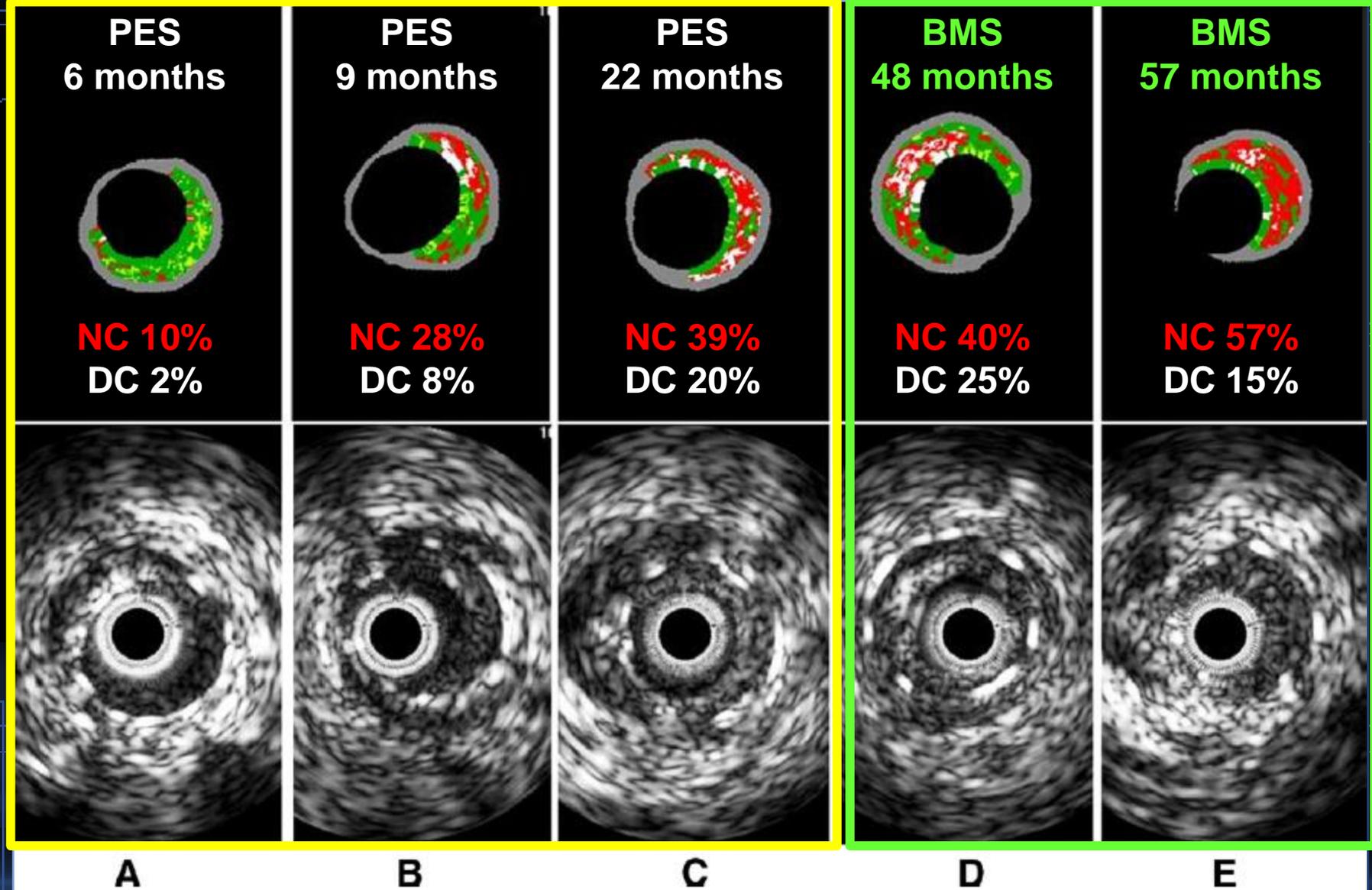
Soo-Jin Kang, MD<sup>a</sup>, Gary S. Mintz, MD<sup>b</sup>, Duk-Woo Park, MD<sup>a</sup>, Seung-Whan Lee, MD<sup>a</sup>, Young-Hak Kim, MD<sup>a</sup>, Cheol Whan Lee, MD<sup>a</sup>, Ki-Hoon Han, MD<sup>a</sup>, Jae-Joong Kim, MD<sup>a</sup>, Seong-Wook Park, MD<sup>a</sup>, and Seung-Jung Park, MD<sup>a,\*</sup>

