MT6

2008 Imaging & Physiology Summit

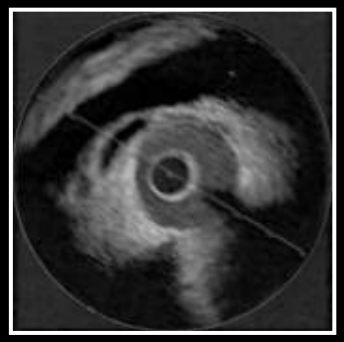
Evaluation of DES using OCT

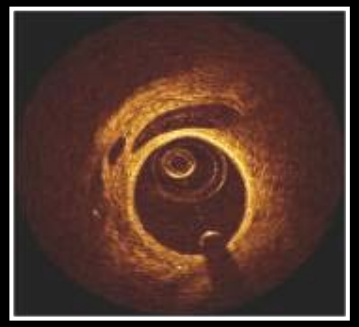
Mitsuyasu Terashima, MD, PhD

Toyohashi Heart Center

MT6 Mitsu, 2005-11-19

IVUS vs OCT





	IVUS	OCT
Resolution (axial)	100 – 150 μm	10 - 15 μm
(lateral)	150 - 300 μm	25 - 40 μm
Frame rate	30 frames/s	15 frames/s
Dynamic range	40 - 60 dB	90 - 110 dB
Scan area	8 - 10 mm	7 mm
Max. depth of tissue penetration	4 - 8 mm	2 mm (Limited by light scattering rather than absorption)
	Blood clearing not required	Requires Blood clearing

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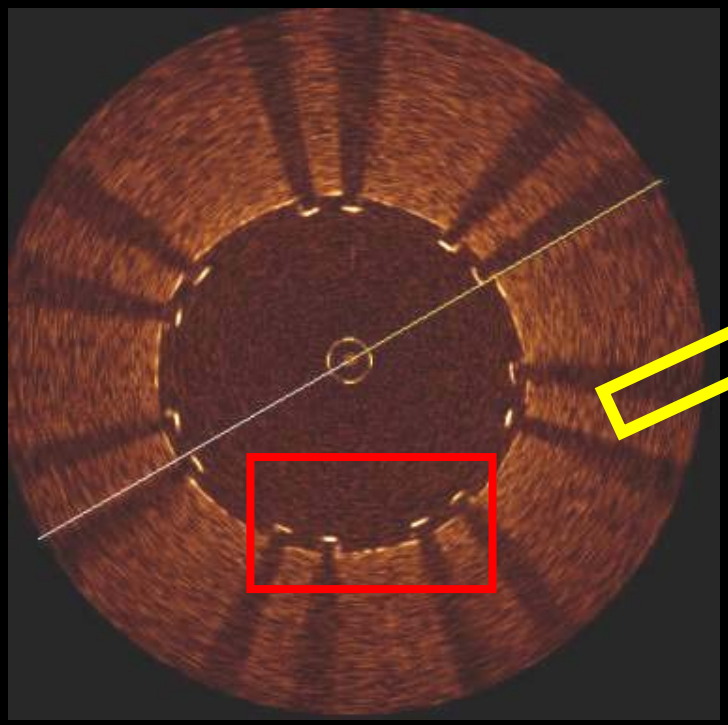
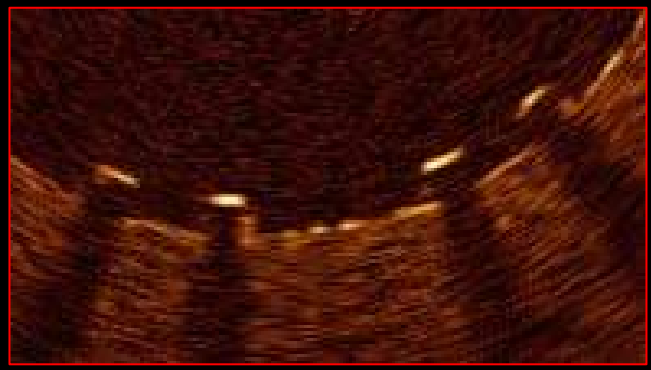
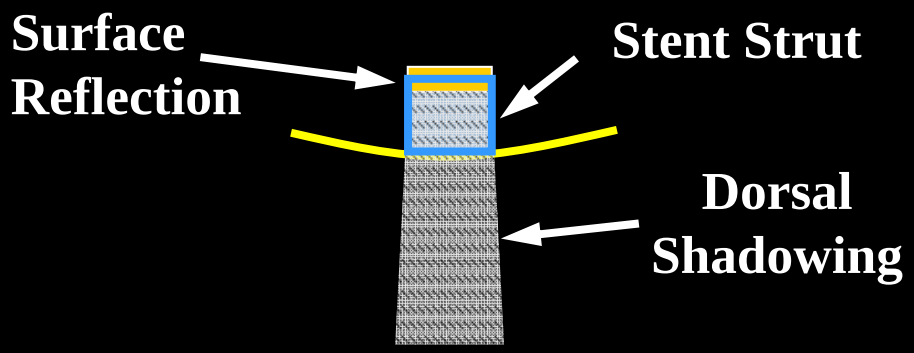
Stent Implantation

Interpretation of OCT Image of Implanted Stent



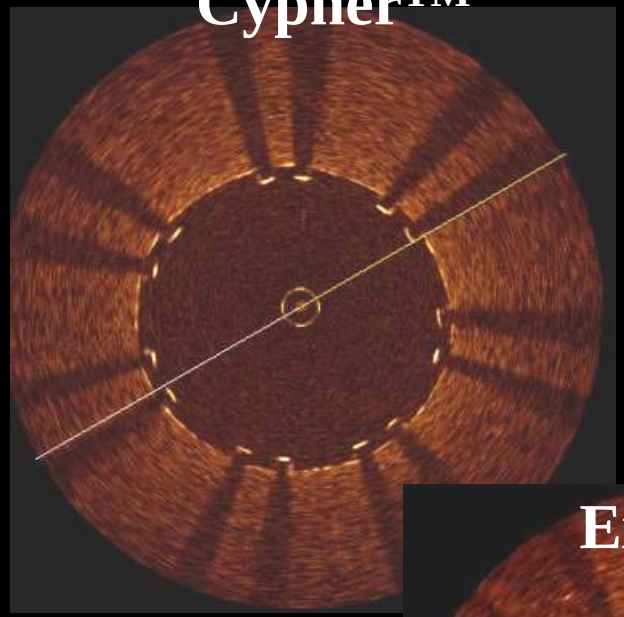




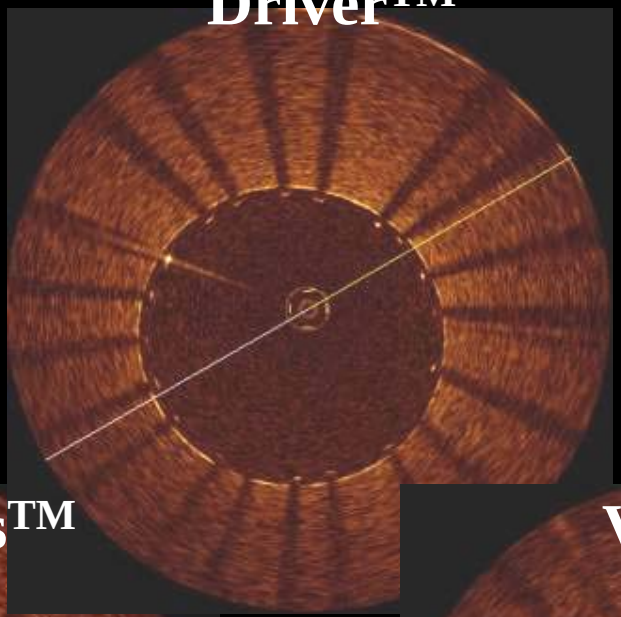
✓ Near infrared light used in OCT cannot penetrate the metallic stent strut, so stent struts are visualized as linear structures with strong surface reflection and typical dorsal shadowing.

OCT Images of Implanted Stents

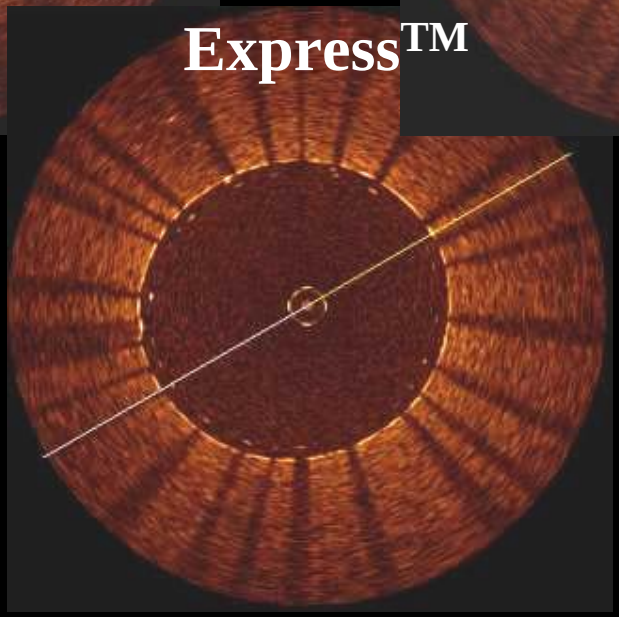
Cypher™



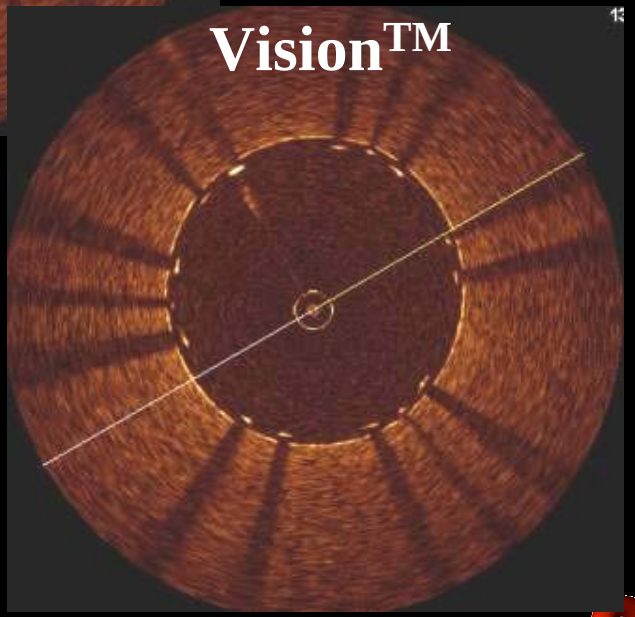
Driver™



Express™



Vision™



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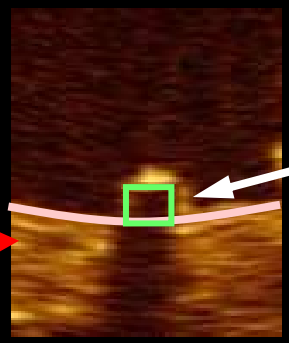
Stent Apposition

OCT Image of Implanted stent Just after Deployment

✓ Apposition of stent strut to the vessel wall is evaluated by measuring the distance between the strut surface and adjacent vessel surface.

Complete stent apposition (CSA)



✓ Near infrared light used in OCT cannot penetrate the metallic stent strut, so stent struts are visualized as linear reflection and typical dorsal shadowing.

