# OCT-guide PCI in DES Era

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*Wakayama Medical University*

# Declaration of Interest

**Within the past 12 months, I or my spouse/partner have had a financial interest/arrangement or affiliation with the organization(s) listed below.**

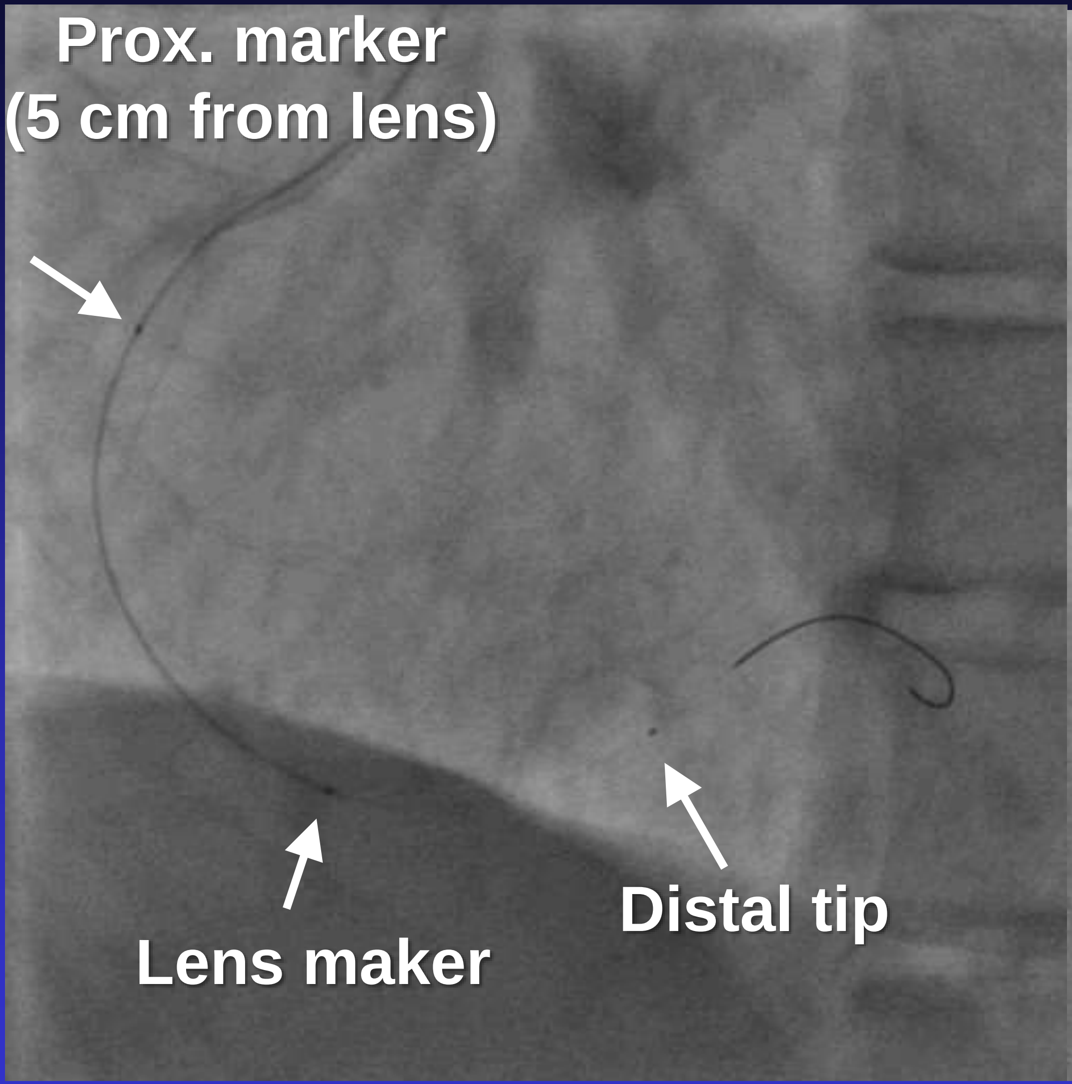
## Affiliation/Financial Relationship

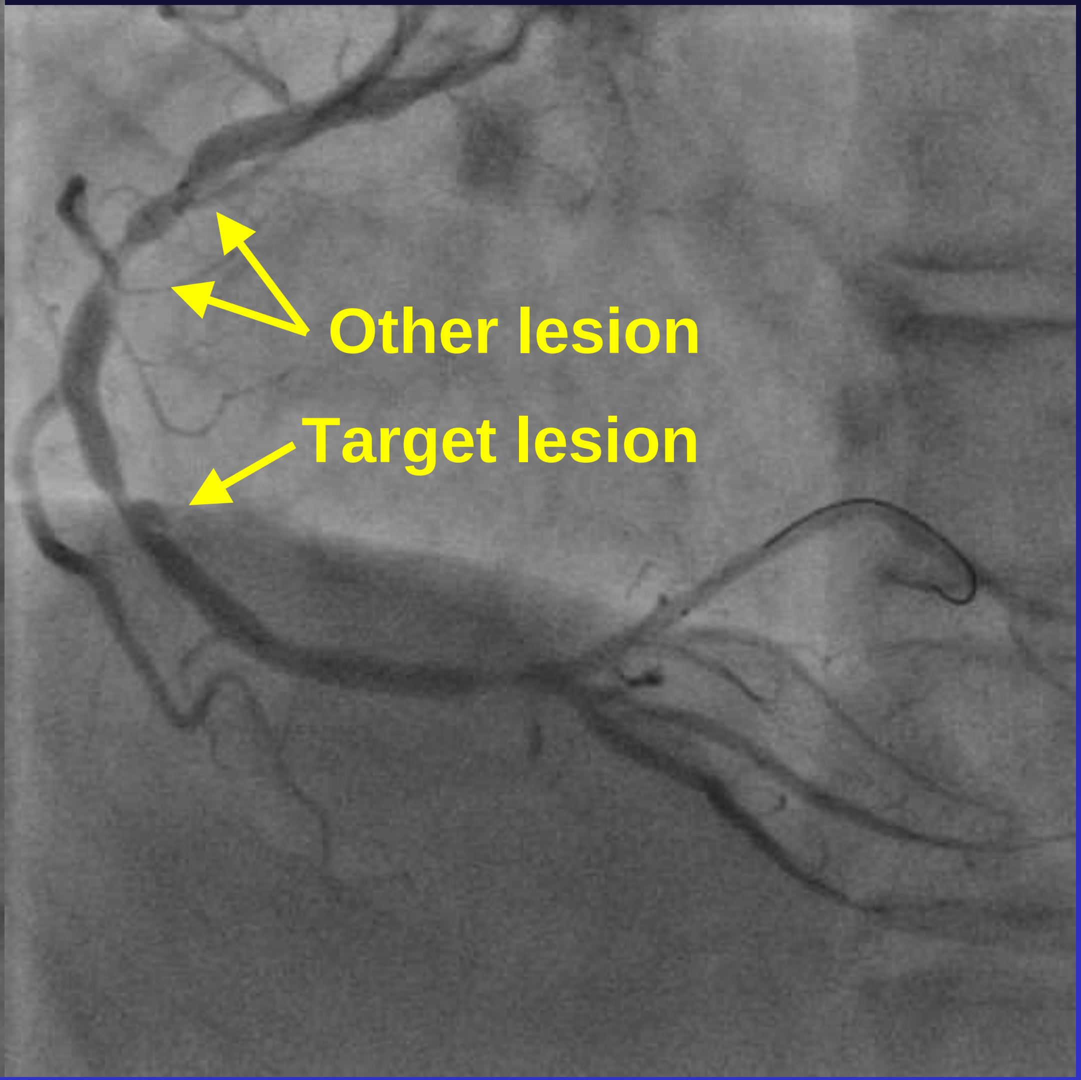
- **Grant/Research Support** : Abbott Vascular Japan
  Boston Scientific Japan
  Goodman Inc.
  St. Jude Medical Japan
  Terumo Inc.
- **Consulting Fees/Honoraria** : Daiichi-Sankyo Pharmaceutical Inc.
  Goodman Inc.
  St. Jude Medical Japan
  Terumo Inc.