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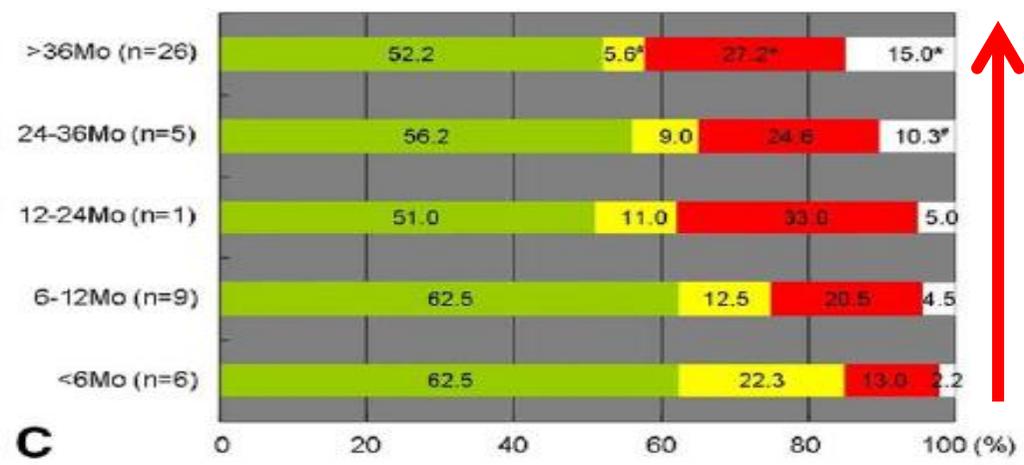
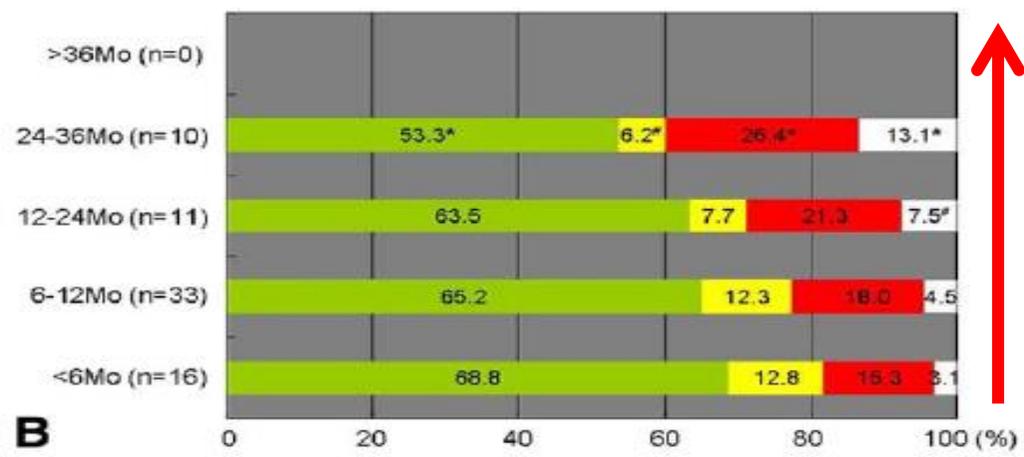
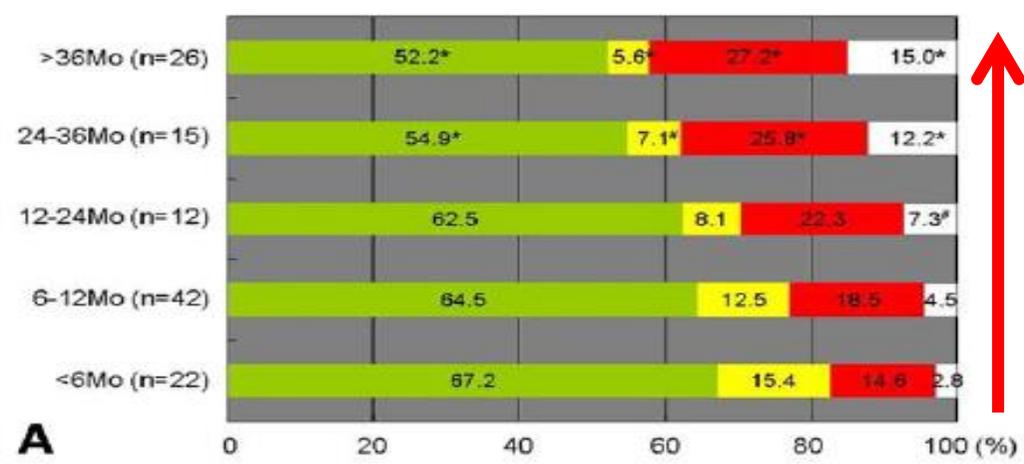
Using virtual histology and intravascular ultrasound (VH-IVUS), tissue characterization of restenotic in-stent neointima after drug-eluting stent (DES) and bare metal stent (BMS) implantation was assessed. VH-IVUS was performed in 117 lesions (70 treated with DESs and 47 treated with BMSs) with angiographic in-stent restenosis and intimal hyperplasia (IH) >50% of the stent area. The region of interest was placed between the luminal border and the inner border of the struts and tissue composition was reported as percentages of IH area (percent fibrous, percent fibrofatty, percent necrotic core, percent dense calcium) at the 2 sites of maximal percent IH and maximal percent necrotic core. Mean follow-up times between stent implantation and VH-IVUS study were 43.5 ± 33.8 months for BMS-treated lesions and 11.1 ± 7.8 months for DES-treated lesions (p <0.001). The 2 groups had greater percent necrotic core and percent dense calcium at maximal percent IH and maximal percent necrotic core sites, especially in stents that had been implanted for longer periods. In conclusion, this VH-IVUS analysis showed that BMS- and DES-treated lesions develop in-stent necrotic core and dense calcium, suggesting the development of in-stent neoatherosclerosis. © 2010 Elsevier Inc. All rights reserved. (Am J Cardiol 2010;106:1561–1565)

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# Plaque Composition of the Neointima at Maximal Percent Intimal Hyperplasia Sites



# Differences in VH-IVUS Composition of In-Stent Neointimal Tissue at Various Follow-up Periods



(A) Overall, 117 lesions combining bare metal and drug-eluting stents

(B) 70 lesions treated with drug-eluting stents

(C) 47 lesions treated with bare metal stents

(\*p 0.01; #p 0.05 vs lesions at follow-up 6 months).

Percentages of necrotic core and dense calcium within the neointima at maximal percent intimal hyperplasia sites increased over time

# Tissue Characterization of In-Stent Neointima Using Intravascular Ultrasound Radiofrequency Data Analysis

Soo-Jin Kang, MD<sup>a</sup>, Gary S. Mintz, MD<sup>b</sup>, Duk-Woo Park, MD<sup>a</sup>, Seung-Whan Lee, MD<sup>a</sup>, Young-Hak Kim, MD<sup>a</sup>, Cheol Whan Lee, MD<sup>a</sup>, Ki-Hoon Han, MD<sup>a</sup>, Jae-Joong Kim, MD<sup>a</sup>, Seong-Wook Park, MD<sup>a</sup>, and Seung-Jung Park, MD<sup>a,\*</sup>

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# OCT Neointima Image Pattern

**Intensity: High**

**Medium**

**Low**



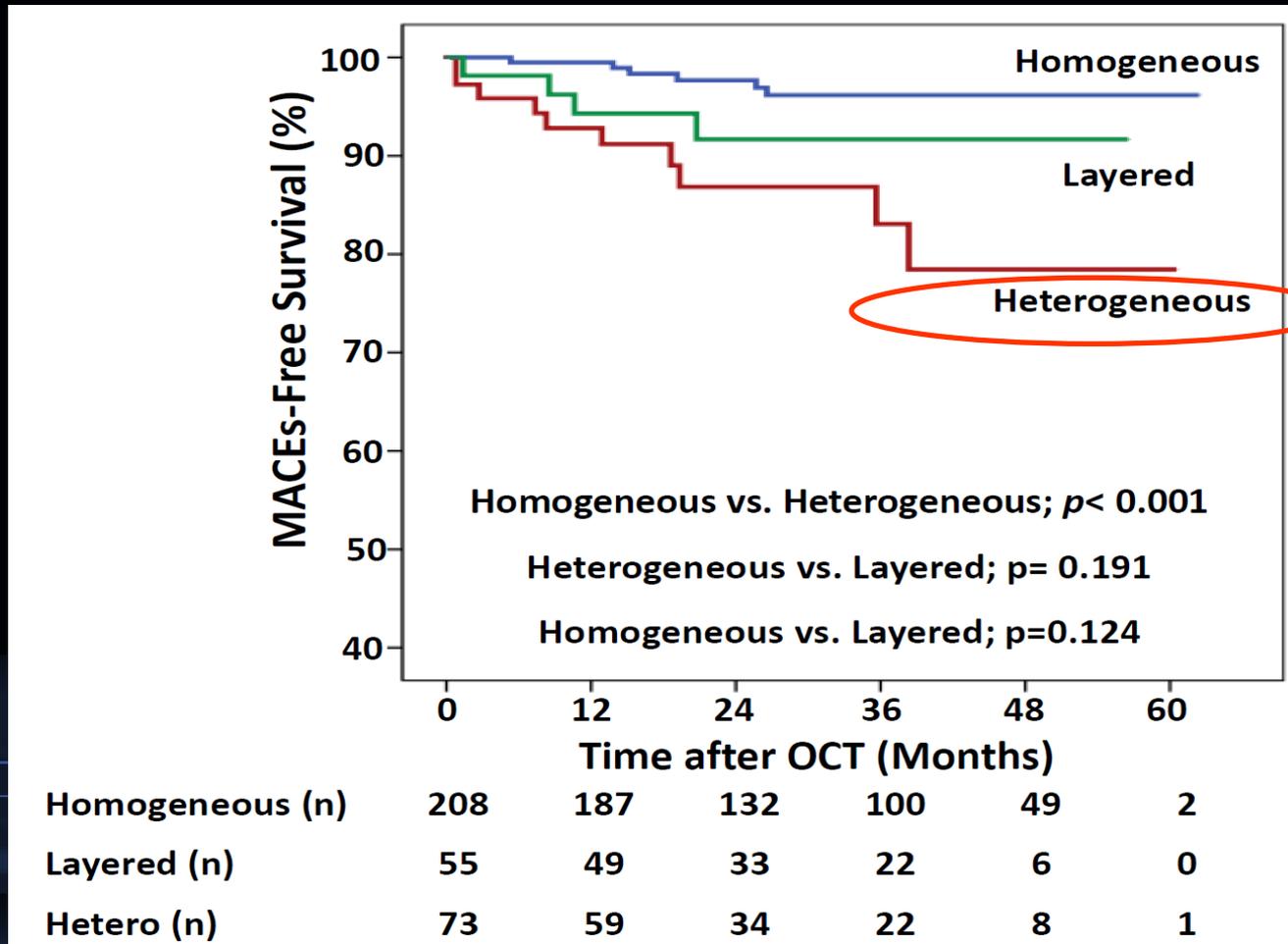
**Texture: Homogeneous  
(low attenuation)**