Incomplete stent apposition (ISA)

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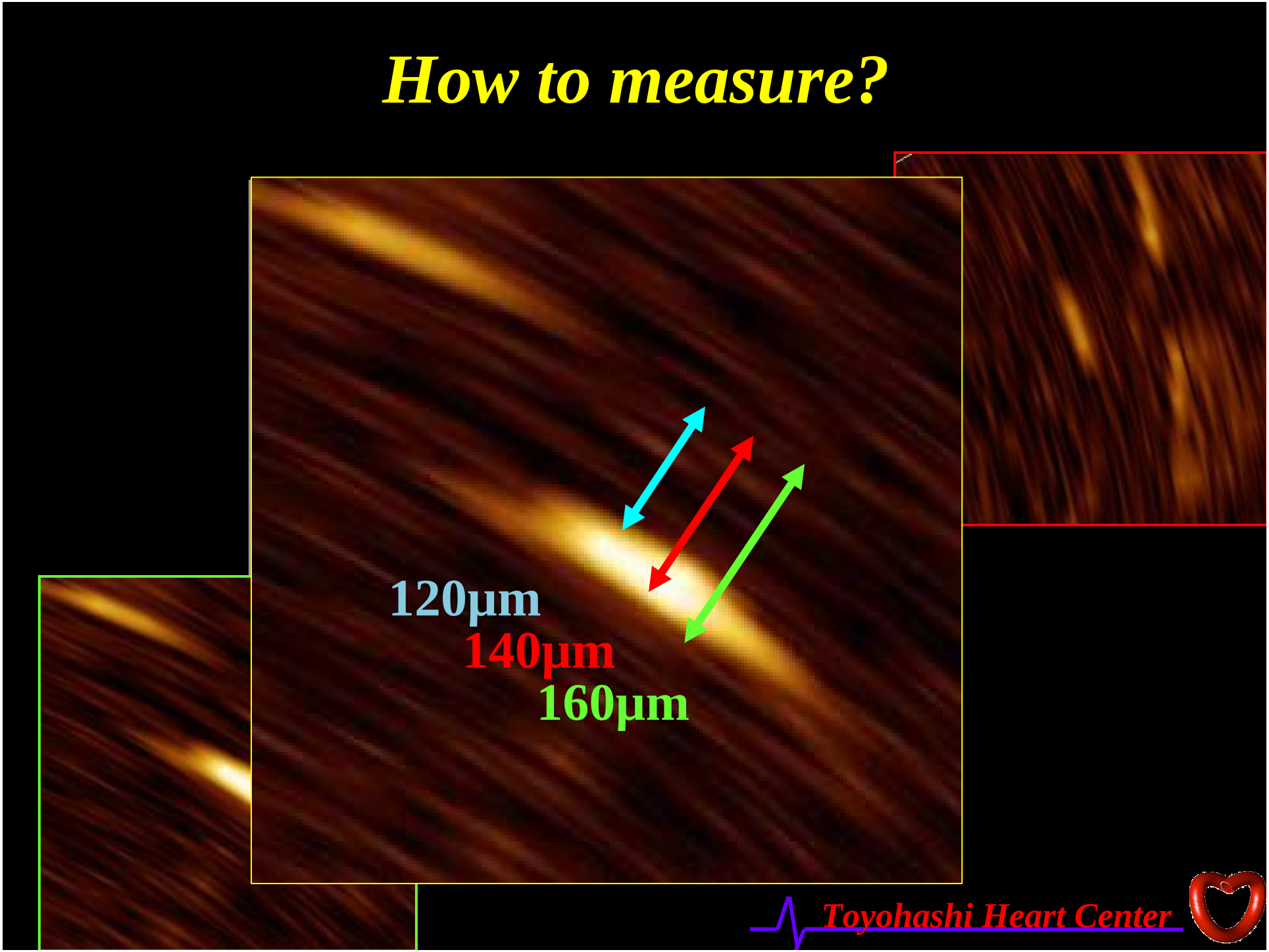
How to measure?



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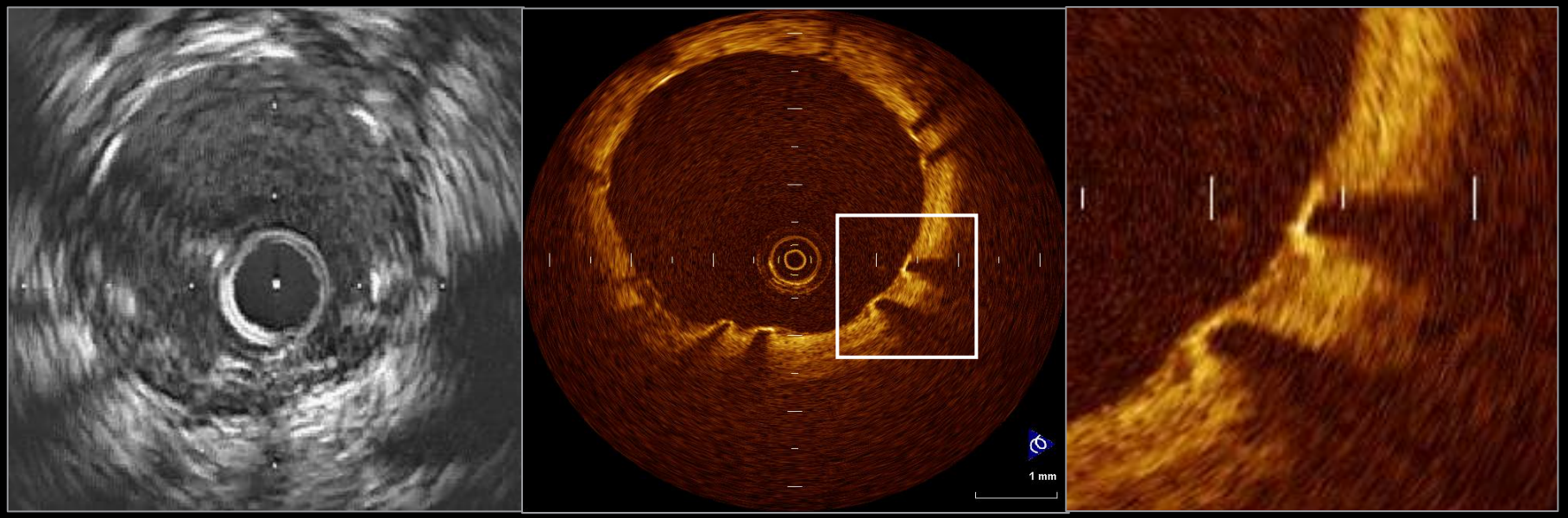
Identification of Chronic Vascular Responses to Coronary Stenting by Optical Coherence Tomography

IVUS and OCT image of SES at 3-month follow-up



✓ **OCT provides detailed visualization of the individual stent struts and a thin neointimal layer over DES struts that IVUS can not detect.**

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Late stent thrombosis

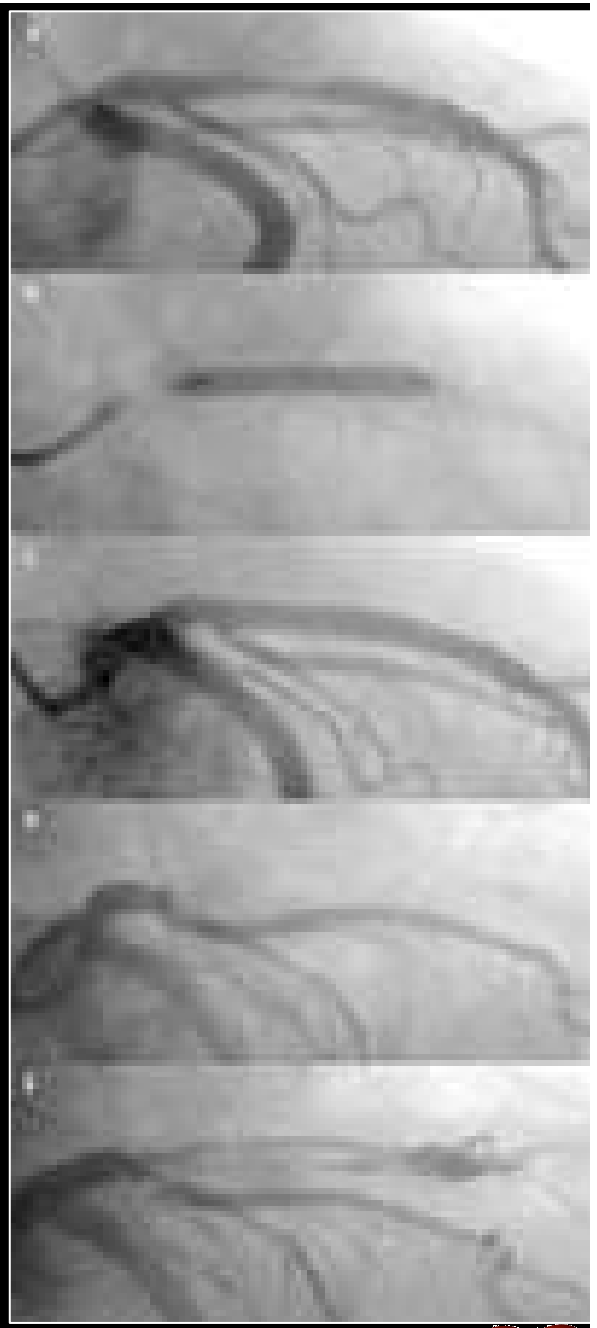
Although DES has reduced rates of restenosis, late thrombosis, a life-threatening complication of this technology has emerged as a major concern.

Lancet 2004; 364: 1519-21

Late thrombosis in drug-eluting coronary stents after discontinuation of antiplatelet therapy

J Am Coll Cardiol 2005;45:2088-92

Late thrombosis: 0.35% (7 / 2,006 patients)
8 late thromboses / 7 patients
Aspirin (+) : 5 late thromboses
No aspirin or clopidogrel : 3 late thromboses



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FDA Advisory Panel on the Safety and Efficacy of Drug Eluting Stents: Summary of Findings and Recommendations

Jeffrey J. Popma, MD, Bonnie Weiner, MD, Michael J. Cowley, MD,
Charles Simonton, MD, Dan McCormick, DO, and Ted Feldman, MD

Supported by an education grant from Medtronic, Inc, and Boston Scientific, Inc.

(@ 2006 AHA annual meeitng)

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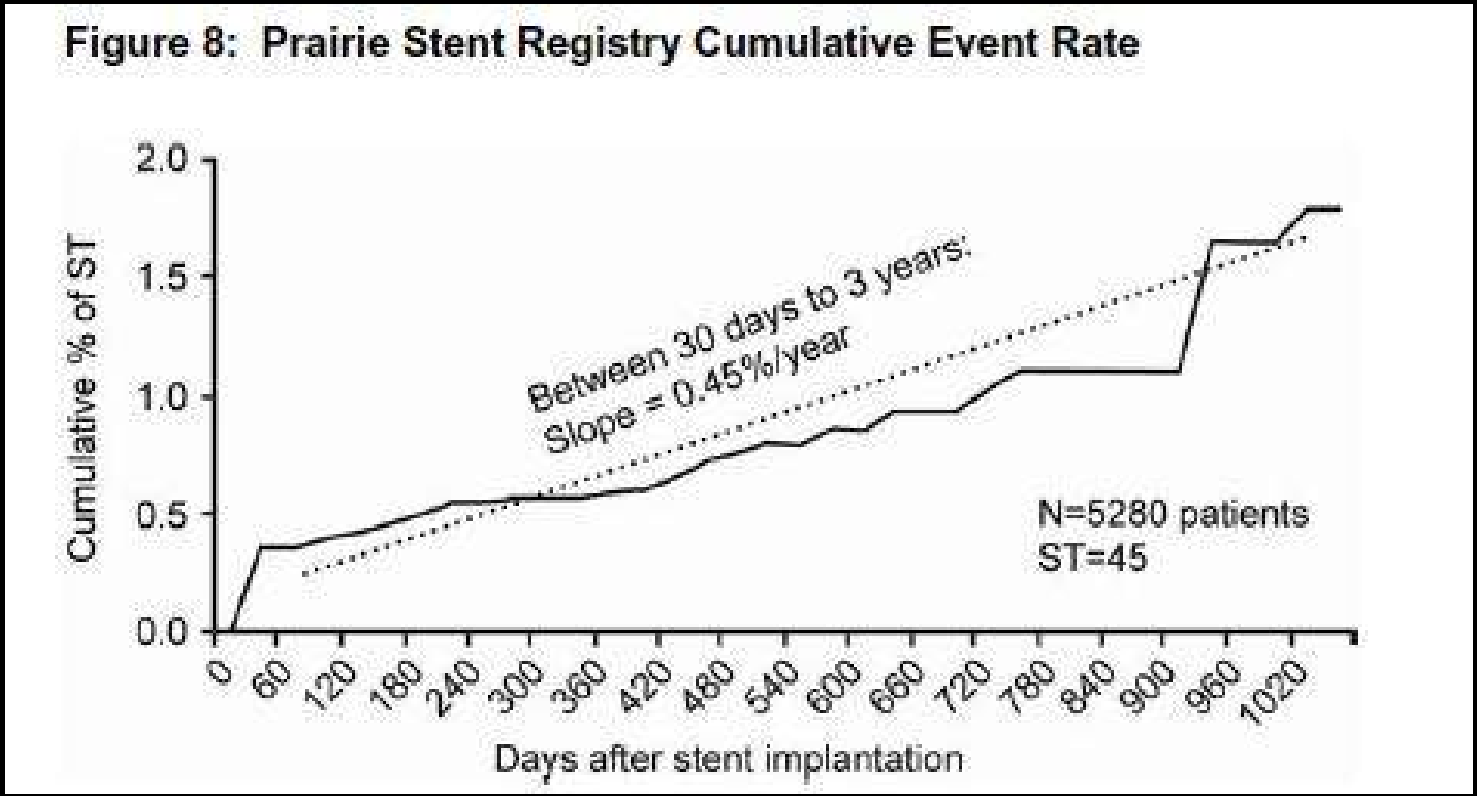
FDA Advisory Panel on the Safety and Efficacy of Drug Eluting Stents (2)