# Agenda

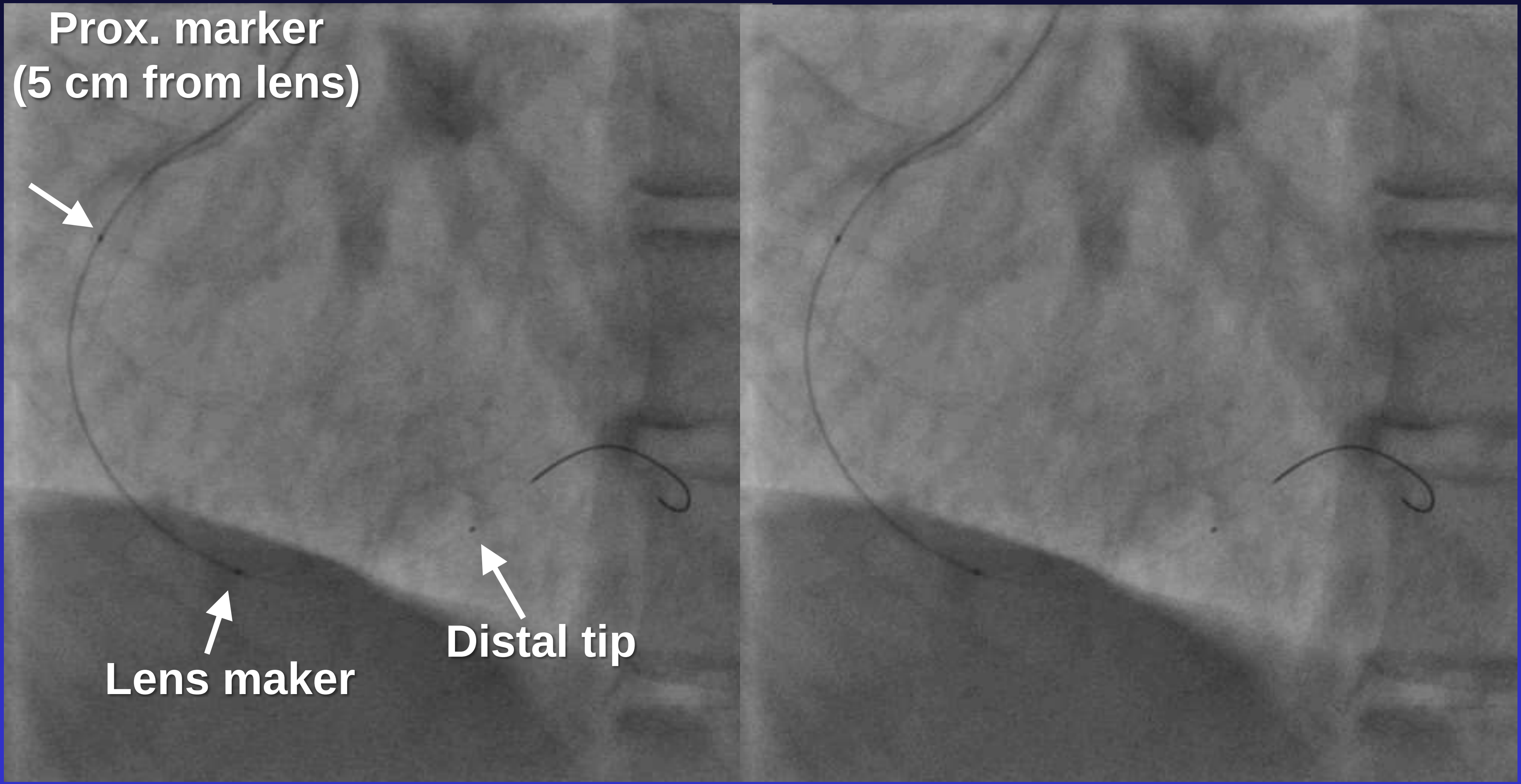
- How to obtain FD-OCT image
- How to select stent size & length
- How to treat stent under-expansion
- How to decide stent apposition
- How to manage other complication
- How to deal calcified lesion
- How to care bifurcation lesion
- How to treat instent restenosis