**Layered  
(high attenuation)**

**Speckled  
(heterogeneous)**

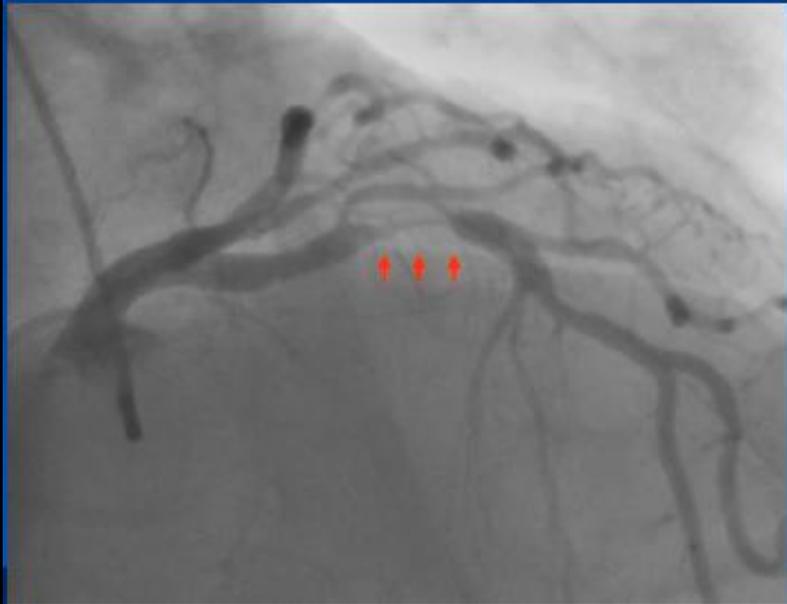


# Heterogeneous Pattern of Neointima has adverse clinical outcome

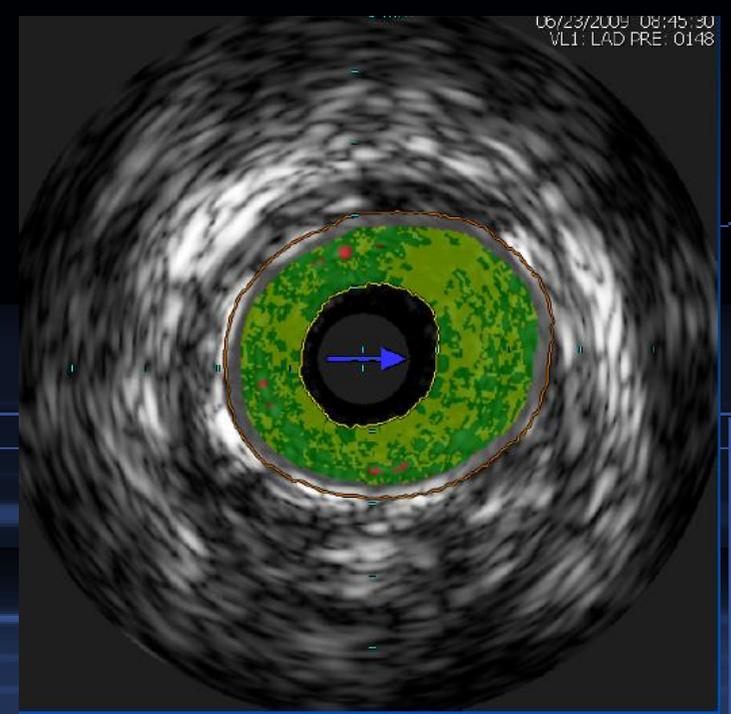
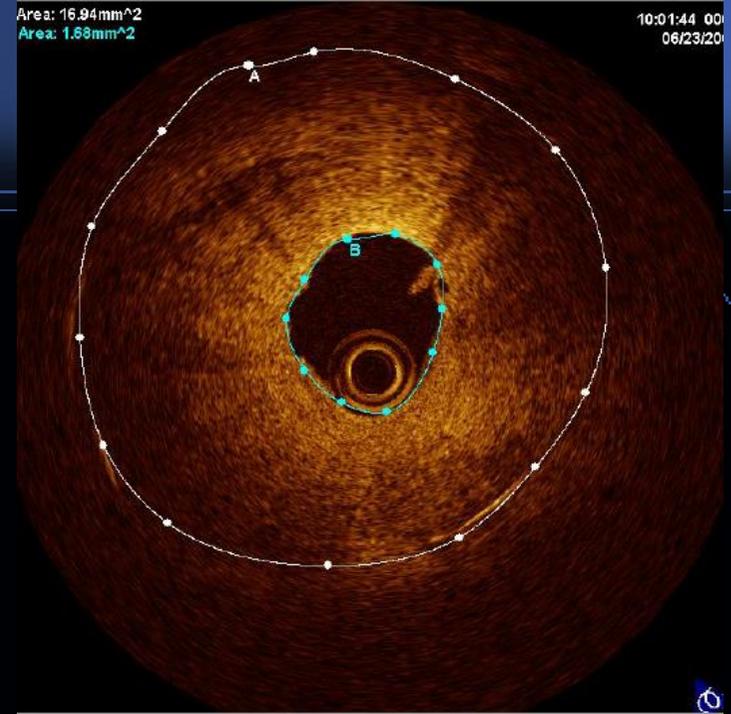