There were 45 (0.85 percent) cases of definite stent thrombosis using the ARC definitions, including 16 that occurred at a steady rate more than one year after DES placement(10) (Figure 8). Over 50 percent of these cases presented with STEMI. The cumulative event rate for definite very late stent thrombosis was 0.45 percent per year.

Procedural Factors

- Incomplete apposition
- Under expansion
- Excessive stent length
- Overlapping stents

Device Factors

- Hypersensitivity reaction
- Uneven distribution of drug
- Incomplete apposition due to poor flexibility

Increased Risk for Late Stent Thrombosis

Lesion Factors

- Penetration of necrotic core or Pre-existing thrombus with necrotic core (AMI)
- Bifurcation / Ostial stenting
- Long lesion
- Bare struts
- Late malappositon (inflammation)

Patient Factors

- Diabetes
- Renal failure
- Low EF
- Not a candidate for long term Anti-platelet therapy
- Premature discontinuation of Antiplatelet therapy

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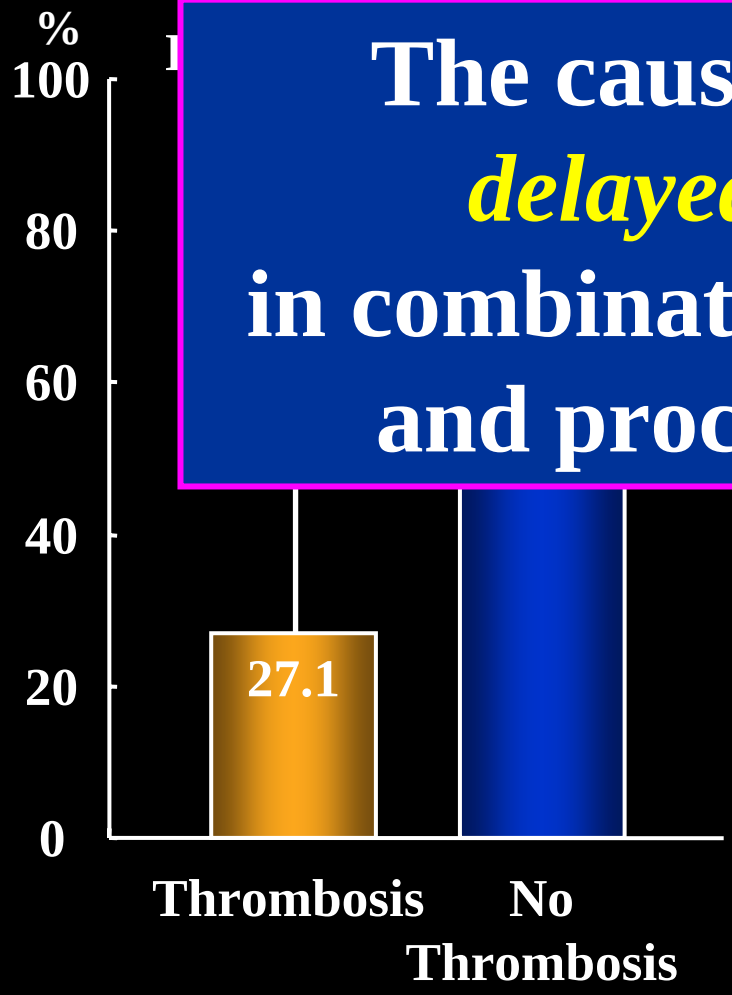
Pathology of Drug-Eluting Stents in Humans: Delayed Healing and Late Thrombotic Risk

Joner, M et al, J Am Coll Cardiol 2006;48:193-202



The cause of LST should be *delayed arterial healing* in combination with other clinical and procedural risk factors

Delayed arterial healing cardinal risk factor of LST

By courtesy of Dr Y. Kobayashi

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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; Mika C. John, MPH; Herman K. Gold, MD; Renu Virmani, MD

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

duration without thrombosis using computer-guided morphometu … was defined as an acute thrombus within a coronary artery stent in place >30 day … ed estimating equations modeling demonstrated that endothelialization was the best predi … orphometric parameter that best correlated with endothelialization was the ratio of uncovered … section. A univariable logistic generalized estimating equations model of occurrence of thromb … versus ratio of uncovered to total stent struts per section demonstrated a marked increase in risk for … ber of uncovered struts increased. The odds ratio for thrombus in a stent with a ratio of uncovered to t … uts per section >30% is 9.0 (95% CI, 3.5 to 22).

Conclusions—The most powerful histological predictor of ste… hrombosis was endothelial coverage. The best morphometric predictor of LST was the ratio of uncovered to total stent struts. Heterogeneity of healing is a common finding in drug-eluting stents with evidence of LST and demonstrates the importance of incomplete healing of the stented segment in the pathophysiology of LST. (***Circulation.*** **2007;115:&NA;-.)**

Key Words: complications ■ stents ■ thrombus ■ pathology ■ endothelium

Finn, AV et al, Circ 2007;115

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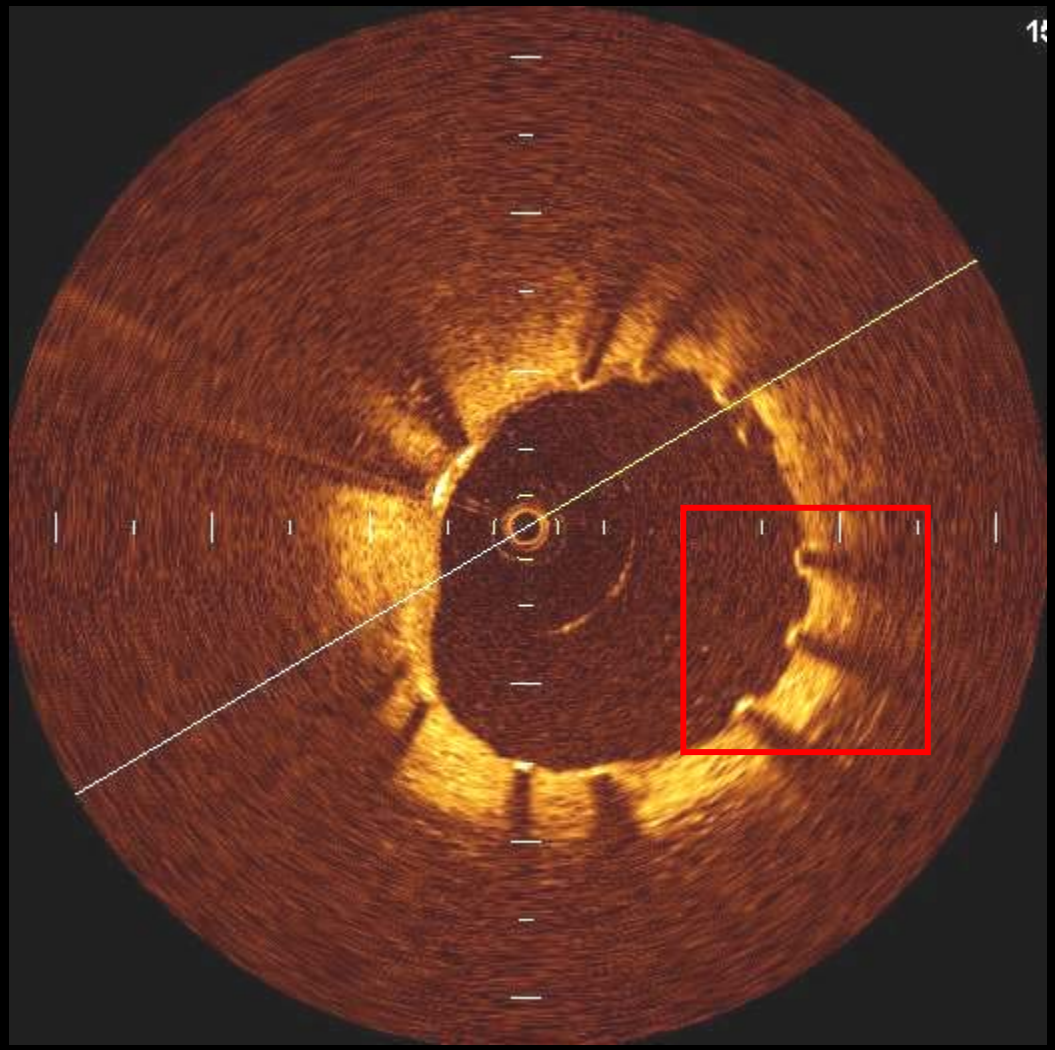
Intimal Stent Strut Coverage Type 1 & 2