# Positioning of OCT Catheter

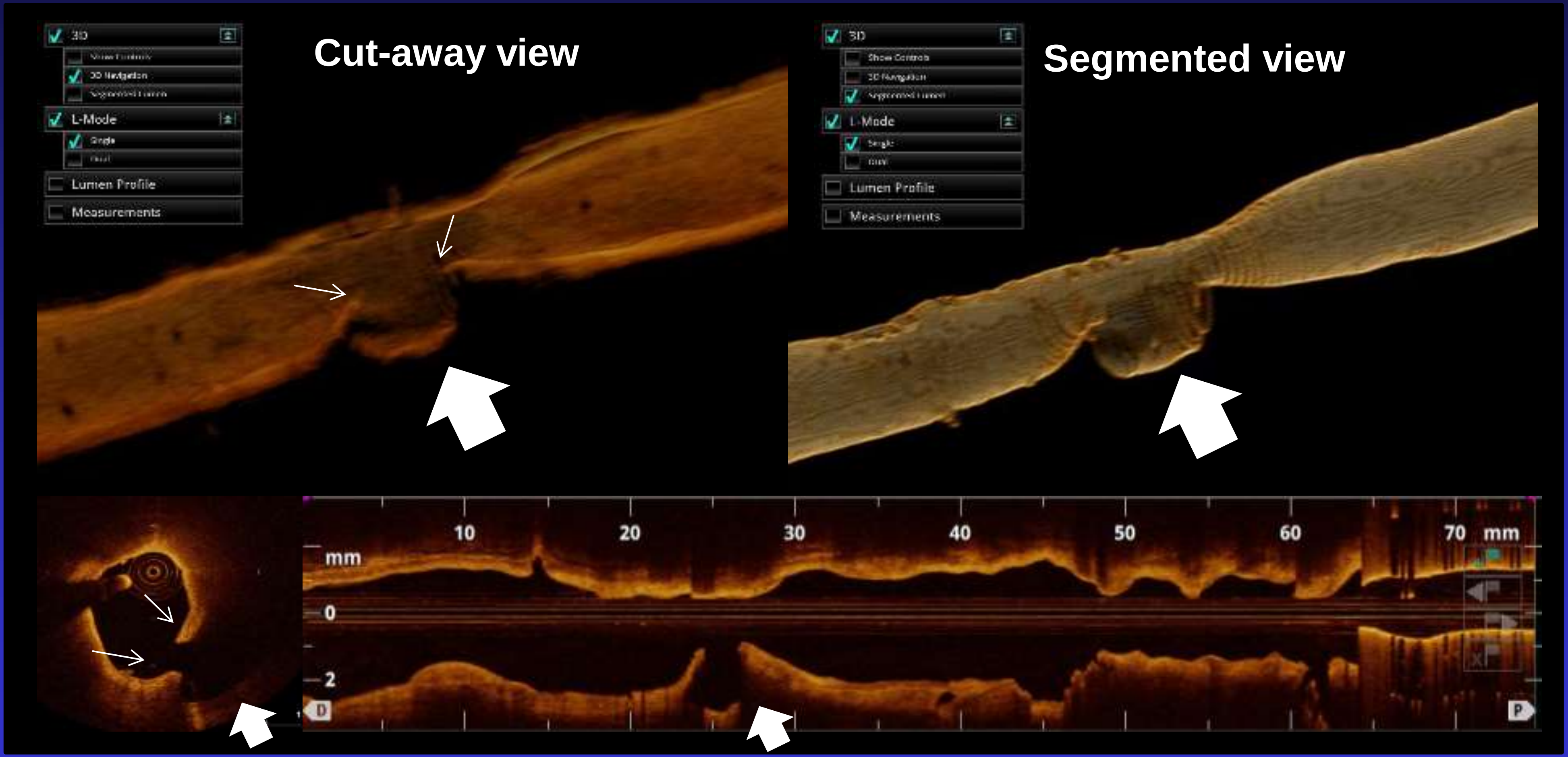


# Positioning of OCT Catheter

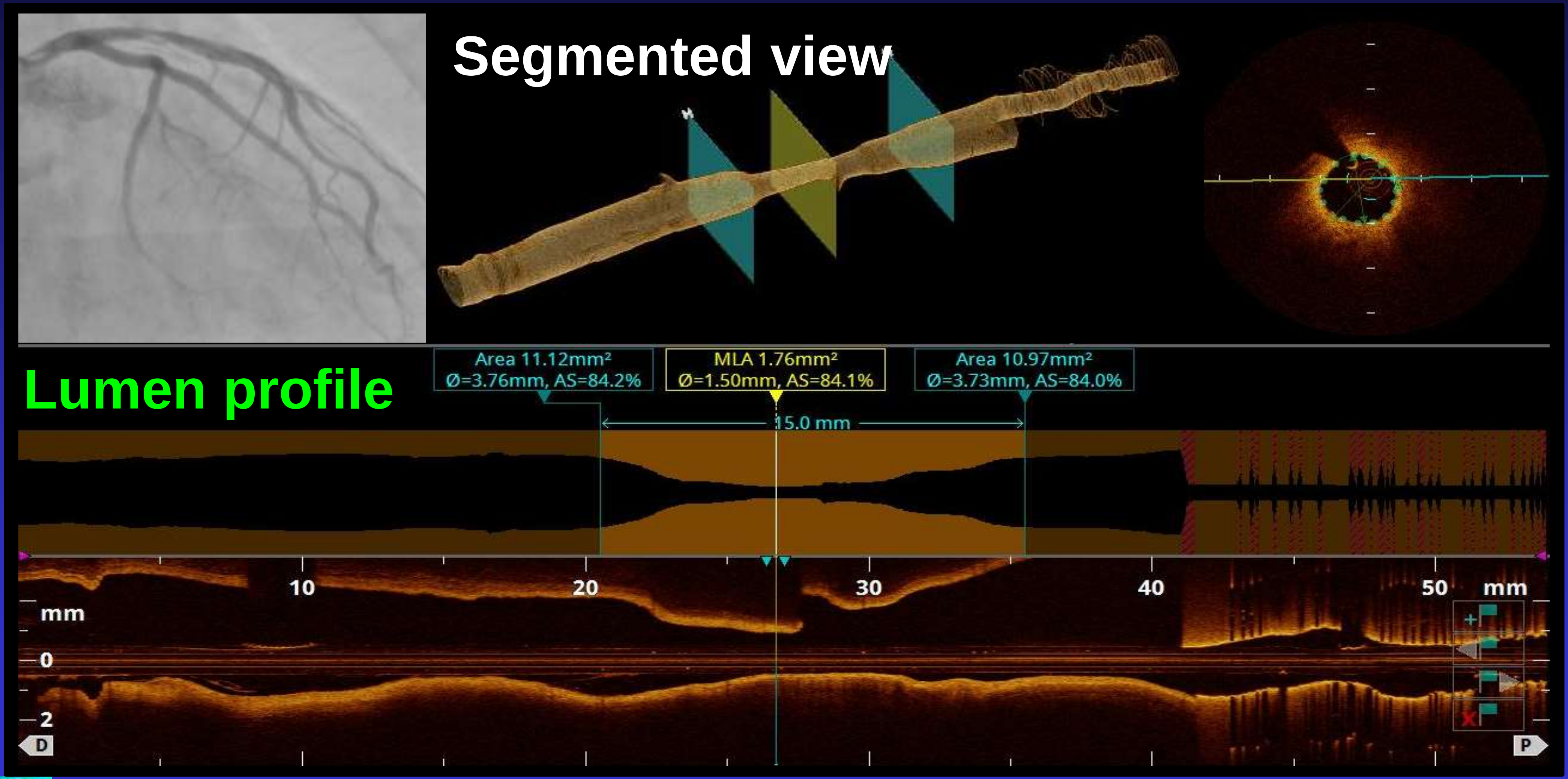


# Advantages of Newly developed FD-OCT system
# ( ILUMIEN OPTIS ® )




*Kubo, Akasaka et al. RC 2013*

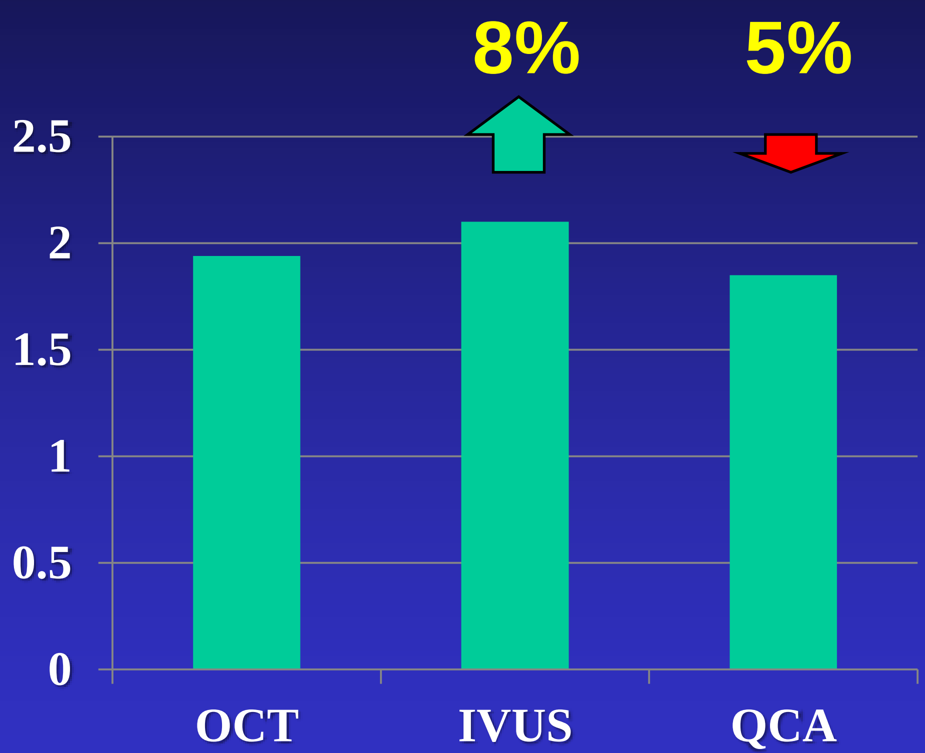
# Pre-PCI assessment, #6 90%, (MultiLink 4.0×15mm)



# Comparison of measurements among OCT, IVUS & QCA

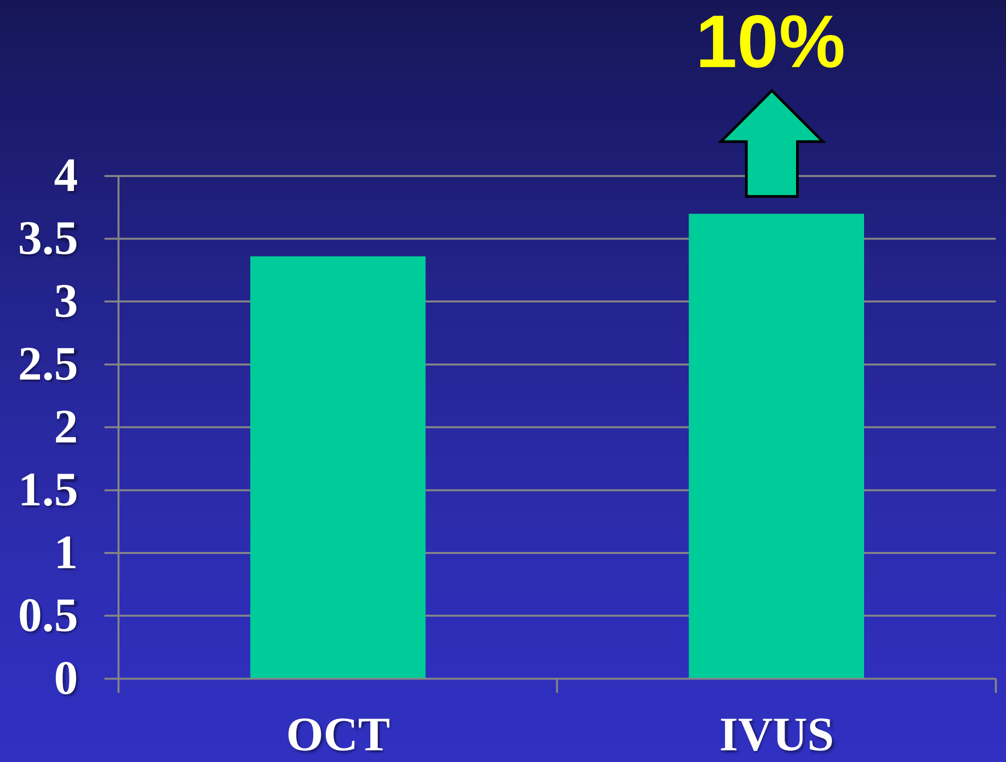
## (OPUS-CLASS study)

### MLD




| OCT | IVUS | QCA |
|---|---|---|
| 1.94± 0.70 mm | 2.10± 0.59 mm | 1.85± 0.77mm |