68/M

# Asymptomatic ISR

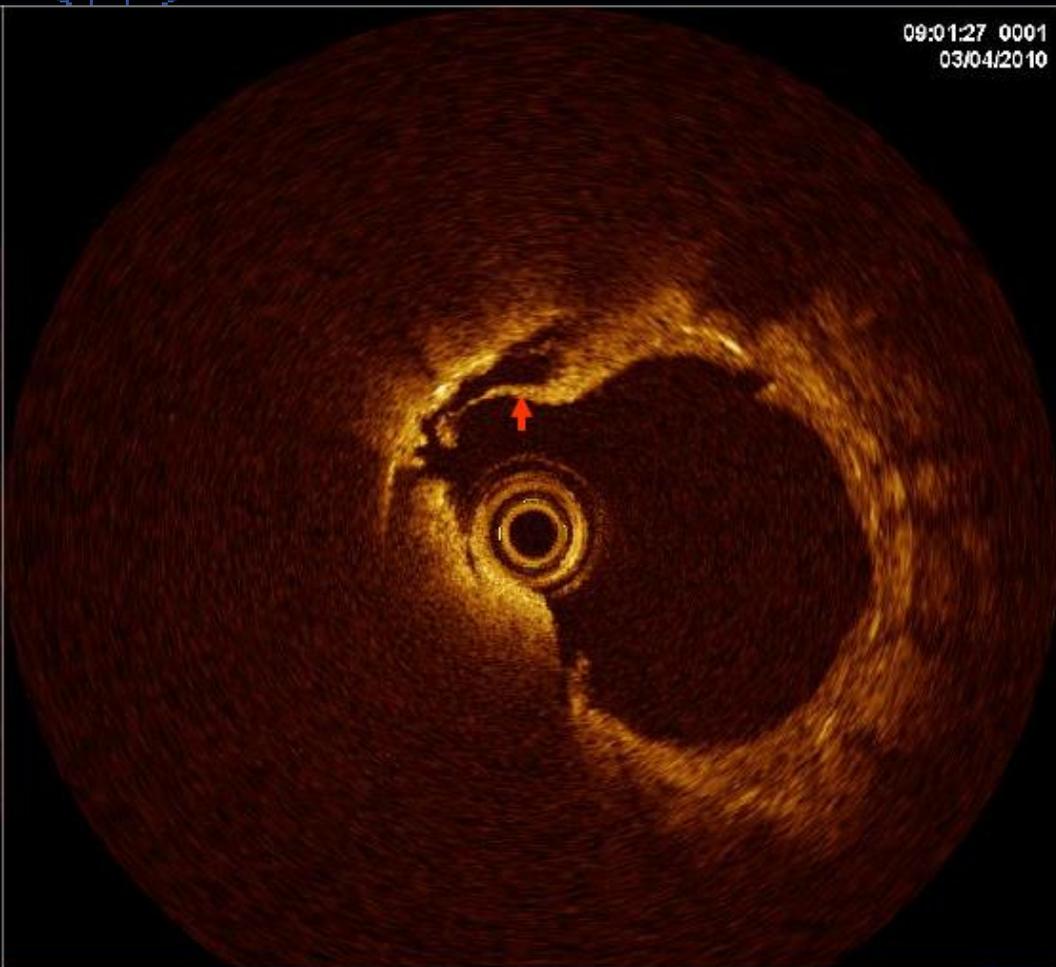


Taxus 4.0\*20mm at mLAD

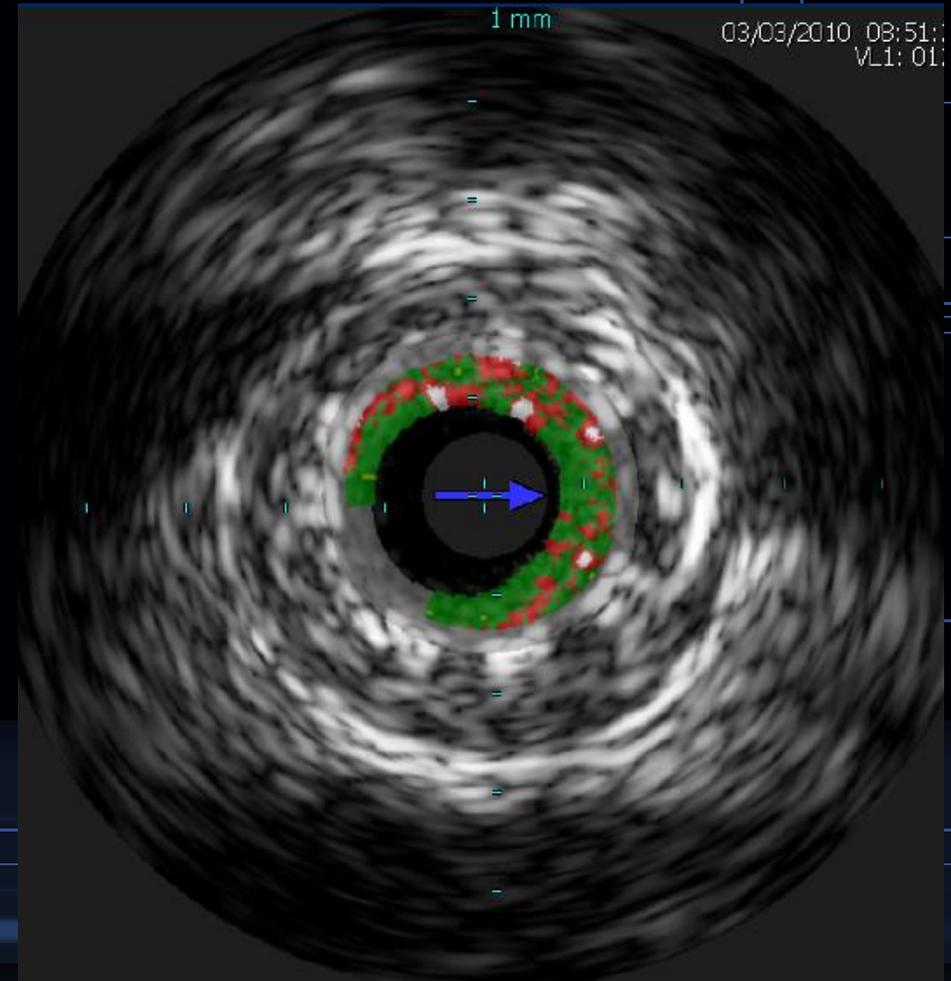


# 59/M, NSTEMI d/t VLST

Cypher 3.0\*23mm, 3.5\*8mm at p~mLAD



**In-Stent Neo-atherosclerosis  
with Vulnerable Intima**



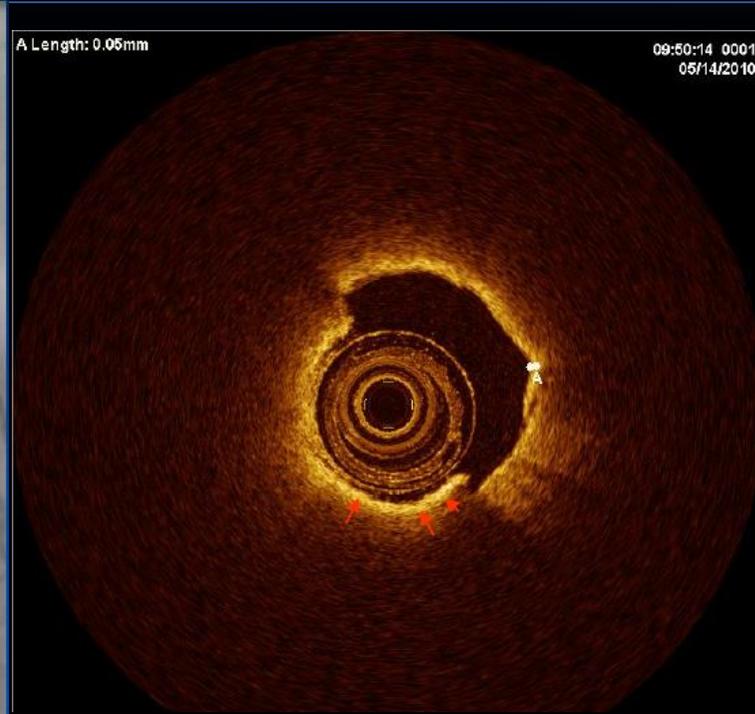
**%NC=30%**

Courtesy of Kang SJ

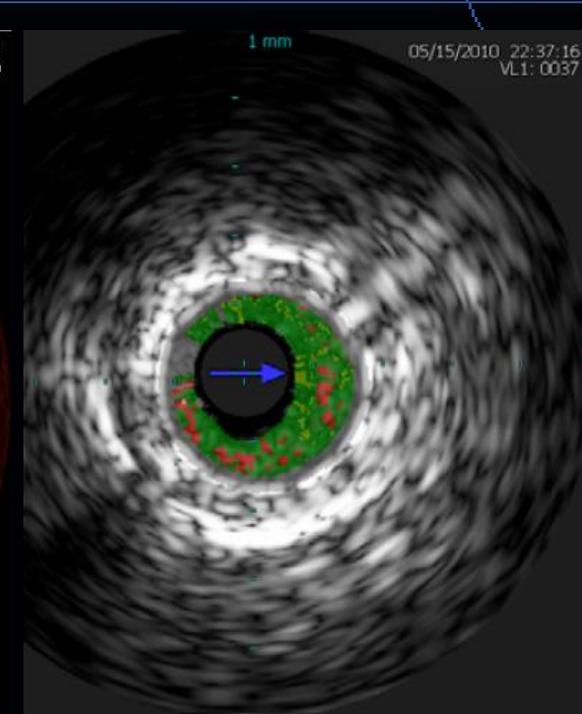
# 71/F, UAP



BMS at mLAD



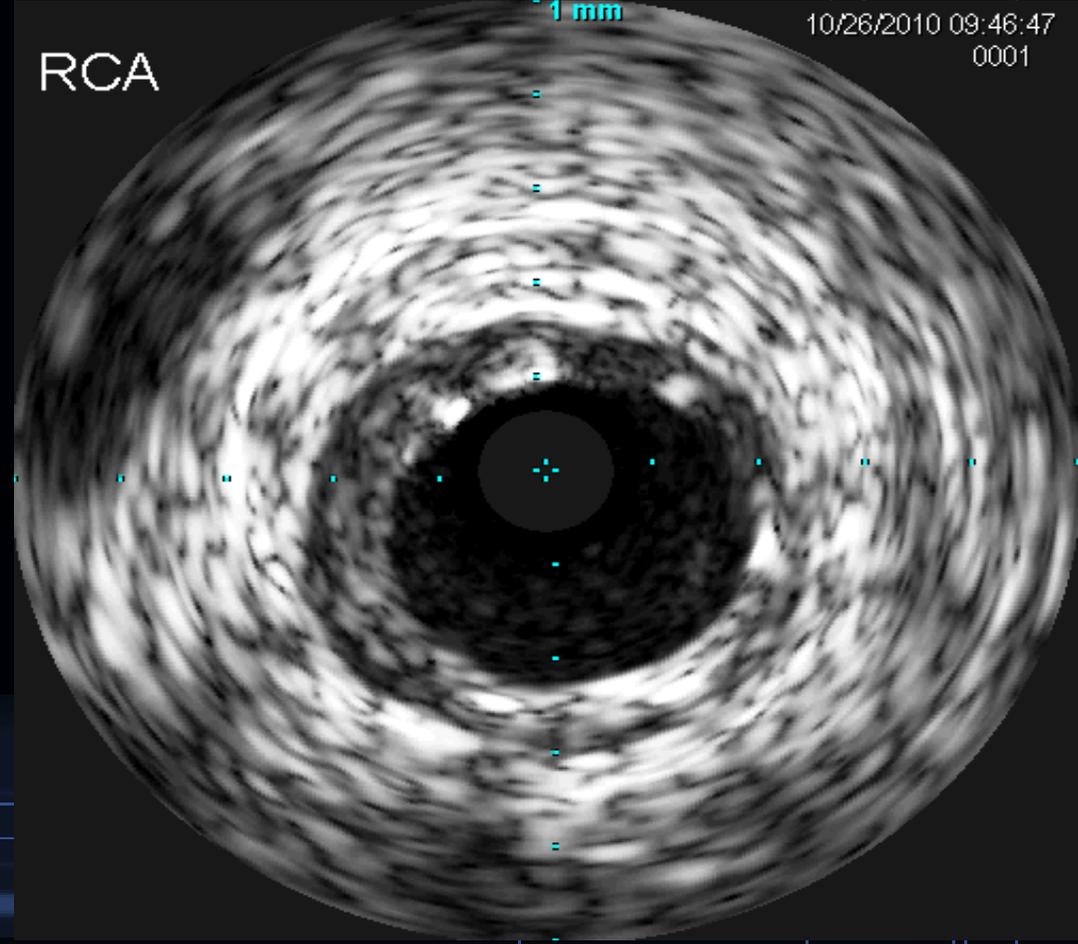
In-Stent Neo-atherosclerosis  
with Vulnerable Intima



**%NC=14%**

ILD View	Statistics	Case E
PATIENT NAME	KIM BOK, N	
PATIENT ID	26620367	
PHYSICIAN	Asan Medical	
Frame Statistics		
LUMEN		
Area:	2.1 mm <sup>2</sup>	
Min Dia:	1.5 mm	
Max Dia:	1.8 mm	
PLAQUE Burden:	70.9 %	
COMPOSITION		
FI:	2.4 mm <sup>2</sup> (78.2%)	
FF:	0.2 mm <sup>2</sup> (7.7%)	
NC:	0.4 mm <sup>2</sup> (14.1%)	
DC:	0.0 mm <sup>2</sup> (0.1%)	
Segment Statistics		
LUMEN		
Avg Area:	2.2 mm <sup>2</sup>	
Min Dia:	1.5 mm (37)	
Max Dia:	1.9 mm (30)	
PLAQUE Vol:	25.0 mm <sup>3</sup>	
LENGTH	4.4 mm	
COMPOSITION		
FI:	10.1 mm <sup>2</sup> (62.1%)	
FF:	1.2 mm <sup>2</sup> (7.6%)	
NC:	3.5 mm <sup>2</sup> (22.2%)	
DC:	1.1 mm <sup>2</sup> (7.1%)	

# 43/M, Inf. STEMI



# 67/M, UAP, CAG

KIM JEONG NAM , 김정남  
112388638

2011-08-11 오전 7:48:34  
112388638E0811028

Chonnam National Universi...