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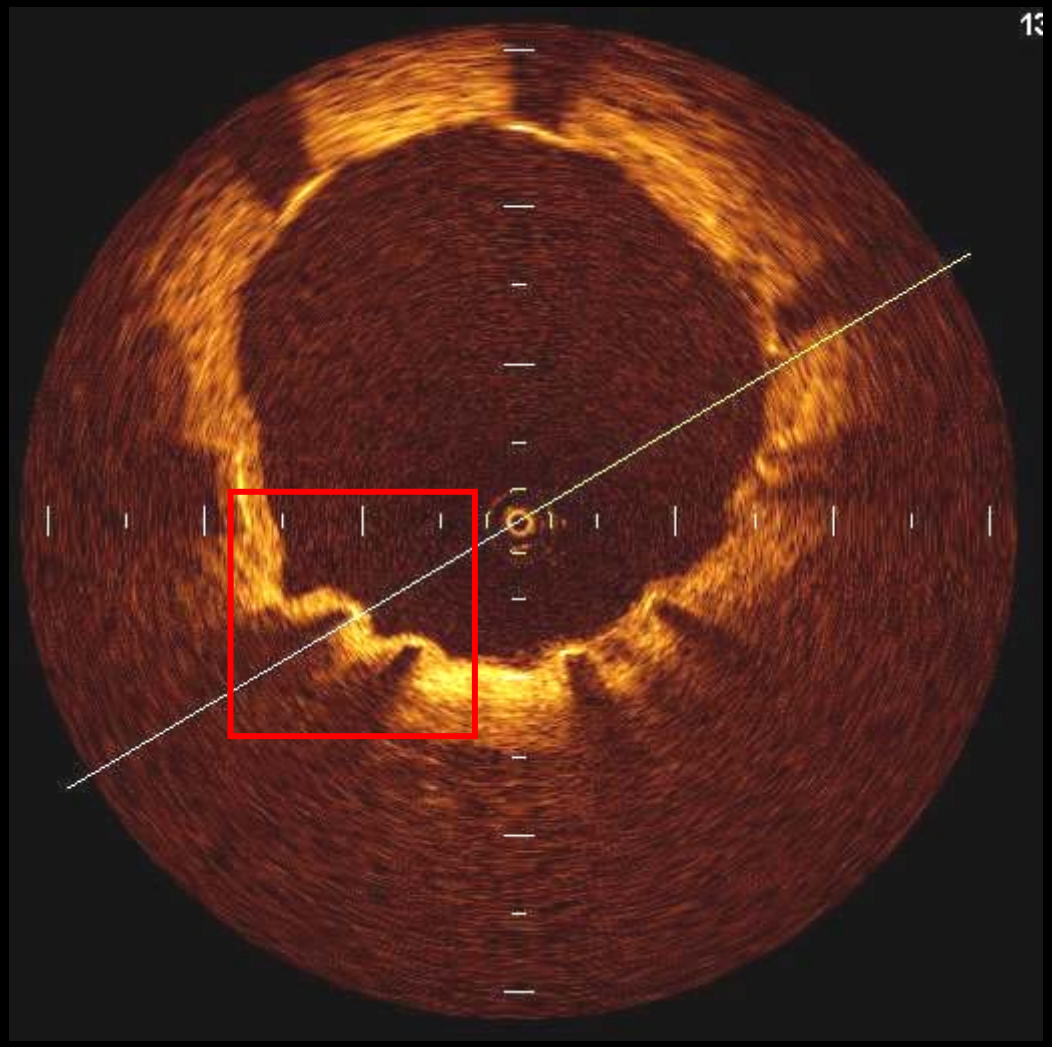
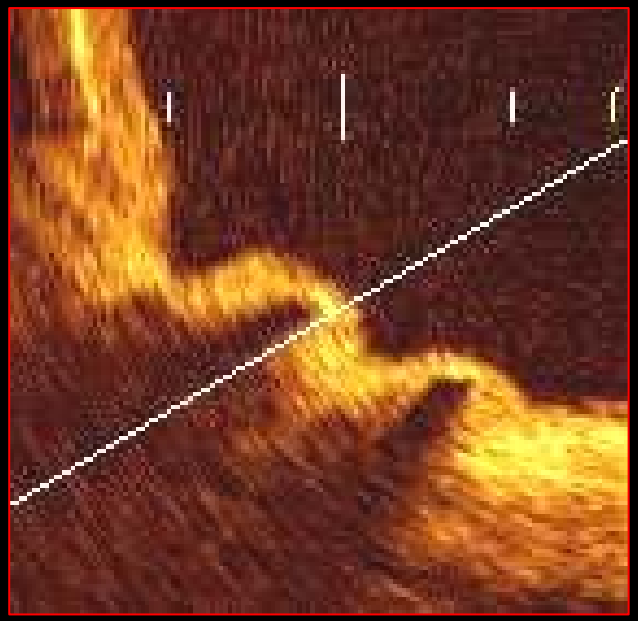
Intimal Stent Strut Coverage Type 3





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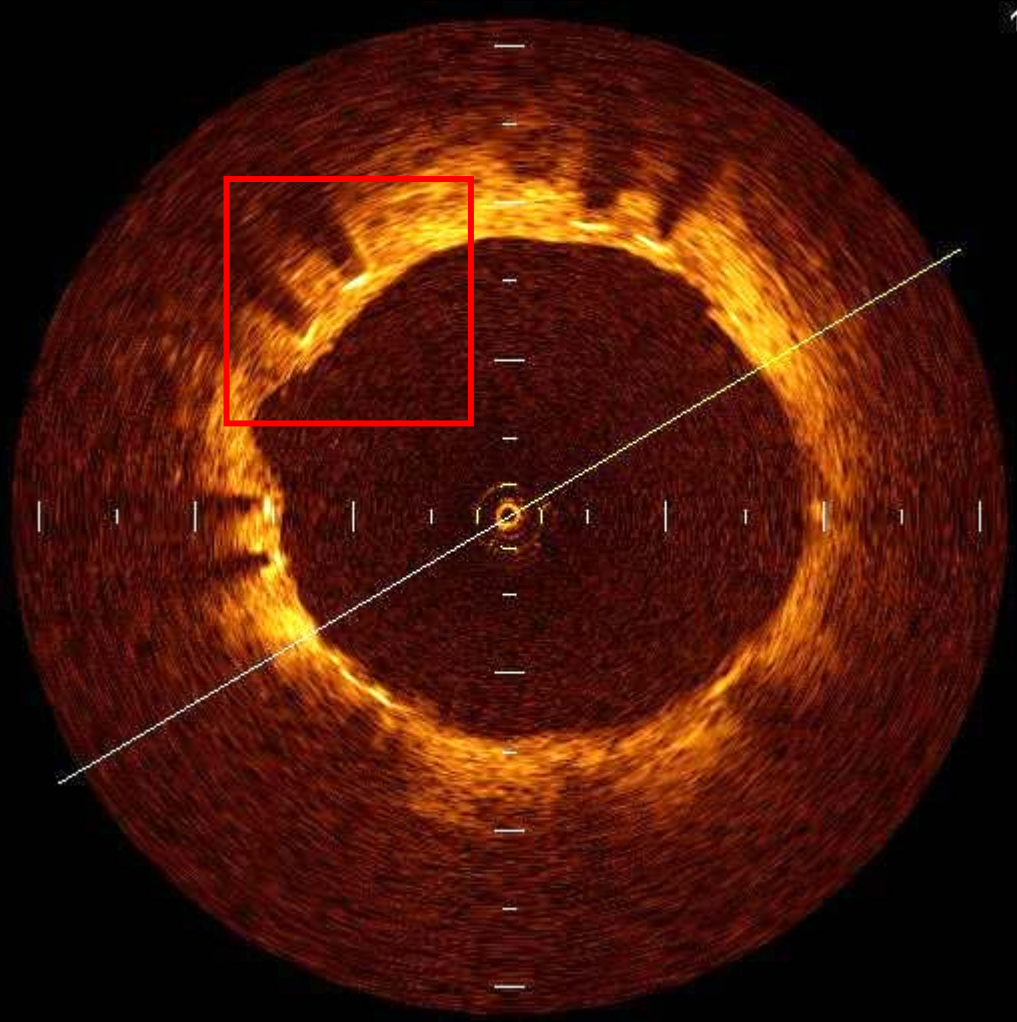
Intimal Stent Strut Coverage Type 4



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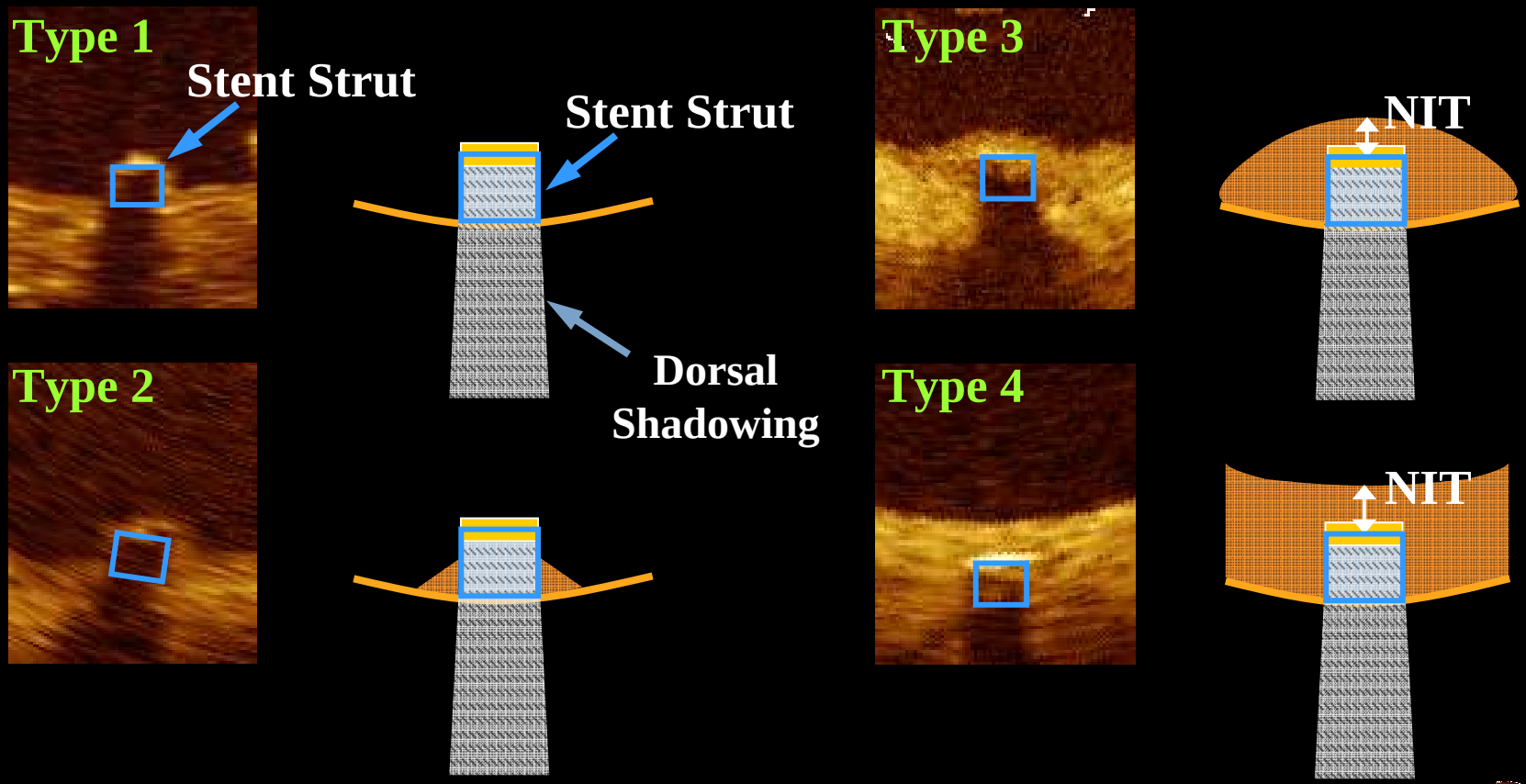
Definition of Neointimal Coverage of Struts

Uncovered Struts

Covered Struts



Ito t, et al, 2006 ACC

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Optical Coherence Tomographic Analysis of Neointimal Stent Coverage in Sirolimus-eluting Stent, Compared with Bare Metal Stent