### MLA




| OCT | IVUS |
|---|---|
| 3.36±2.28$mm^2$ | 3.70±2.04$mm^2$ |

*Kubo T, Akasaka T, et al. JACC Cardiovasc Img. 2013;6:1095-1104*

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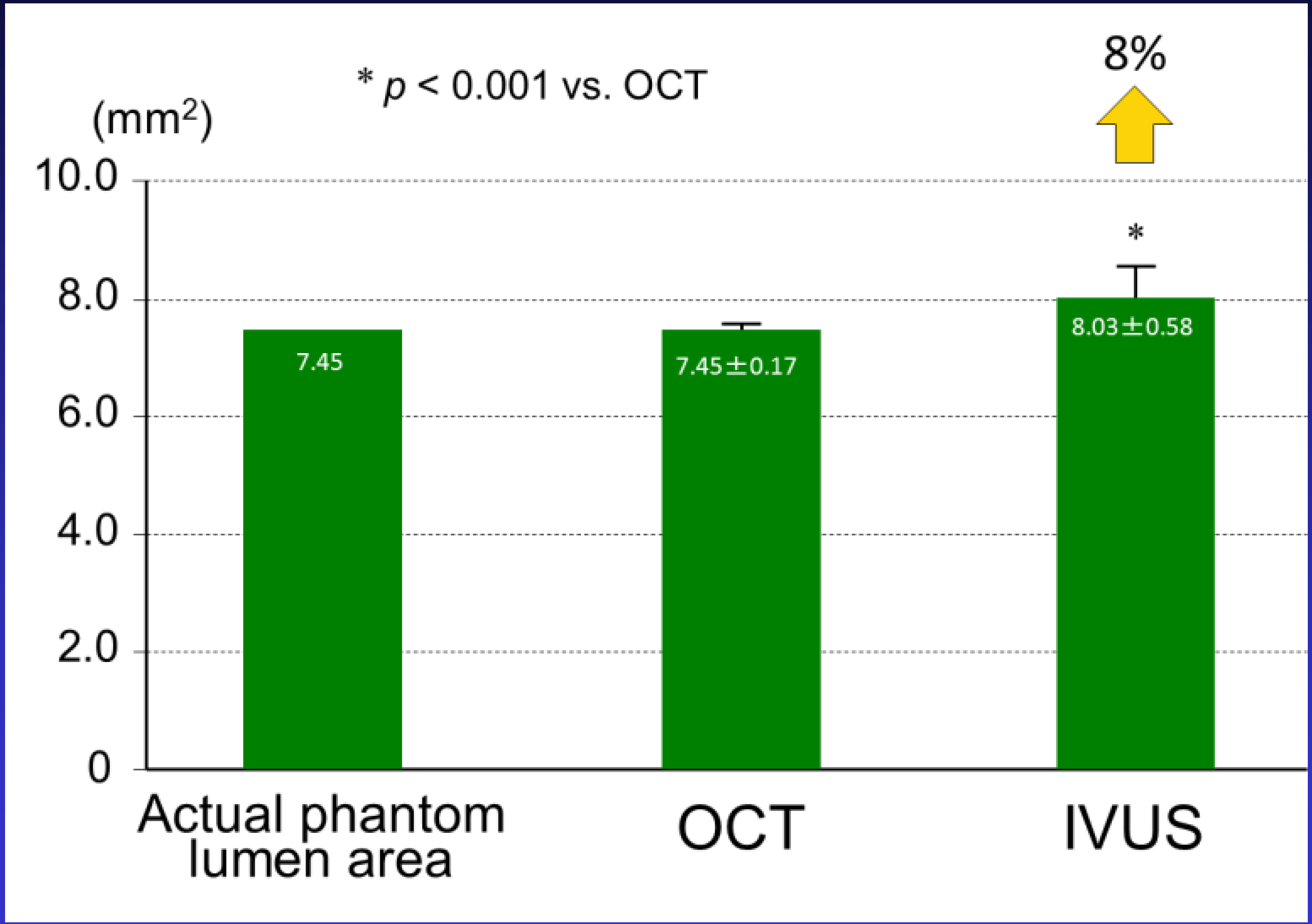
# Accuracy of the measurement: MLA

## (OPUS-CLASS study)




*Kubo T, Akasaka T, et al, JACC Cardiovasc Img. 2013;6:1095-1104*

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doi:10.1093/ehjci/jev229

# Multi-laboratory inter-institute reproducibility study of IVOCT and IVUS assessments using published consensus document definitions

Edouard Gerbaud[1], Giora Weisz[2,3], Atsushi Tanaka[1], Manabu Kashiwagi[1],
Takehisa Shimi
Melissa J. Suter
Mireille Rosenb
Akiko Maehara[2

**Aims** The aim of this study was to investigate the reproducibility of intravascular optical coherence tomography (IVOCT) assessments, including a comparison to intravascular ultrasound (IVUS). Intra-observer and inter-observer variabilities of IVOCT have been previously described, whereas inter-institute reliability in multiple laboratories has never been systematically studied.

**Methods and results** In 2 independent laboratories with intravascular imaging expertise, 100 randomized matched data sets of IVOCT and IVUS images were analysed by 4 independent observers according to published consensus document definitions. Intra-observer, inter-observer, and inter-institute variabilities of IVOCT qualitative and quantitative measurements vs. IVUS measurements were assessed. Minor inter- and intra-observer variability of both imaging techniques was observed for detailed qualitative and geometric analysis, except for inter-observer mixed plaque identification on IVUS ($\kappa = 0.70$) and for inter-observer fibrous cap thickness measurement reproducibility on IVOCT (ICC = 0.48). The magnitude of inter-institute measurement differences for IVOCT was statistically significantly less than that for IVUS concerning lumen cross-sectional area (CSA), maximum and minimum lumen diameters, stent CSA, and maximum and minimum stent diameters ($P < 0.001$, $P < 0.001$, $P < 0.001$, $P = 0.02$, $P < 0.001$, and $P = 0.01$, respectively). Minor inter-institute measurement variabilities using both techniques were also found for plaque identification.

**Conclusion** In the measurement of lumen CSA, maximum and minimum lumen diameters, stent CSA, and maximum and minimum stent diameters by analysts from two different laboratories reproducibility of IVOCT was more consistent than that of IVUS.

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# Comparison of Stent Expansion Guided by Optical Coherence Tomography Versus Intravascular Ultrasound

## The ILUMIEN II Study (Observational Study of Optical Coherence Tomography [OCT] in Patients Undergoing Fractional Flow Reserve [FFR] and Percutaneous Coronary Intervention)

Akiko Maehara, MD,*† Ori Ben-Yehuda, MD,*† Ziad Ali, MD,*† William Wijns, MD, PhD,‡ Hiram G. Bezerra, MD,§ Junya Shite, MD,|| Philippe Généreux, MD,*†¶ Melissa Nichols, MS,† Paul Jenkins, PhD,† Bernhard Witzenbichler, MD,# Gary S. Mintz, MD,† Gregg W. Stone, MD*†

ce tomography (OCT) guidance results in
(IVUS) guidance.

sis and restenosis) after stent implanta-

e minimal stent area divided by the mean
patients in the ILUMIEN (Observational
al Flow Reserve [FFR] and Percutaneous
ADAPT-DES (Assessment of Dual Anti-
platelet Therapy With Drug-Eluting Stents) study (N = 586). Stent expansion was examined in all 940 patients in a covariate-adjusted analysis as well as in 286 propensity-matched pairs (total N = 572).

**RESULTS** In the matched-pair analysis, the degree of stent expansion was not significantly different between OCT and IVUS guidance (median [first, third quartiles] = 72.8% [63.3, 81.3] vs. 70.6% [62.3, 78.8], respectively, p = 0.29). Similarly, after adjustment for baseline differences in the entire population, the degree of stent expansion was also not different between the 2 imaging modalities (p = 0.84). Although a higher prevalence of post-PCI stent malapposition, tissue protrusion, and edge dissections was detected by OCT, the rates of major malapposition, tissue protrusion, and dissections were similar after OCT- and IVUS-guided stenting.

**CONCLUSIONS** In the present post-hoc analysis of 2 prospective studies, OCT and IVUS guidance resulted in a comparable degree of stent expansion. Randomized trials are warranted to compare the outcomes of OCT- and IVUS-guided coronary stent implantation. (J Am Coll Cardiol Intv 2015;8:1704–14) © 2015 by the American College of Cardiology Foundation.