1  
1  
1/56

10.47 RAO  
37.14 CRA

KIM JEONG NAM , 김정남  
112388638

2011-08-11 오전 7:48:34  
112388638E0811028

Chonnam National Universi...

2  
2  
1/48

47.90 LAO  
25.83 CAU

**Critical ISR in p-to m-LAD (C,85%,II)**

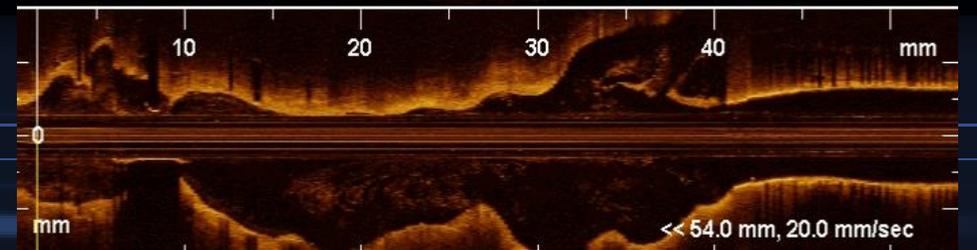
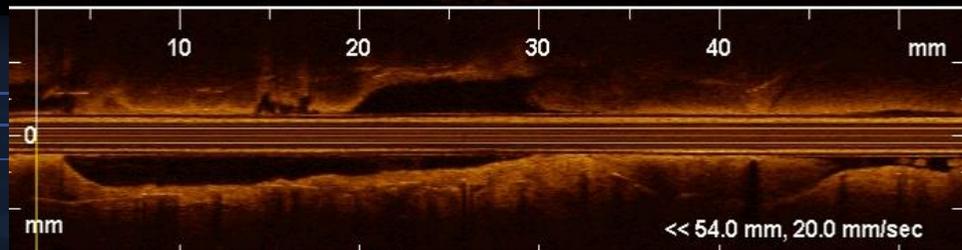
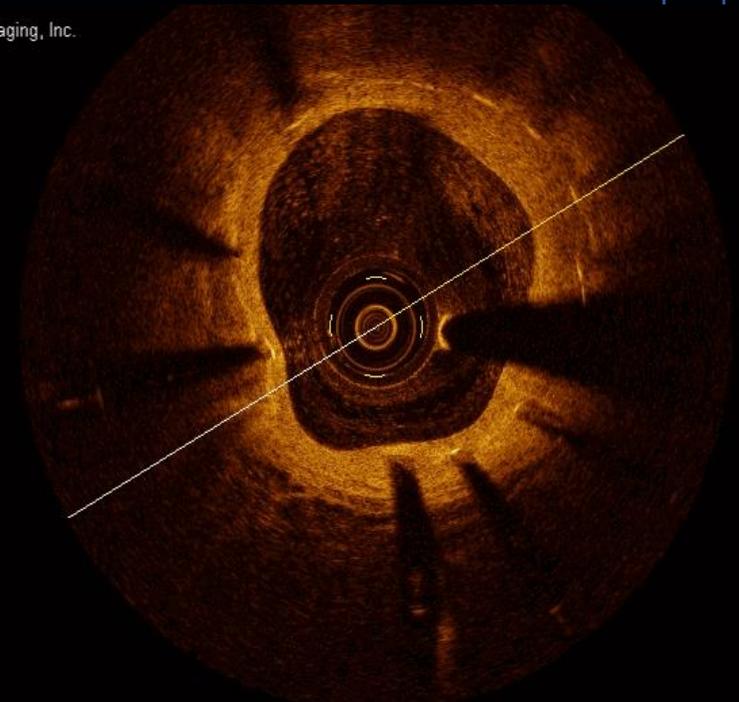
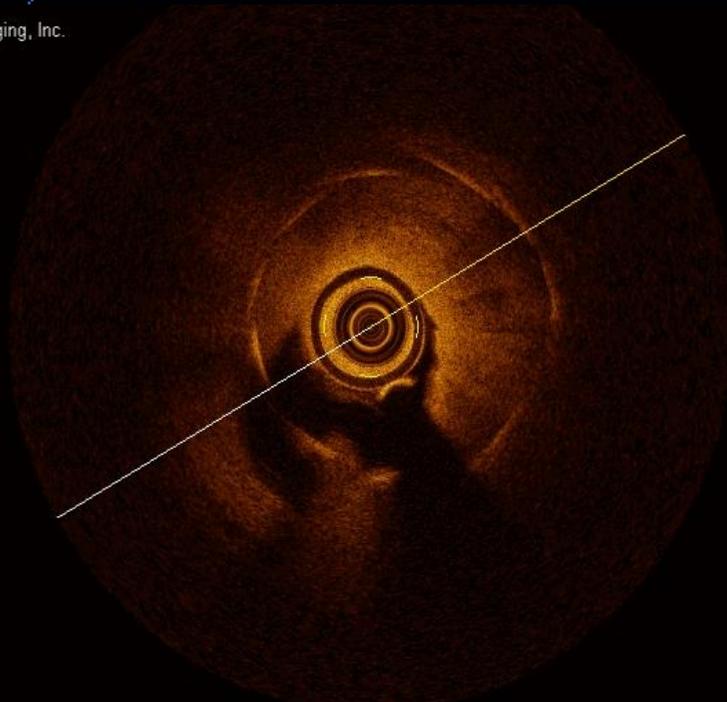
# OCT

LightLab Imaging, Inc.

1  
1  
11/27/1

LightLab Imaging, Inc.