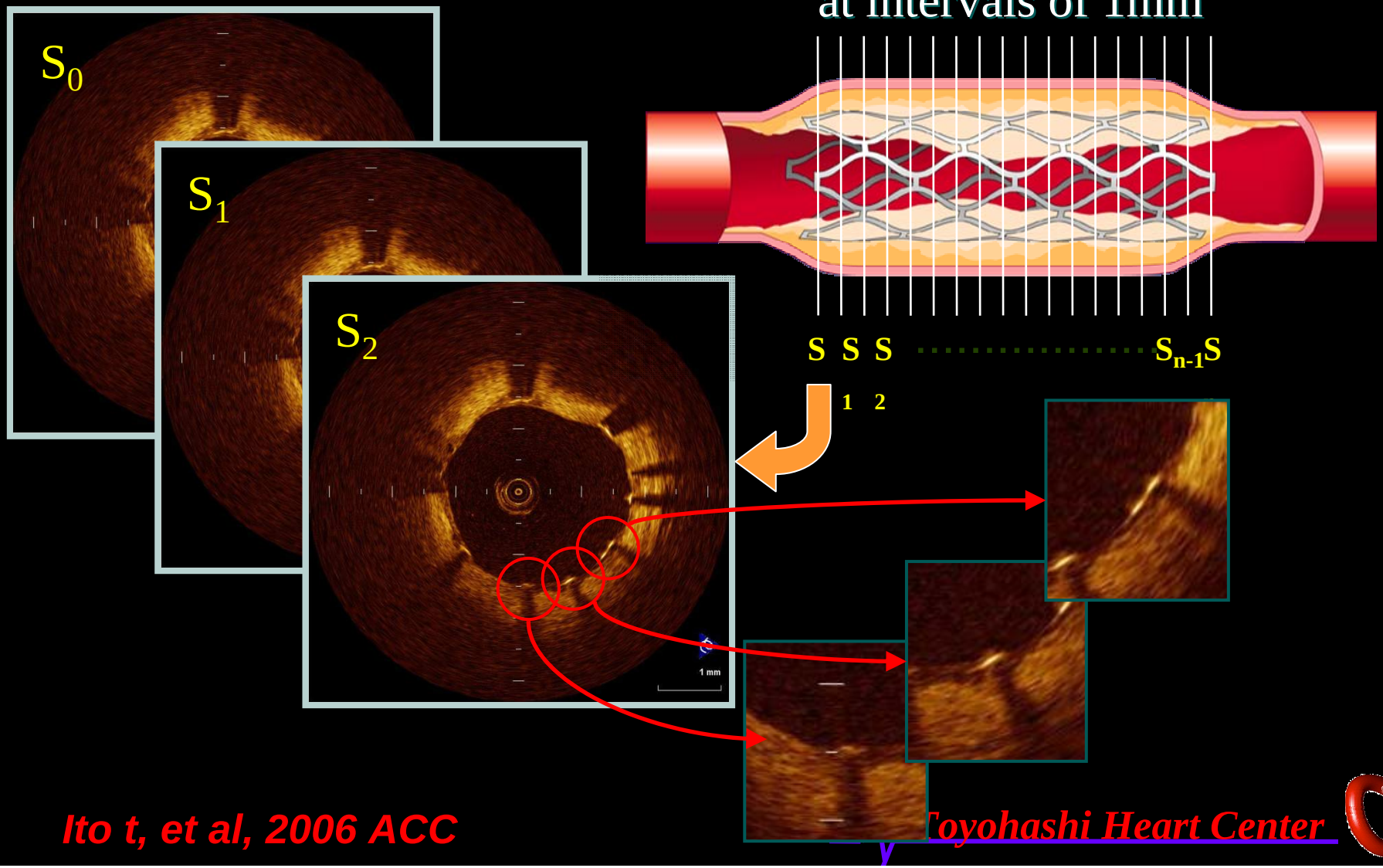
Toyohashi Heart Center, Toyohashi, Japan

Tatsuya Ito,
Mitsuyasu Terashima, Yoshihiro Takeda, Osamu Katoh, Tetsuo Matsubara, Etsuo Tsuchikane, Mariko Ehara, Yoshihisa Kinoshita, Kenya Nasu, Jean-François Surmely, Nobuyoshi Tanaka, Akira Murata, Hiroshi Fujita, Koyo Sato, Takahiko Suzuki

Ito t, et al, 2006 ACC

OCT Analysis of Stented segment

(Excluding branch and overlapped segment)



Ito t, et al, 2006 ACC

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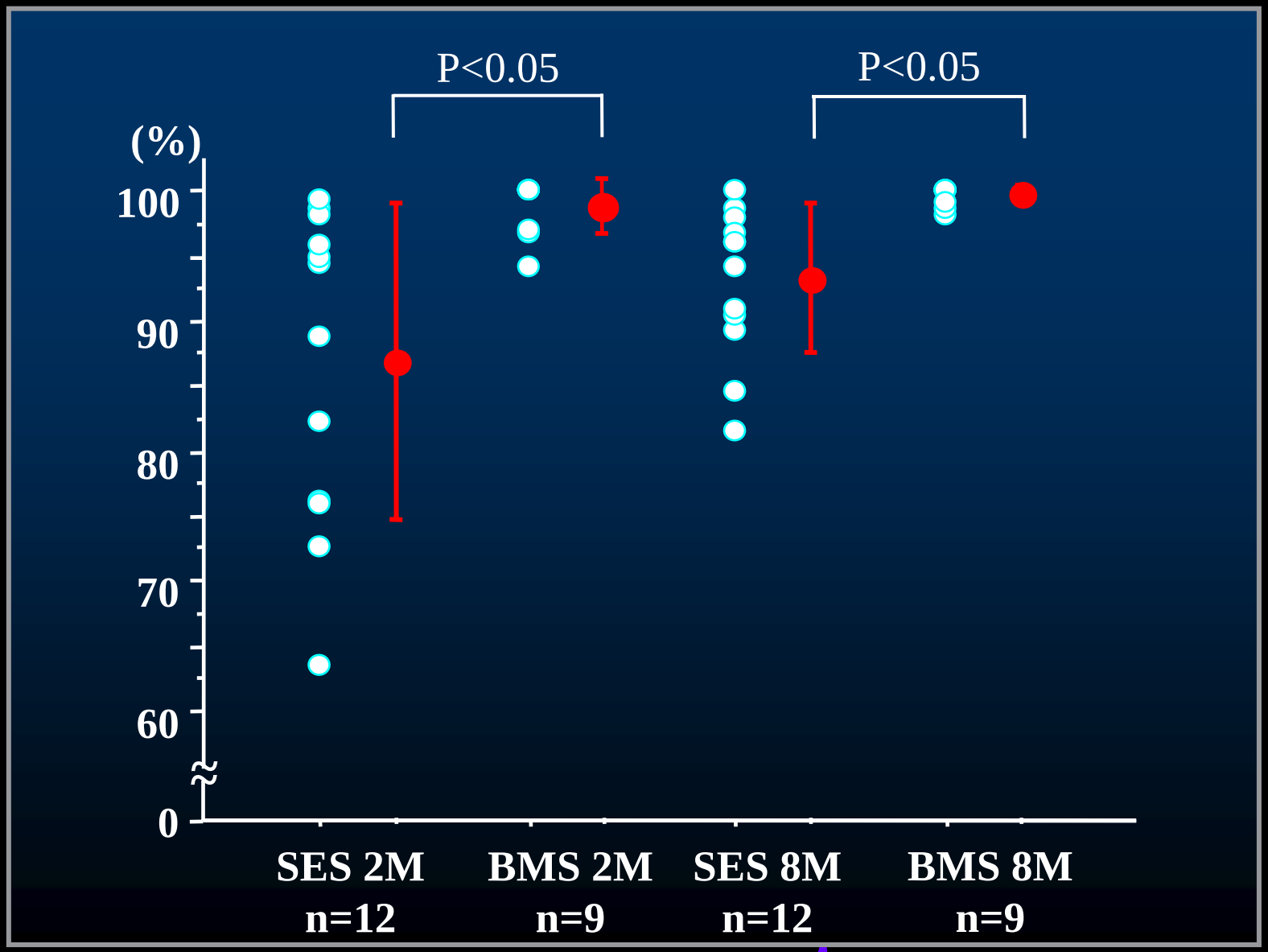
Neointimal Stent Coverage (%)



Ito t, et al, 2006 ACC

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Differences between Angioscopy and OCT

Grade 0 **Grade 1** **Grade 2**

Incomplete coverage by CAS

Complete coverage by CAS

Incomplete coverage by OCT

Complete coverage by OCT

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Advantage of OCT

- ✓ High resolution
- ✓ Quantitative analysis of
  the ratio of uncovered to total stent struts
  and thickness of neointima

Disadvantage of OCT

- ✓ limitation to distinguish accurately
  between neointima and small amount of
  fibrin deposition or thrombus

Predictors of Late Stent Thrombosis

Although the exact pathophysiology has not been fully elucidated, multiple factors are apparently involved in the development of late stent thrombosis.

- ✓ **Antiplatelet therapy discontinuation**
- ✓ **Hemodialysis**
- ✓ **Diabetes mellitus**
- ✓ **Low ejection fraction (≦40%)**
- ✓ **Bifurcation lesion**
- ✓ **In-stent restenosis**
- ✓ **Long lesion**

Ong AT et al. J Am Coll Cardiol 2005; 45: 2008-2092
Iakovou L et al. JAMA 2005; 293: 2126-2130
Bavry AA et al. J Am Coll Cardiol 2005; 45: 941-946
Takeyasu N et al. Circ J 2005; 69: 780-785
Kuchulakanti PK et al. Circulation 2006; 1108-1113
Bavry AA et al. Am J Cardiol 2005; 95: 1469-1472

A Bifurcation Lesion is the one of the most important Predictors of Late Stent Thrombosis

Interventional Cardiology

Correlates and Long-Term Outcomes of Angiographically Proven Stent Thrombosis With Sirolimus- and Paclitaxel-Eluting Stents

Pramod K. Kuchulakanti, MD; William W. Chu, MD, PhD; Rebecca Torguson, BS; Patrick Ohlmann, MD; Seung-Woon Rha, MD; Leonardo C. Clavijo, MD, PhD; Sang-Wook Kim, MD; Ahn Bui, MD; Natalie Gevorkian, MD; Zhenyi Xue, MS; Kimberly Smith, BS; Jana Fournadjieva, PhD; William O. Suddath, MD; Lowell F. Satler, MD; Augusto D. Pichard, MD; Kenneth M. Kent, MD; Ron Waksman, MD

There were **more bifurcation lesions**, type C lesion, and a trend for smaller diameter stents.

...n regardless of the ...003, we identified ...atients, subacutely ...l variables of these ...implantation and did not experience ST during a follow-up of 12 months. Logistic re... ...nducted to determine the correlates of ST. Compared with patients without ST, patients with ST had a higher freque... ...iabetes, acute postprocedural renal failure, and chronic renal failure. There were more bifurcation lesions, type C lesions, and a trend for smaller-diameter stents. Discontinuation of clopidogrel was higher in these patients (36.8% versus 10.7%; $P<0.0001$). The mean duration to ST from the stent implantation was 8.9±8.5 days in subacute and 152.7±100.4 days in late thrombosis cases. Mortality was significantly higher in patients with ST compared with those without ST at 6 months (31% versus 3%; $P<0.001$). Multivariate analysis detected cessation of clopidogrel therapy, renal failure, bifurcation lesions, and in-stent restenosis as significant correlates of ST ($P<0.05$).

Conclusions—ST continues to be a serious complication of contemporary DES use. Careful management is warranted in patients with renal failure and in those undergoing treatment for in-stent restenosis and bifurcations. Special focus on clopidogrel compliance may minimize the incidence of ST after DES implantation. (***Circulation*. 2006;113:1108-1113.**)

Key Words: angioplasty ■ clopidogrel ■ stents ■ thrombosis

Circulation 2006:113:1608

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Angioscopic Analysis of Intimal Coverage of DES By Kotani et al

Abbreviations and Acronyms

BMS = bare-metal stent
IVUS = intravascular ultrasound
SES = sirolimus
VBT =

artery and
stent to the
graphic guid
Angioscop
strut neointi
white throm
grades (Fig.
fully visible,
Grade 1 was
lumen and, although
Grade 2 was defined as stent
clearly seen (i.e., they w
defined as stent struts th
(i.e., they were embed
crossed side branches were excluded from grading because they all showed grade 0 coverage. (This grading system evolved from one previously reported [11].) Taken together, grade 0/1 indicated incomplete neointimal coverage,

whereas grade 2/3 indicated complete coverage. In three SES and three BMS, neointimal coverage was heterogeneous; in these six cases the dominant pattern was tabulated.

Angiographic assessment. Coronary angiography was per-
ative coronary
Med-
h the
(12).
d us-
lina).
and
ance.
and
r 2 ×

Struts that crossed side branche d from grading ll showed grade 0 coverage.

Really?