# Agenda

- How to obtain FD-OCT image
- **How to select stent size & length**
- How to treat stent under-expansion
- How to decide stent apposition
- How to manage other complication
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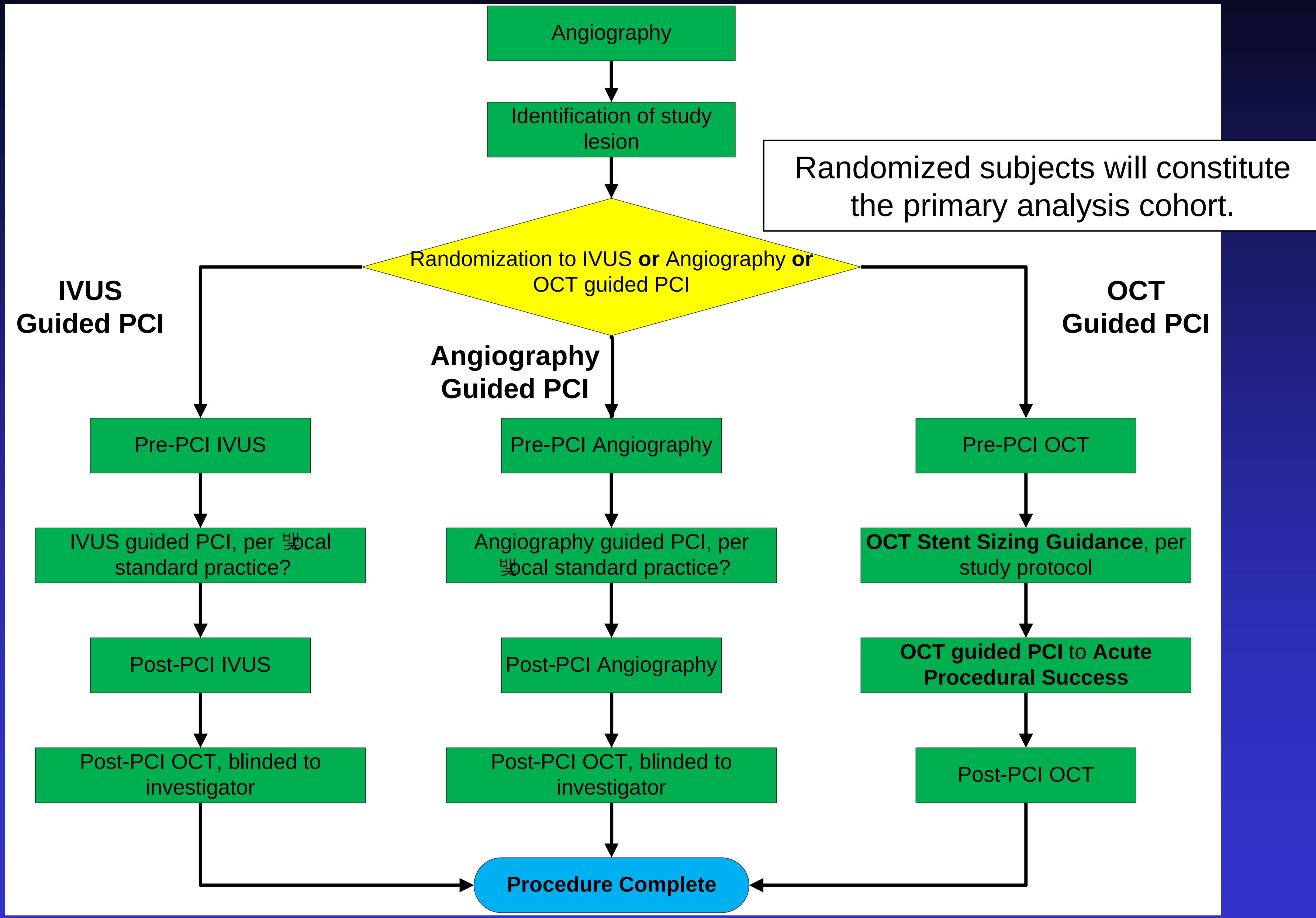
# ILUMIEN III : OPTIMIZE PCI (Study Protocol)

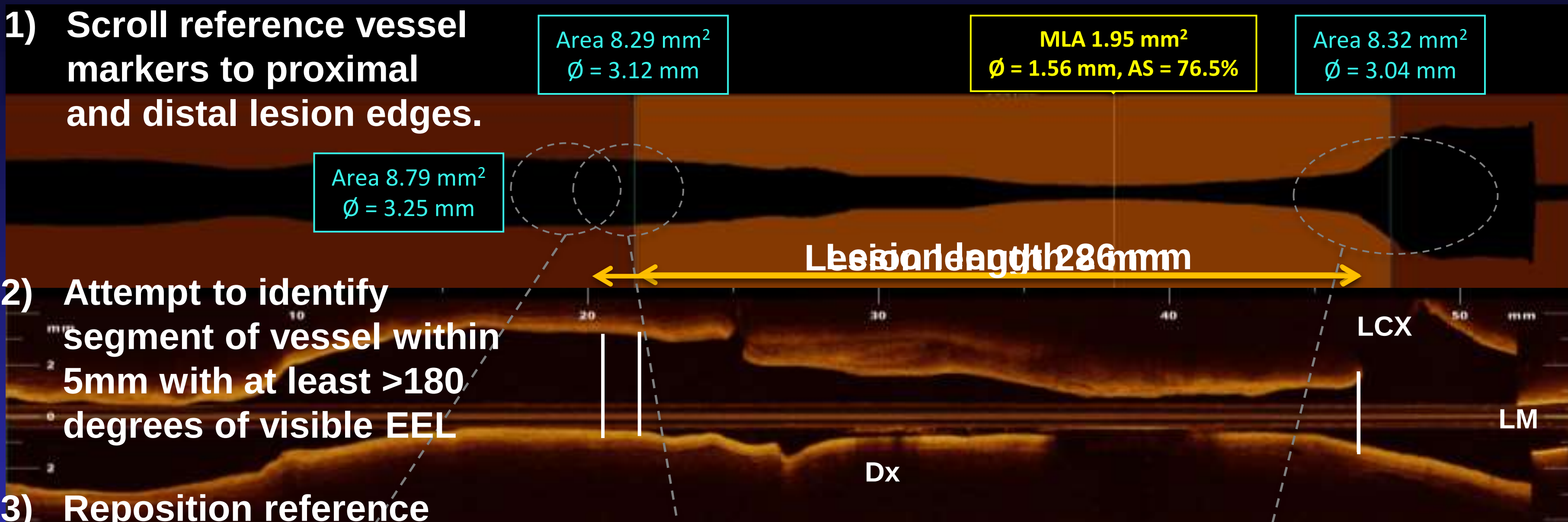


# How to identify reference segments; stent length

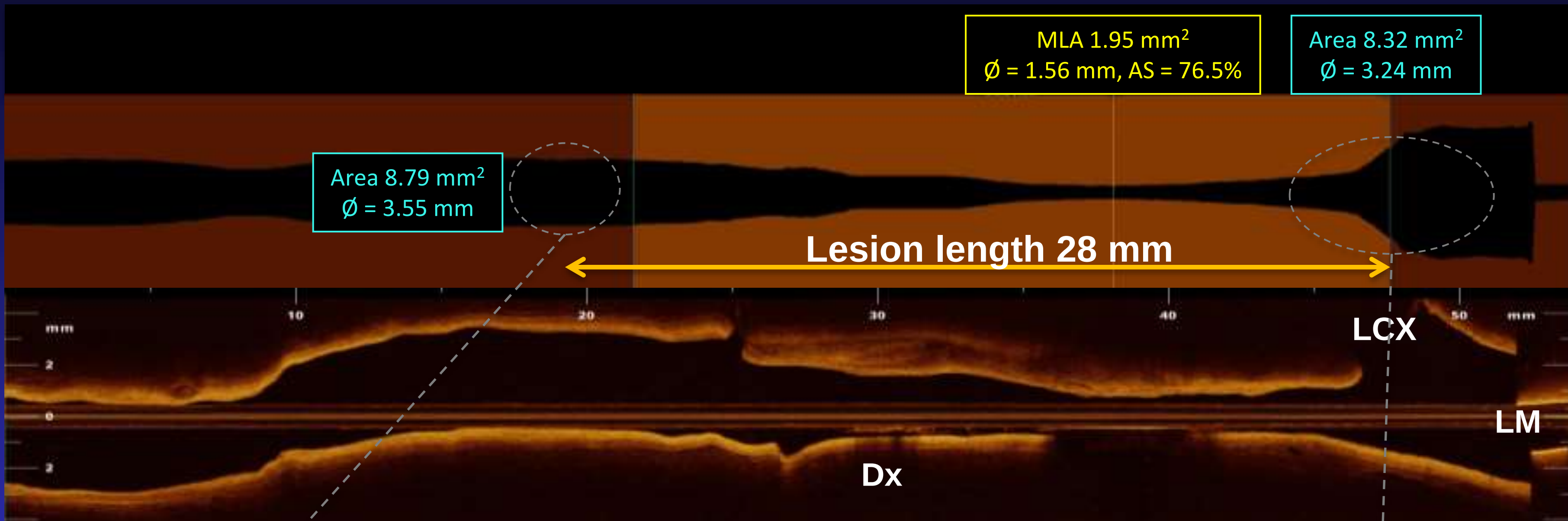
1) Scroll reference vessel markers to proximal and distal lesion edges.