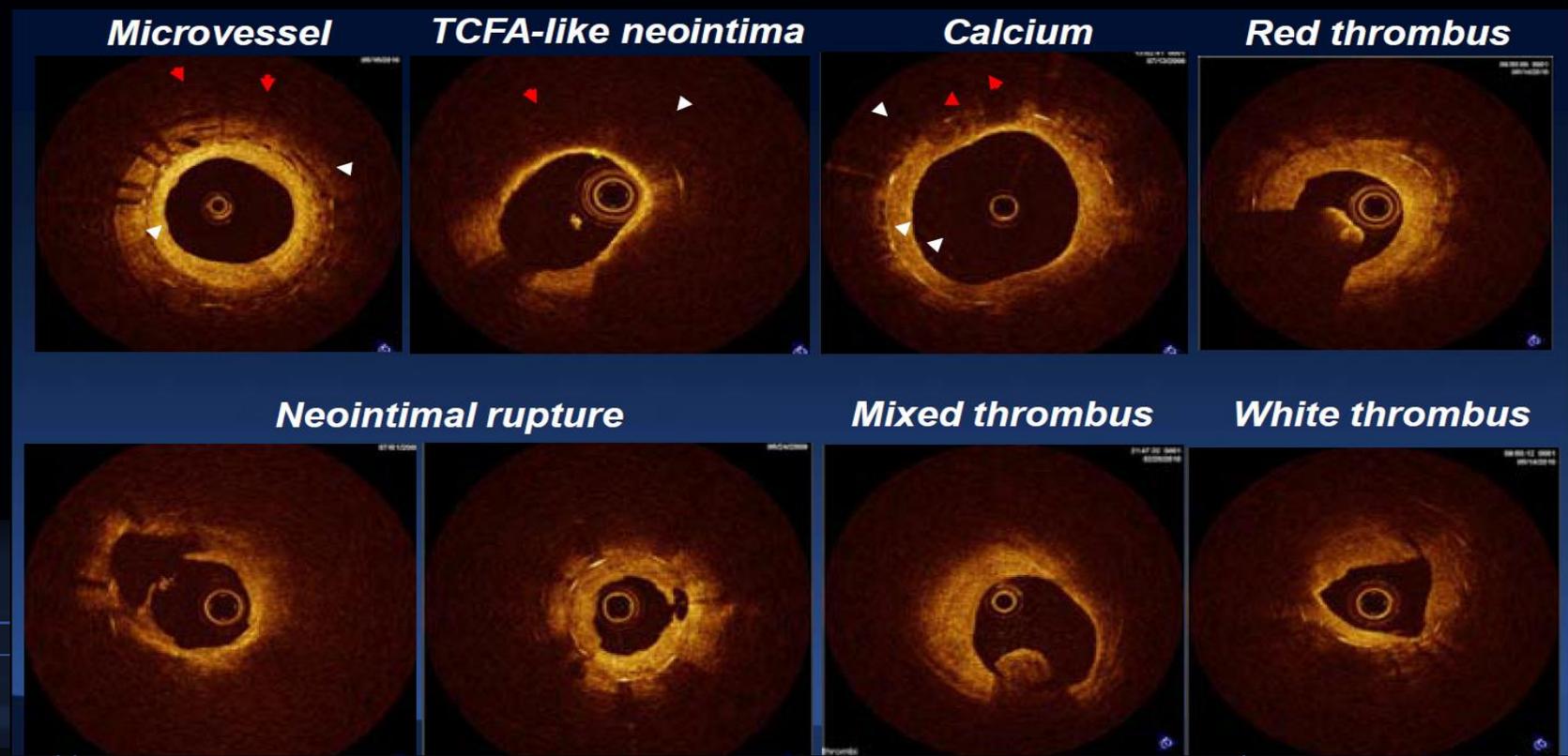
1  
4  
1  
9/27/1



# Late in-stent neoatherosclerosis in DES

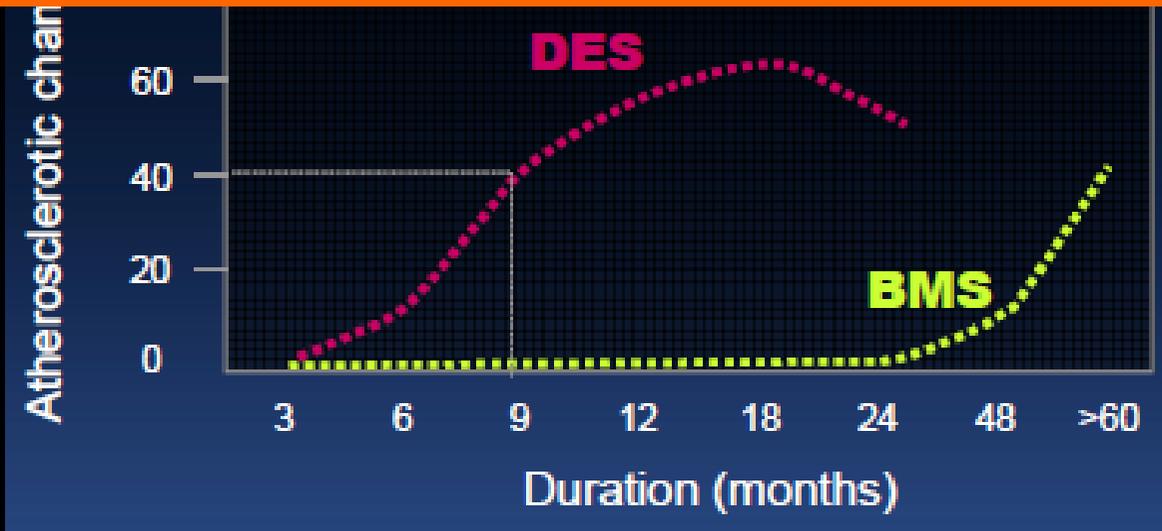
(n=50, median follow-up of 32 months)

*20 months post-implantation was the best cut-off to predict TCFA-like neointima*



# Different Timing of “Neoatherosclerosis”

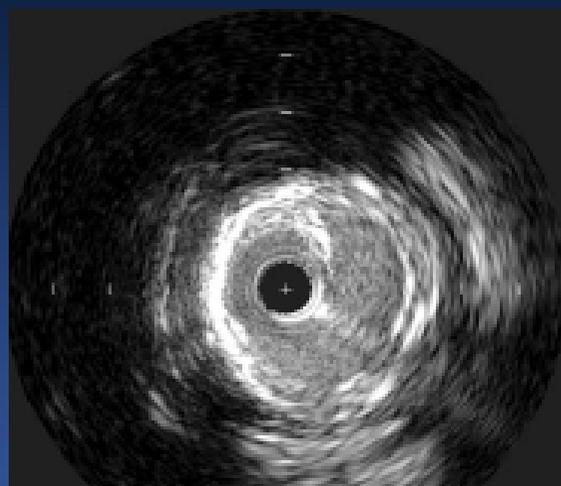
The earliest necrotic core formation in DES was observed at 9 months, which was earlier than BMS lesions developed at 5 years



	<2 years		2-6 years	
	DES	BMS	DES	BMS
Neoatherosclerosis	29%	0%	41%	22%
Foamy mØ clusters	14%	0%	19%	3%
Fibroatheroma (NC)	13%	0%	22%	15%

## Intravascular Ultrasound Findings in Patients With Very Late Stent Thrombosis After Either Drug-Eluting or Bare-Metal Stent Implantation