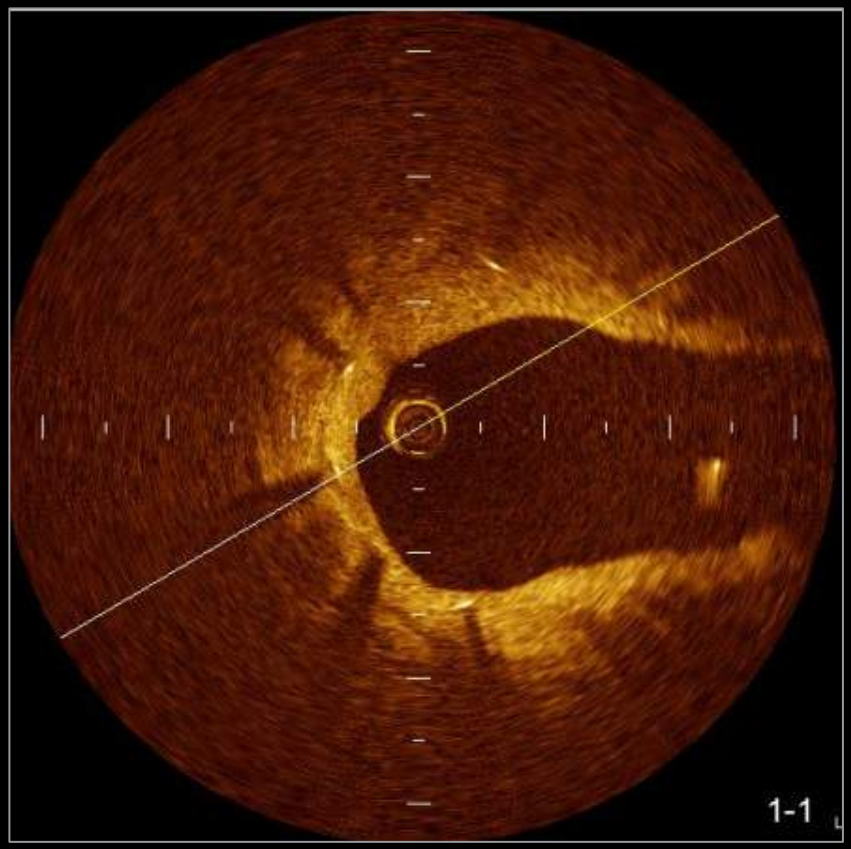
but not
Grade 3 was
visible by angioscopy
the neointima).

RESULTS

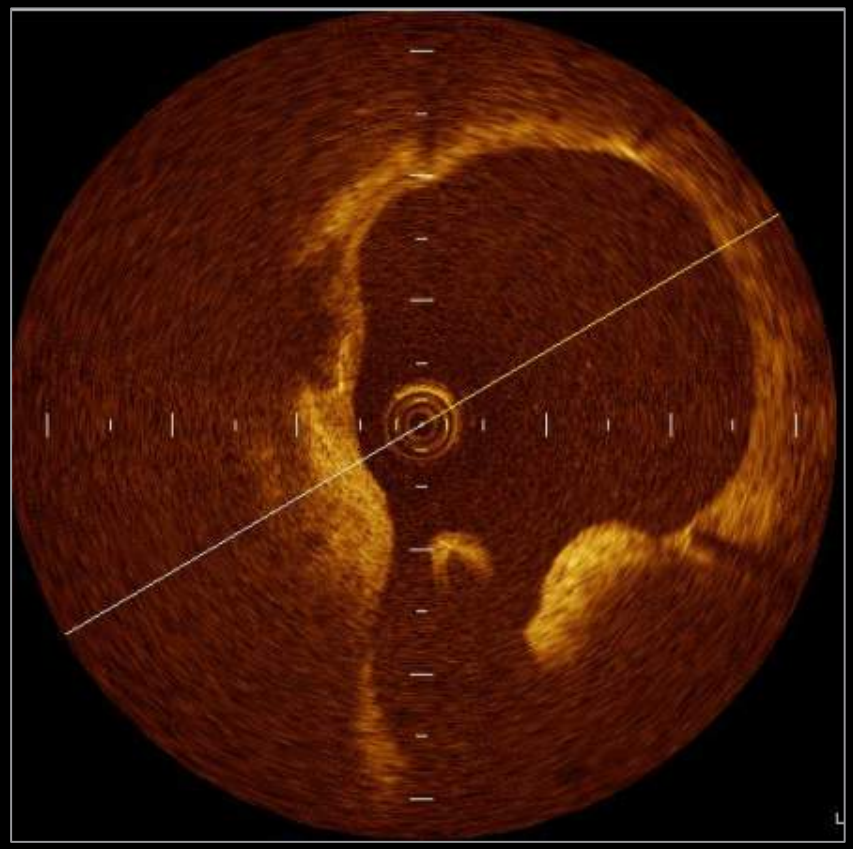
Patient and lesion characteristics. There were no significant differences in demographics (age, gender, past history, and coronary risk factors) between patients receiving BMS versus SES (data not shown). Lesion characteristics were also similar between the two groups (Table 1). There was no difference in diabetes frequency between BMS (n = 15; 68.2%) and SES (n = 11; 73.3%) (p = 1.0). There was no

Tissue Growth on the Stent Strut crossing a side branch in BMS and SES at 9-months follow-up

BMS



SES



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Neointimal Coverage of SES struts Crossing a Side-branch

2008 AHA in New Orleans

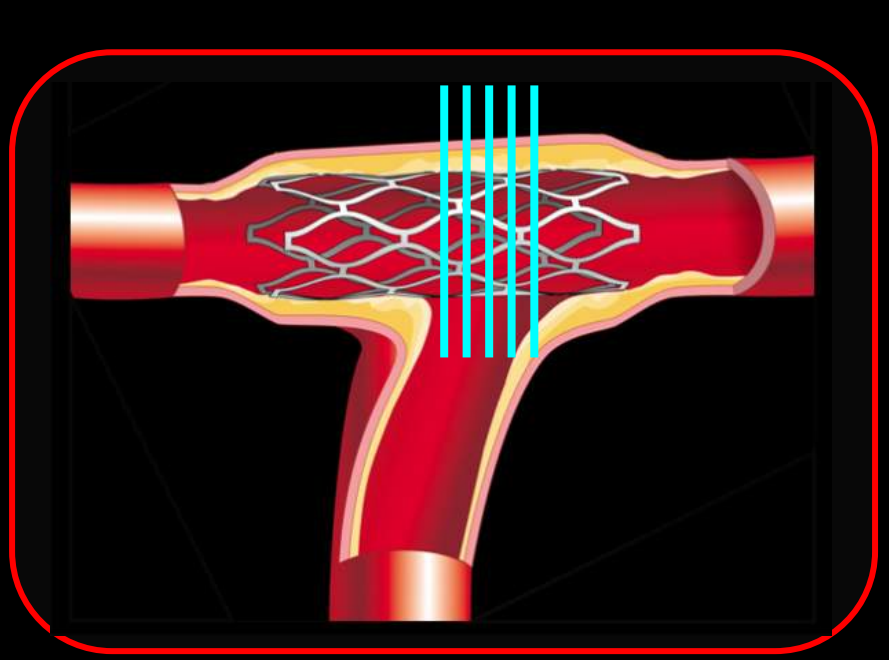
Difference in Neointimal Growth on the Stent Struts Crossing a Side Branch Between Sirolimus-Eluting Stent and Bare-Metal Stent: An Optical Coherence Tomography Analysis

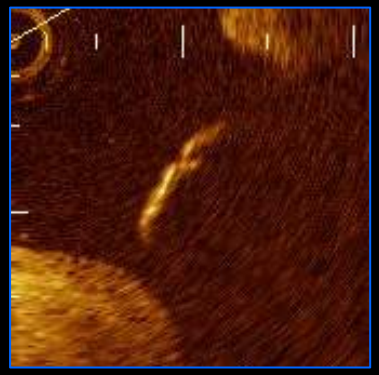
Mitsuyasu Terashima

Yoshiaki Nakayama, Yasuyoshi Suzuki, Tsuyoshi Inada, Yasushi Asakura, Tetsuo Matsubara, Hitoshi Matsuo, Keiko Asakura, Etsuo Tsuchikane, Mariko Ehara, Yoshihisa Kinoshita, Masashi Kimura, Kenya Nasu, Osamu Katoh, and Takahiko Suzuki

Toyohashi Heart Center, Toyohashi, Japan

OCT Analysis





- **27 struts of 9 SES** crossing a side branch
- **At 2 months and 8 months** after SES implantation

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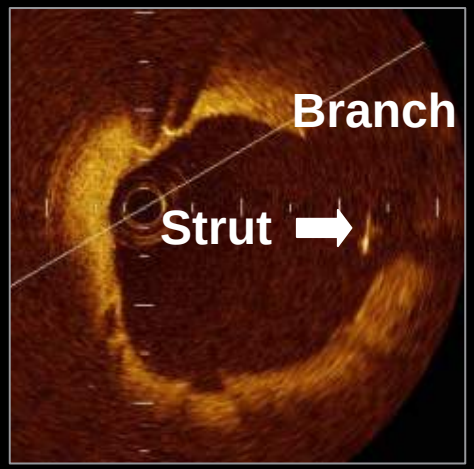
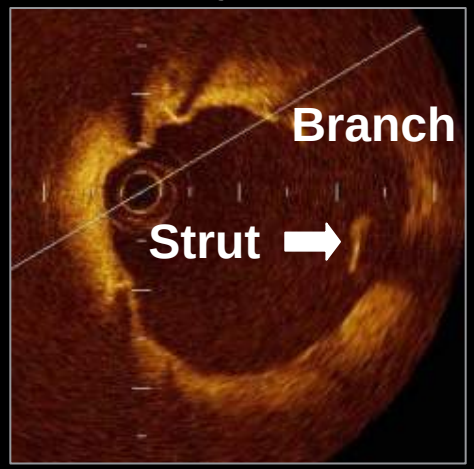
Definition of Neointimal Coverage of Stent Struts Crossing a Side Branch