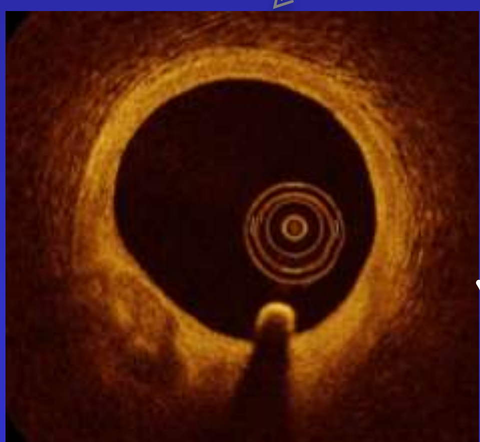
2) Attempt to identify segment of vessel within 5mm with at least >180 degrees of visible EEL

3) Reposition reference scroll marker accordingly



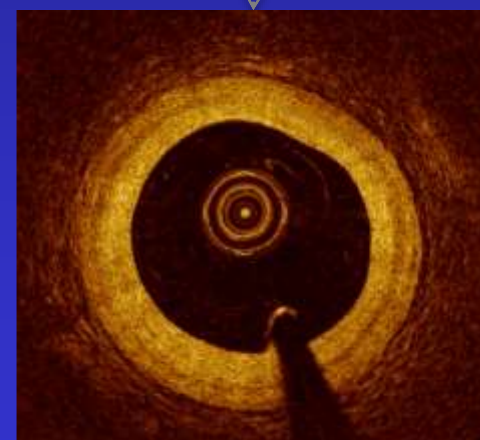

# How to identify the EEL; stent diameter



**Increasingly aggressive**

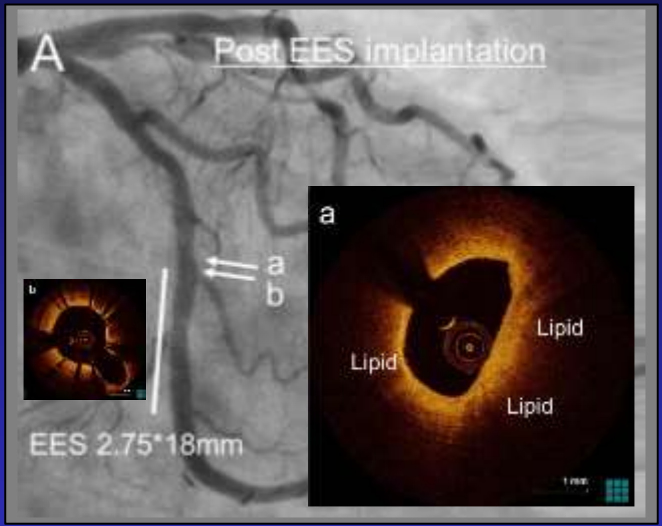
- Largest reference lumen (prox or dist)
- Mid-wall
- Media-to-media (typically discounted)



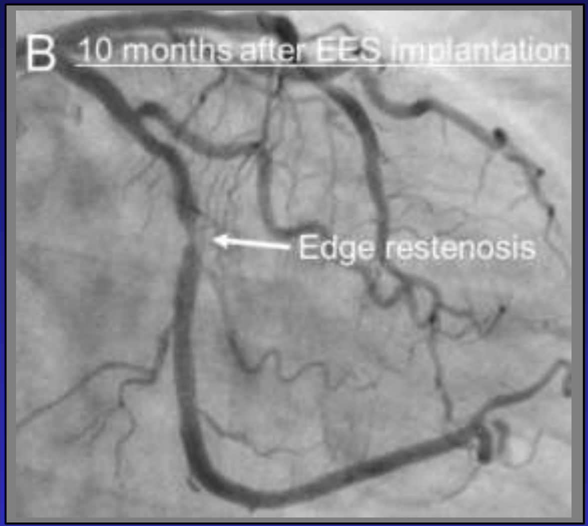
# Precursor lesion of stent edge restenosis

**In 744 stent (EES) edge segments, OCT was used to evaluate morphological characteristics of the coronary plaques that developed stent edge restenosis.**

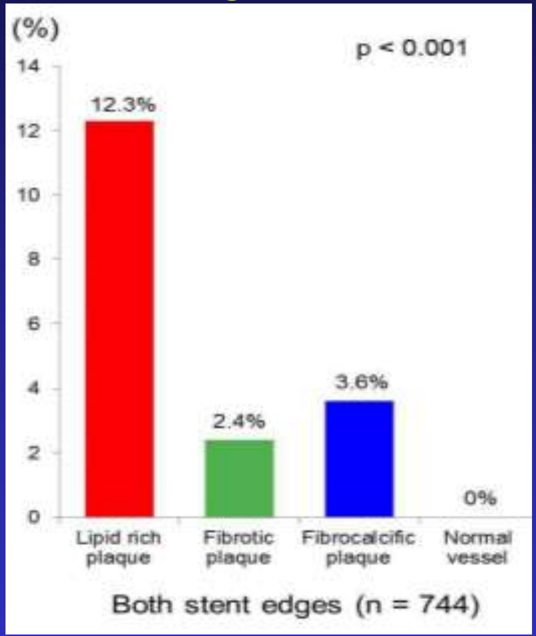
**Post-stenting**




**10 months follow-up**




**Stent edge restenosis**




**(A) Immediately after EES implantation, OCT images showed lipid rich plaque at the proximal stent edge (a, b).**
**(B) At 10-month follow-up, angiography demonstrated stent edge restenosis at the proximal edge of the stent.**

**Conclusion: Lipidic plaque in the stent edge segments at post-PCI was a predictor of late stent edge restenosis.**

Ino Y, Kubo T, Akasaka T, et al. submitting

*Wakayama Medical University*

# ILUMIEN III: Stent sizing

**Pre-PCI OCT**

↓

**Can the EEL be identified at both proximal and distal reference segments**

**Yes** ↙ ↘ **No**

**Yes:** Reference stent diameter decided by OCT measurement of smallest mean EEL to EEL diameter at reference site

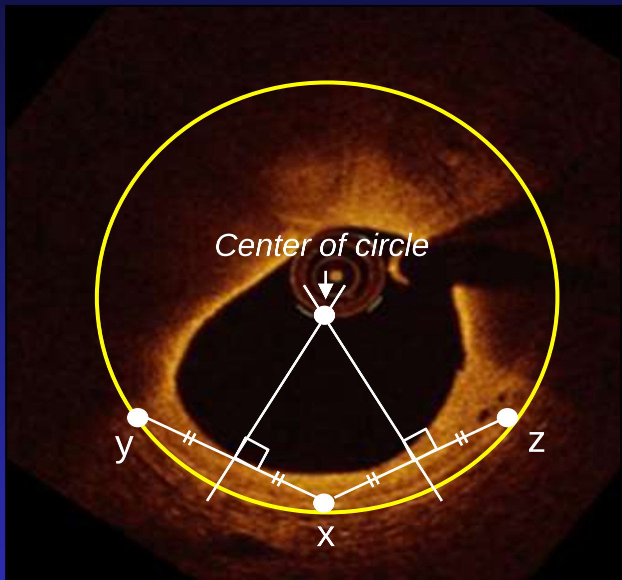
**No:** Reference stent diameter decided by OCT automation based on smallest mean lumen diameter at reference site

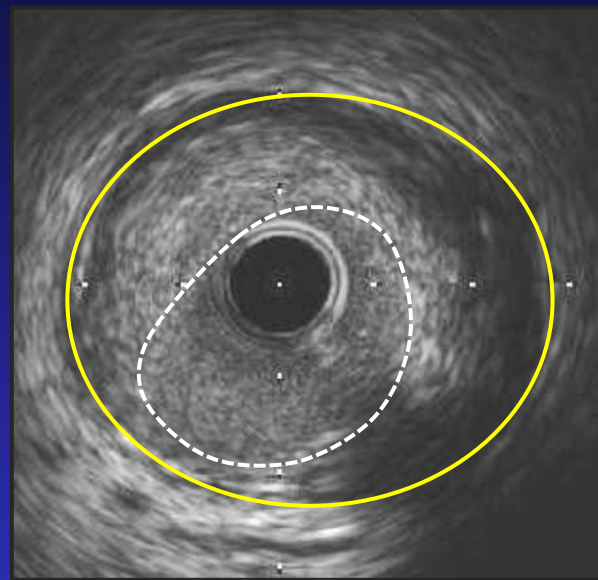
↓

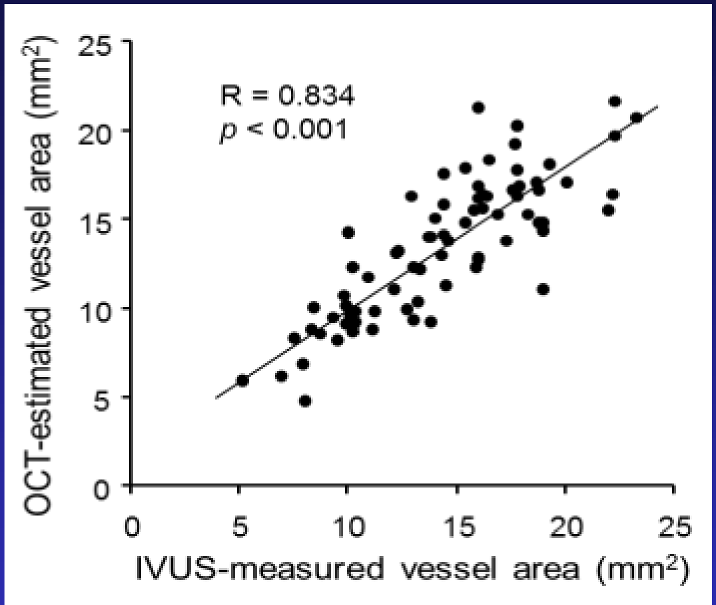
**Reference stent length decided by OCT Automation**