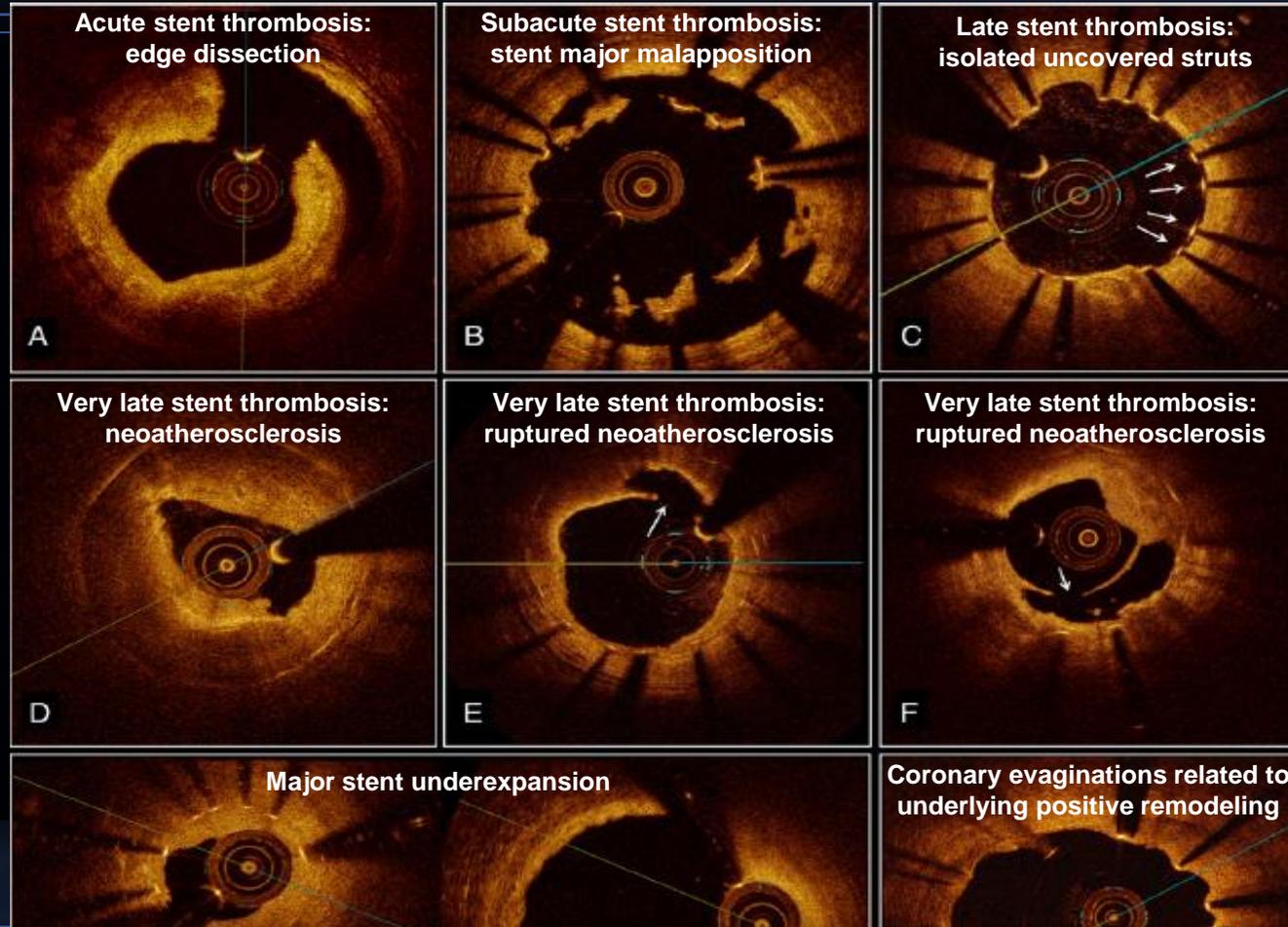
30 AMI with VLST (Mean F/U 33 Mo in DES, 108 Mo in BMS)



	DES (n=23)	BMS (n=7)
Mean EEM CSA, mm <sup>2</sup>	19.5±6.0	18.3±4.1
Mean Lumen CSA, mm <sup>2</sup>	4.2±1.4	4.7±4.6
Mean Neointima, mm <sup>2</sup>	3.0±1.1	5.0±1.7*
Minimal stent CSA, mm <sup>2</sup>	6.1±1.5	7.4±3.7
<b>Neointima rupture</b>	<b>10 (44%)</b>	<b>7 (100%)*</b>

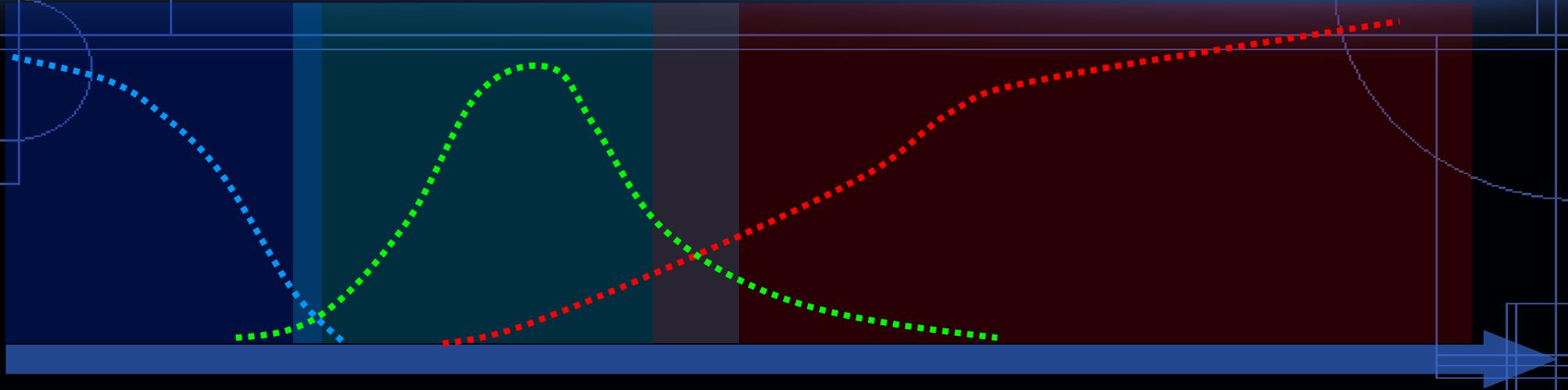
**Neoatheroclerosis may contribute to the development of VLST as a common mechanism in BMS and DES.**

# Mechanisms of ST by OCT Analysis



LST & VLST were mainly related to malapposition (31%) and neoatherosclerosis (28%), while prominent mechanisms for AST & SAST were malapposition (48%) and underexpansion (26%).

# Timing and Mechanism of DES Thrombosis



<b>Early (&lt;30d)</b>	<b>Late (1-12 Mo)</b>	<b>Very late (&gt;12 Mo)</b>
<b>Procedural</b>	<b>Delayed healing</b>	<b>Abnormal vascular response</b>
Underexpansion Edge dissection Residual plaque	Uncovered struts Fibrin deposition	Hypersensitivity Extensive fibrin deposition Late malapposition? <b>Neoatherosclerosis</b>

**STATE-OF-THE-ART PAPER**

## **In-Stent Neoatherosclerosis**

### *A Final Common Pathway of Late Stent Failure*

Seung-Jung Park, MD, PHD,\* Soo-Jin Kang, MD, PHD,\* Renu Virmani, MD,†  
Masataka Nakano, MD,† Yasunori Ueda, MD‡

*Seoul, South Korea; Gaithersburg, Maryland; and Osaka, Japan*

**Neoatherosclerosis increases intimal vulnerability and  
contributes to development of late stent failure as a  
common pathway**

# Conclusions

- **Stents that have been implanted for longer periods and develop late DES ISR have in-stent tissue composition that includes necrotic core and dense calcium suggestive of in-stent neoatherosclerosis.**
- **Large necrotic core containing DES ISR lesions can also rupture and thrombose to cause very late stent thrombosis.**

**Thank You For Your Attention**