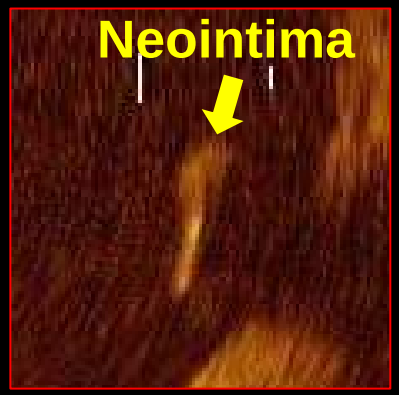
Incomplete Coverage

Uncovered



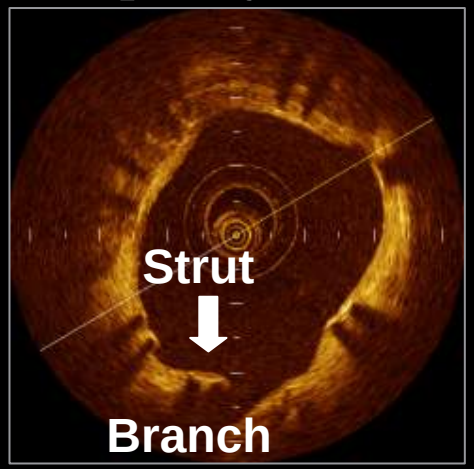
Partially covered

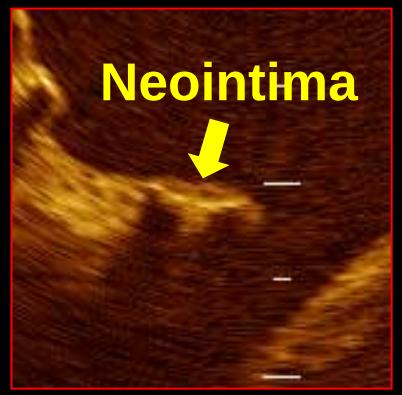




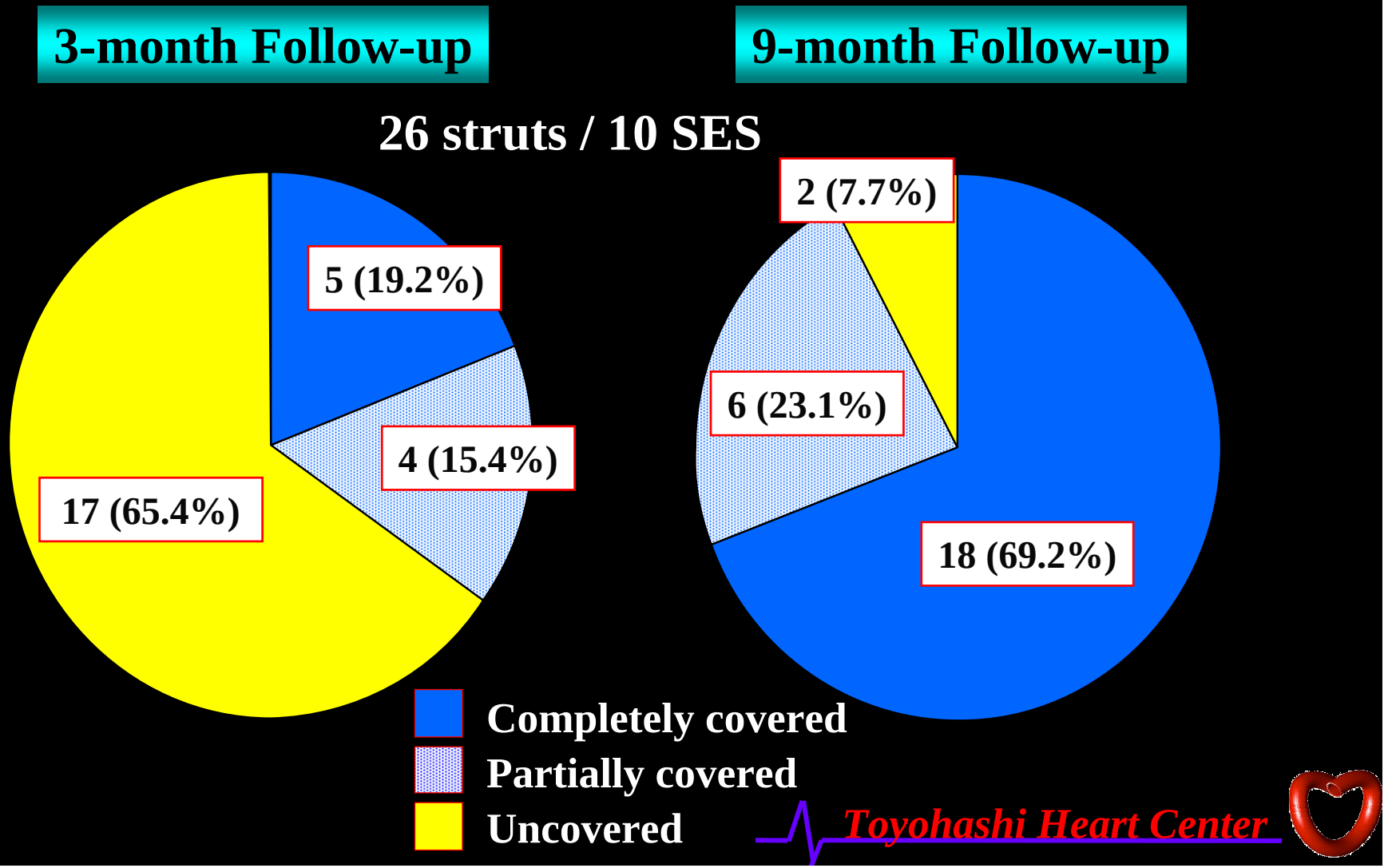
Complete Coverage

Completely covered



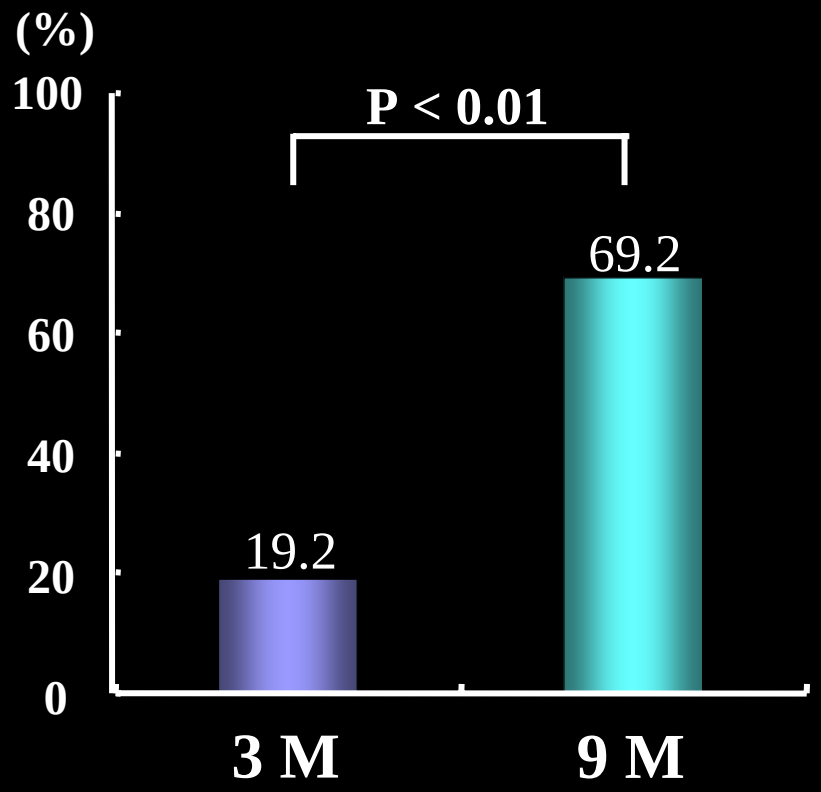


Serial Change of Neointimal Coverage of Struts Crossing a Side Branch between 3 and 9 Months after SES Implantation

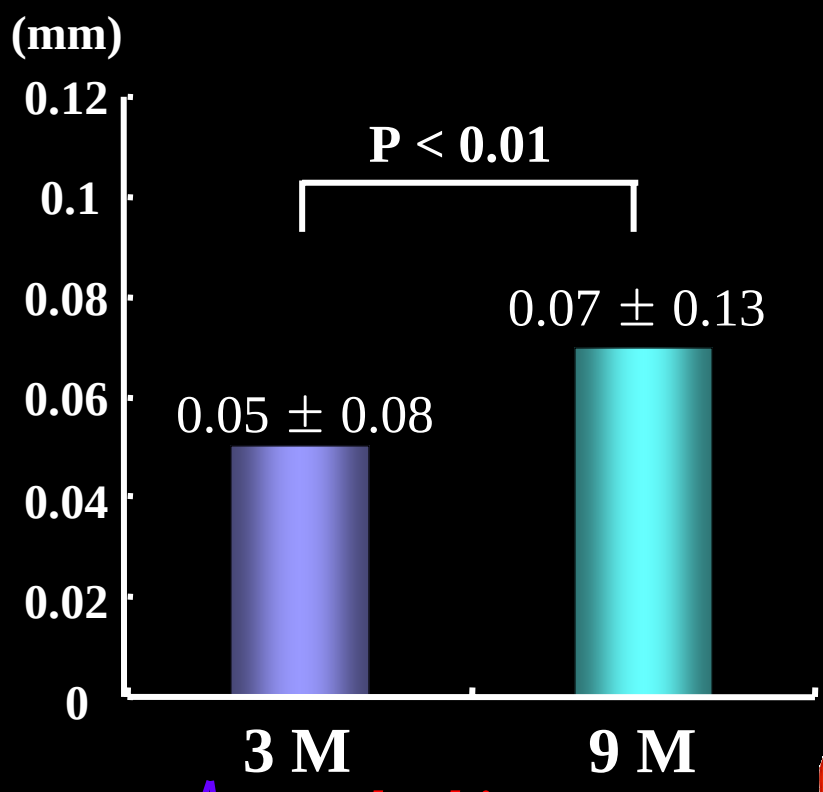


Serial Change of Frequencies of Complete Neointimal Coverage and of Neointimal Thickness Between 3 and 9 Months After SES Implantation

Frequencies of complete neointimal struts coverage



Neointimal thickness



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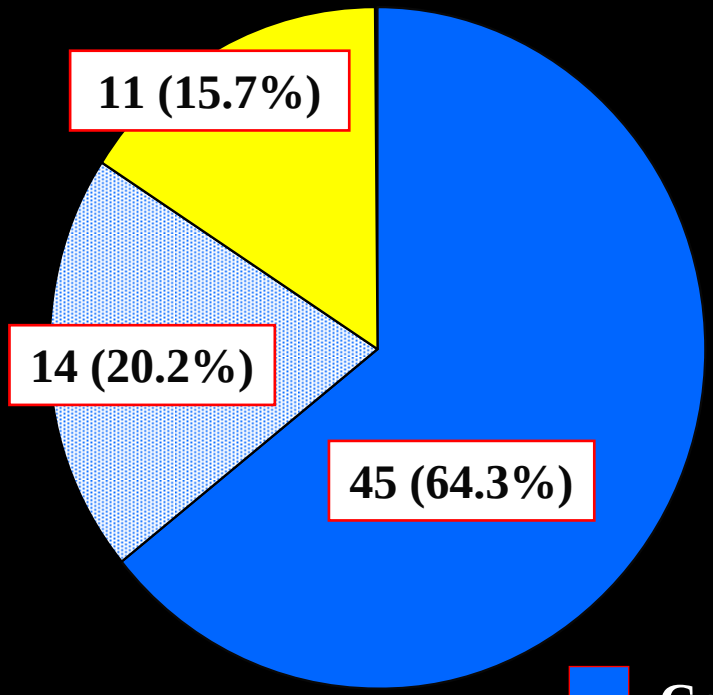
Comparison of Neointimal Coverage of Struts Crossing a Side Branch between SES and BMS at 9 months