# Vessel circumference approximation in OCT

**Feasibility of approximating algorithm of vessel circumference in OCT were evaluated in 80 coronary artery segments.**






**Three points (x, y, z) are placed on the visible circular arc. The central point (x) is connected with the other two points (y and z) by straight lines. Through the mid-point of each straight line, perpendicular line is drawn. Intersection of the two perpendicular lines is assumed to be the center of the circle. This makes circular approximation.**

**Conclusion: By approximating algorithm of vessel circumference, OCT can estimate vessel area even in coronary arteries with lipidic plaque.**

*Kubo T, Akasaka T et al, Circ J 2015:79;600-606*

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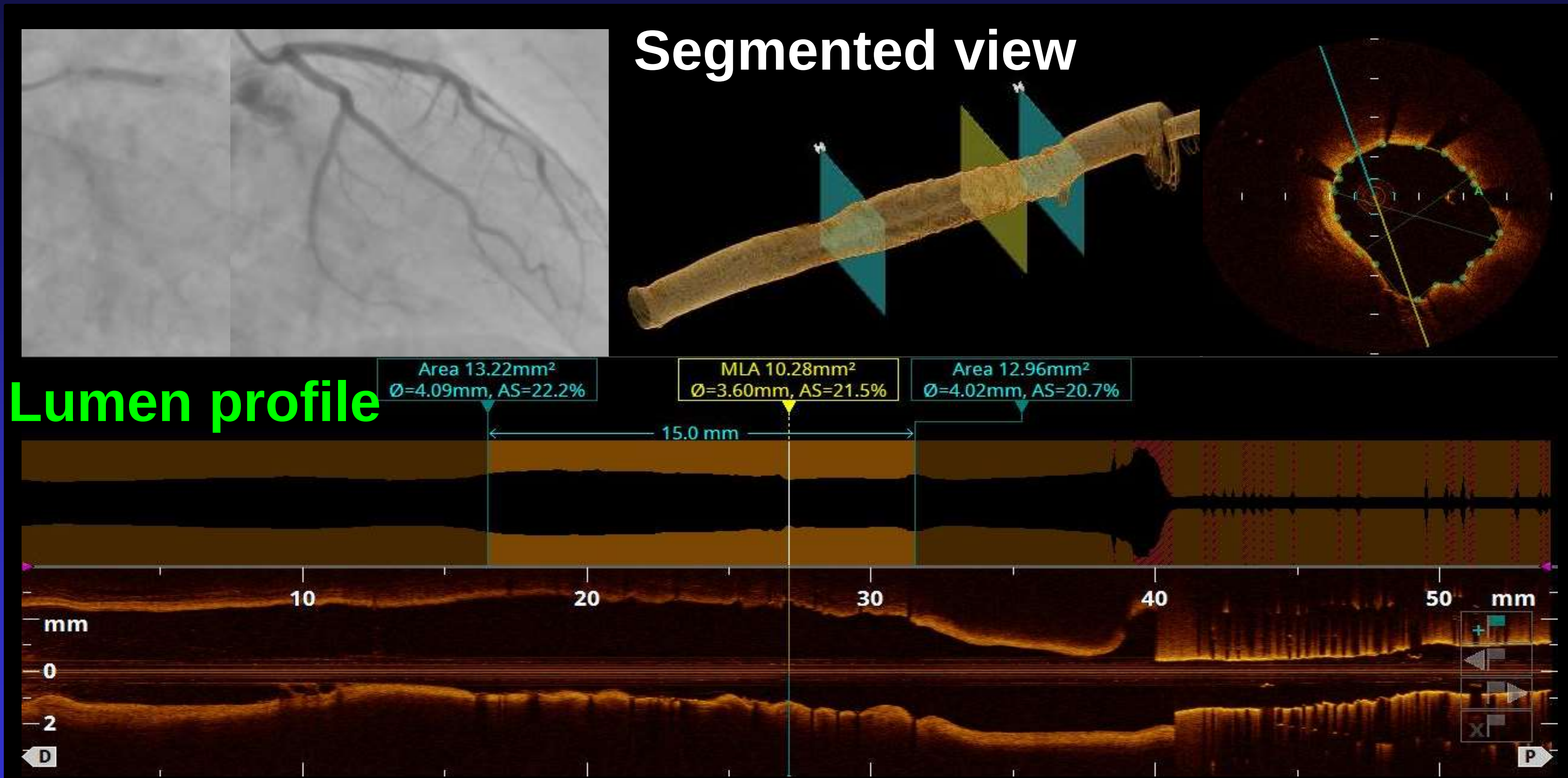
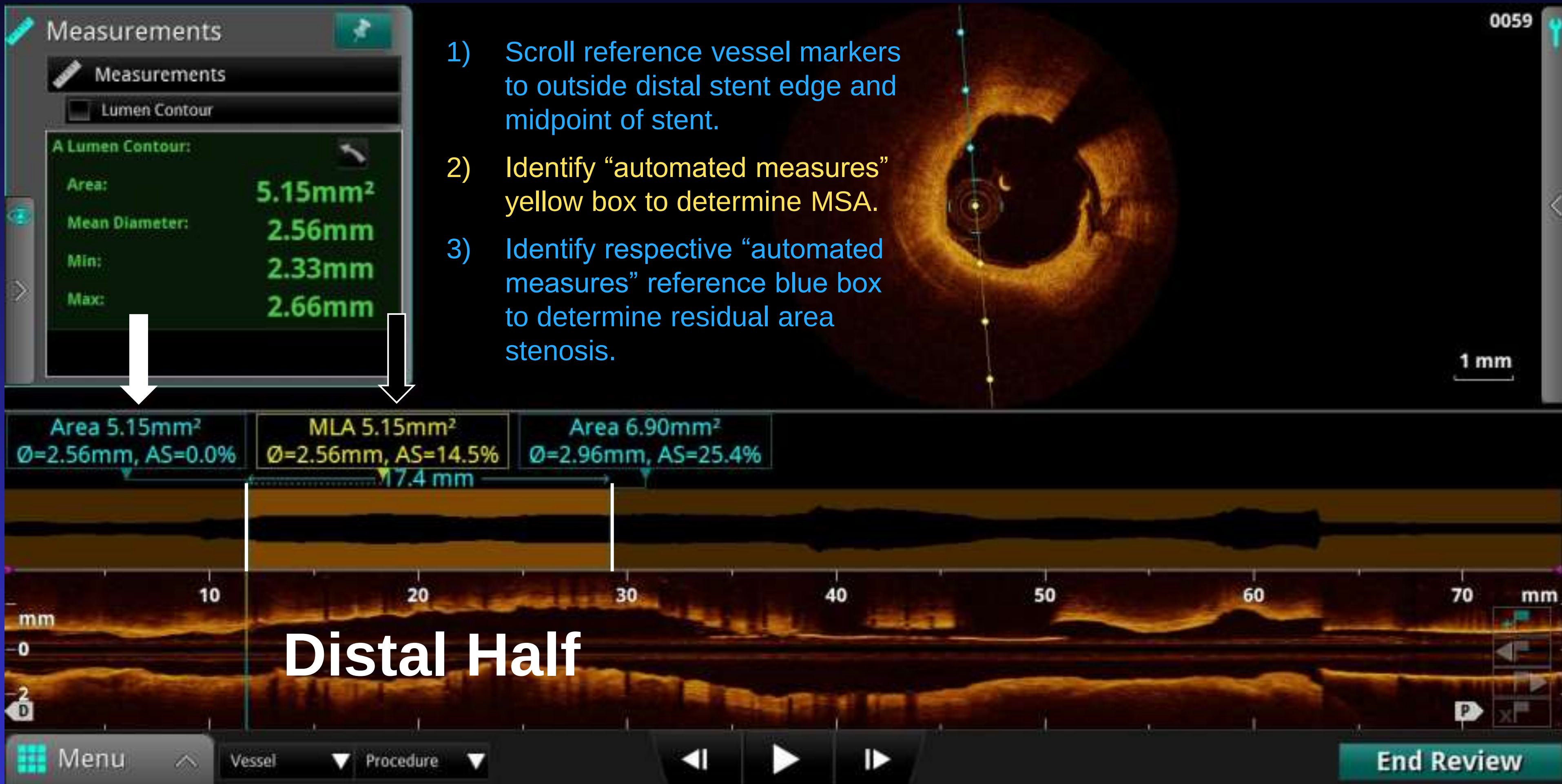
# Post-PCI assessment, #6 90%, (MultiLink 4.0×15mm)