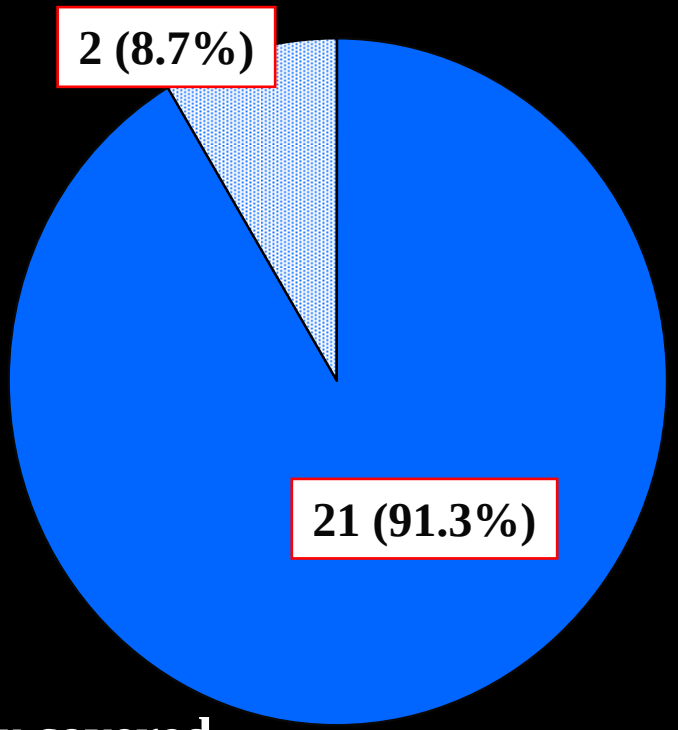
SES

70 struts / 25 SES



BMS

23 struts / 13 BMS



Completely covered
Partially covered
Uncovered

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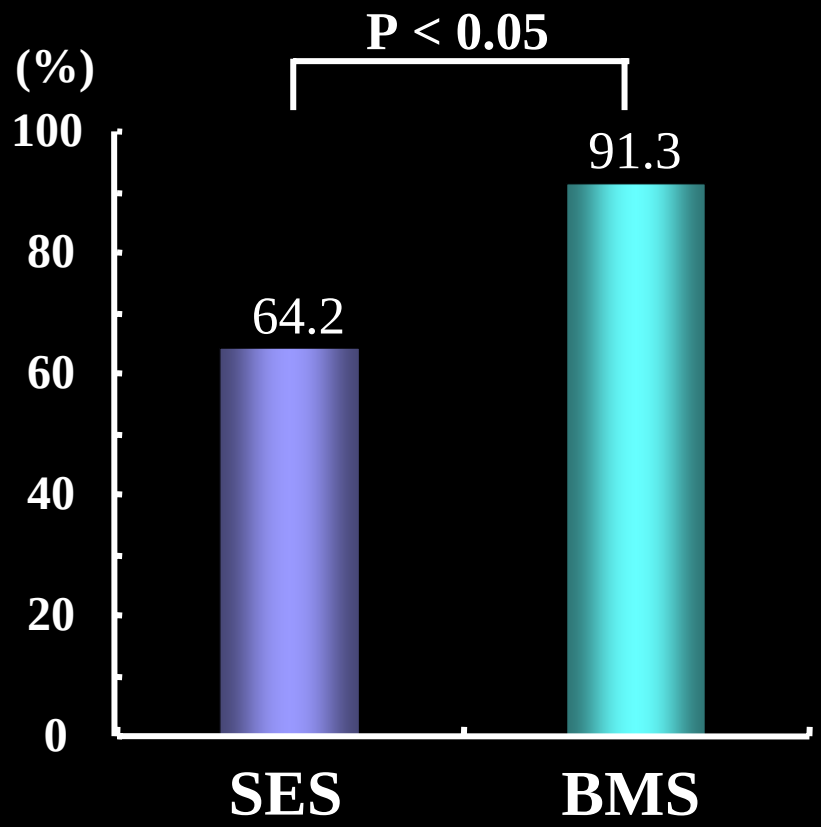
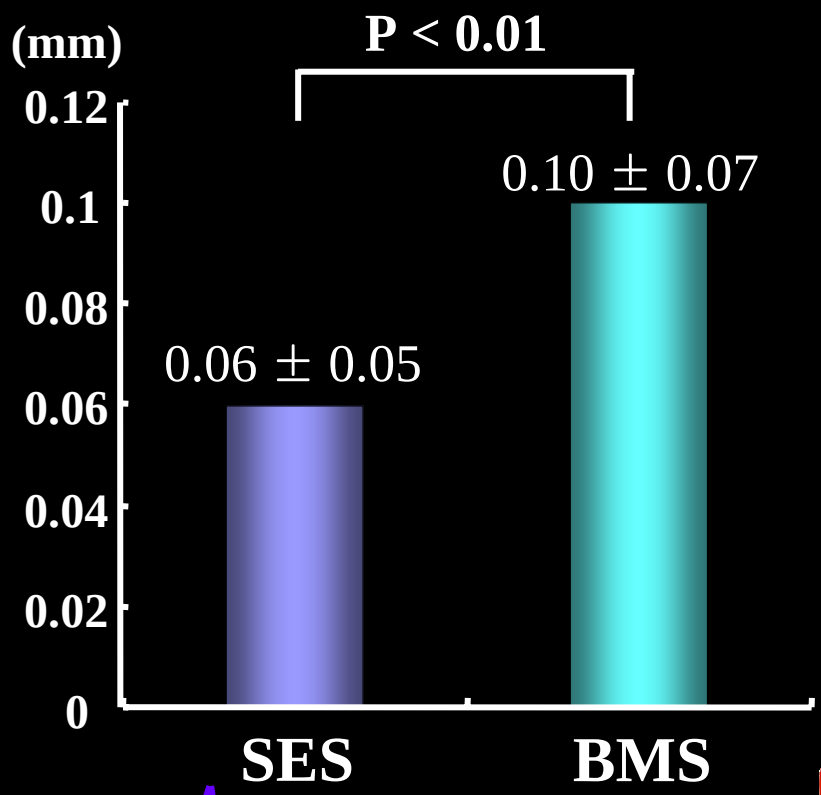
Comparison of Frequencies of Complete Neointimal Coverage and of Neointimal Thickness between SES and BMS at 9 months

Frequencies of complete neointimal struts coverage



Neointimal thickness



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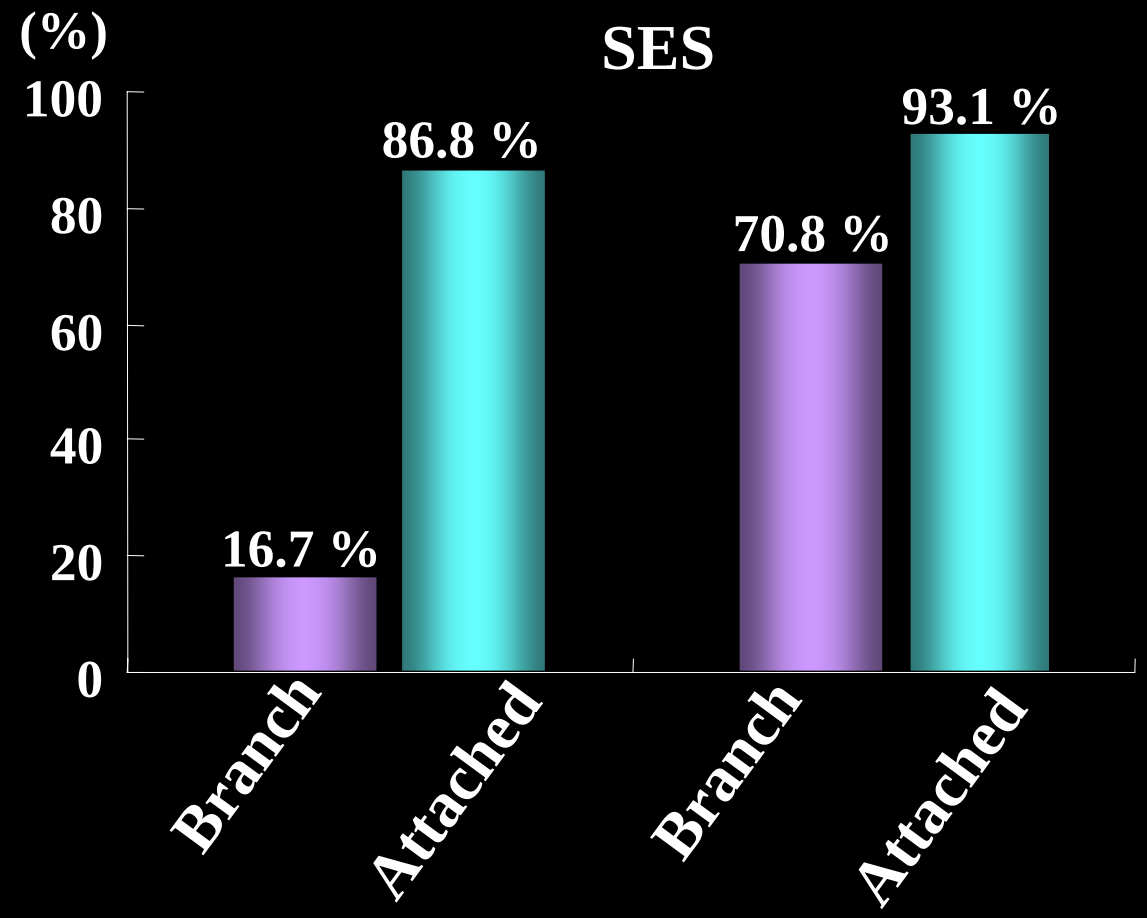
Comparison of Frequencies of Complete Neointimal Coverage between Side-branch and Attached struts in SES at 3- and 8-month follow-up



Terashima M, et al, 2006 ACC

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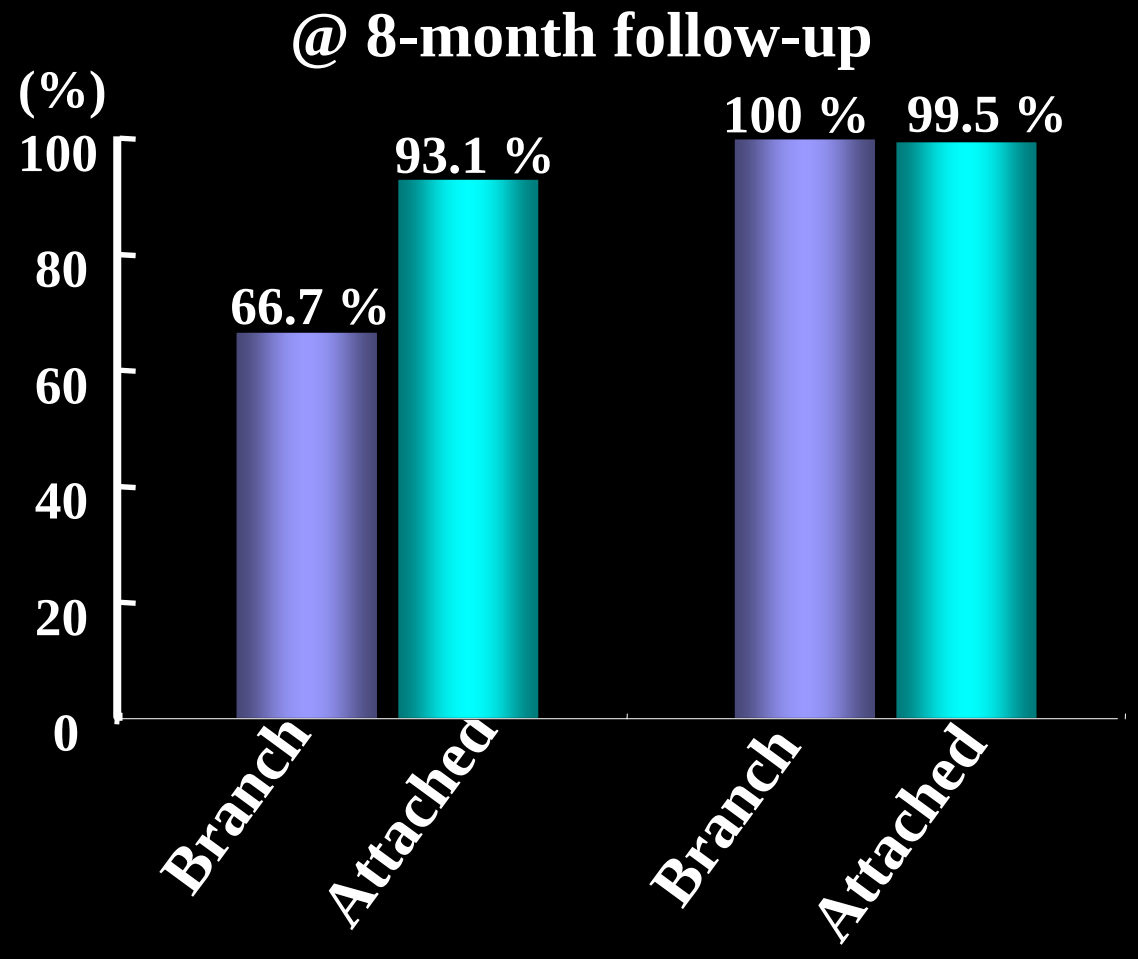
Comparison of Frequencies of Complete Neointimal Coverage between Side-branch and Attached struts in SES and BMS at 8-month follow-up



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Evaluation of DES by OCT

✓ **OCT provides various information of acute and chronic vascular response to PCI.**

✓ **OCT might be a powerful imaging tool in DES era.**