# DETERMINE EXPANSION/MSA - DISTAL




95% of distal reference lumen area

90% of distal reference lumen area

**Distal MSA meets ideal criteria**

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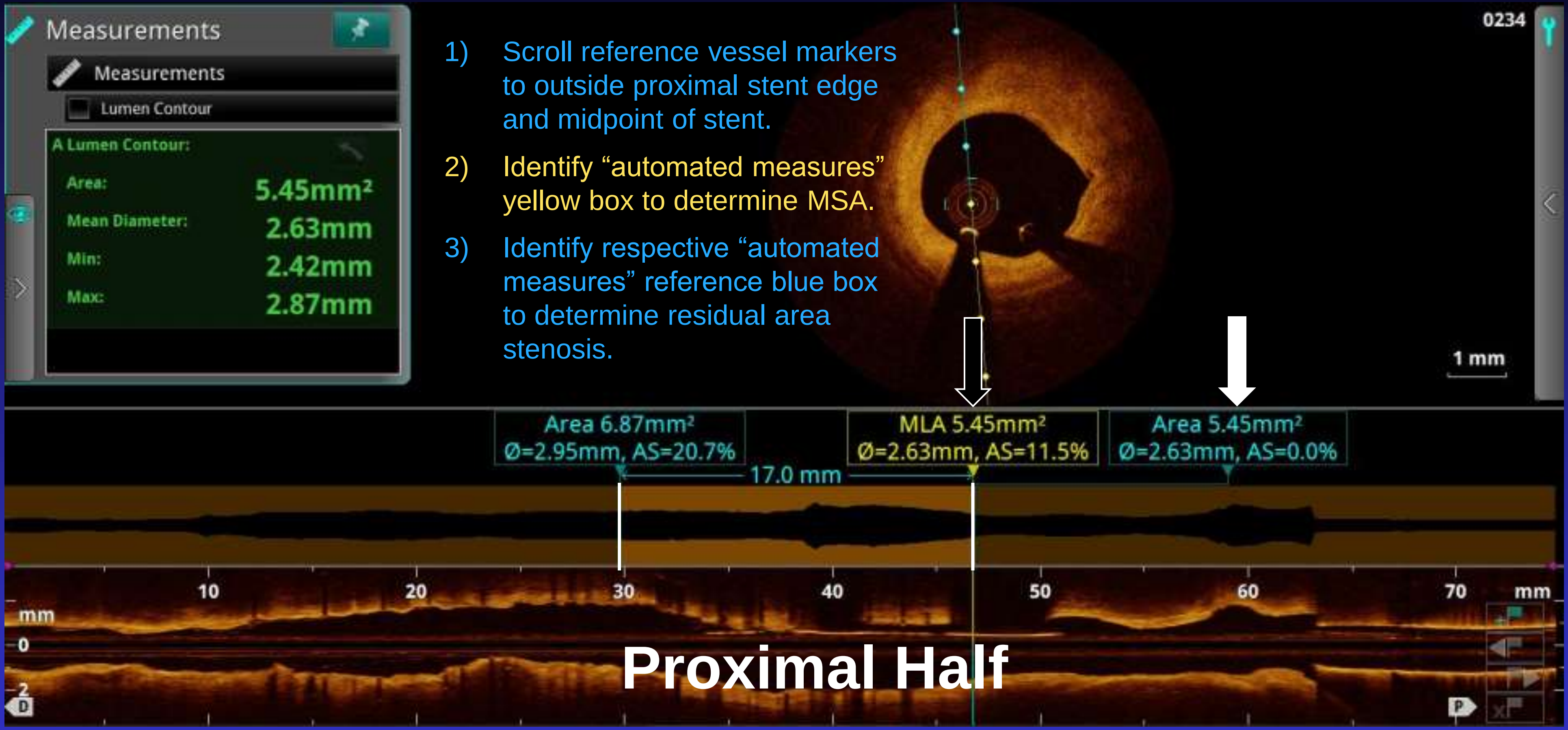
# DETERMINE EXPANSION/MSA - PROXIMAL




1) Scroll reference vessel markers to outside proximal stent edge and midpoint of stent.
2) Identify "automated measures" yellow box to determine MSA.
3) Identify respective "automated measures" reference blue box to determine residual area stenosis.

**95% of proximal reference lumen area**
**90% of proximal reference lumen area**

**Proximal MSA meets ideal criteria**

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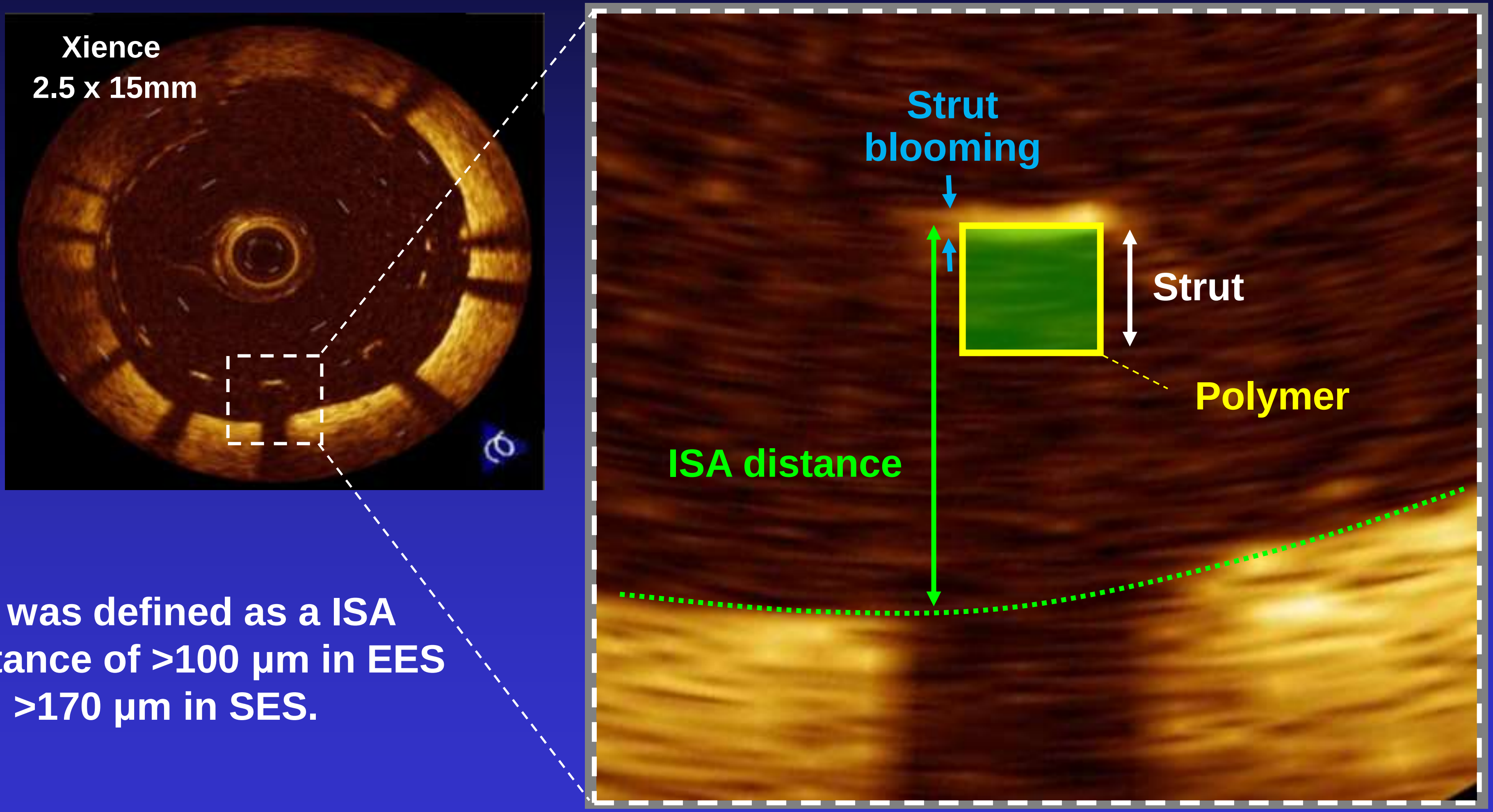
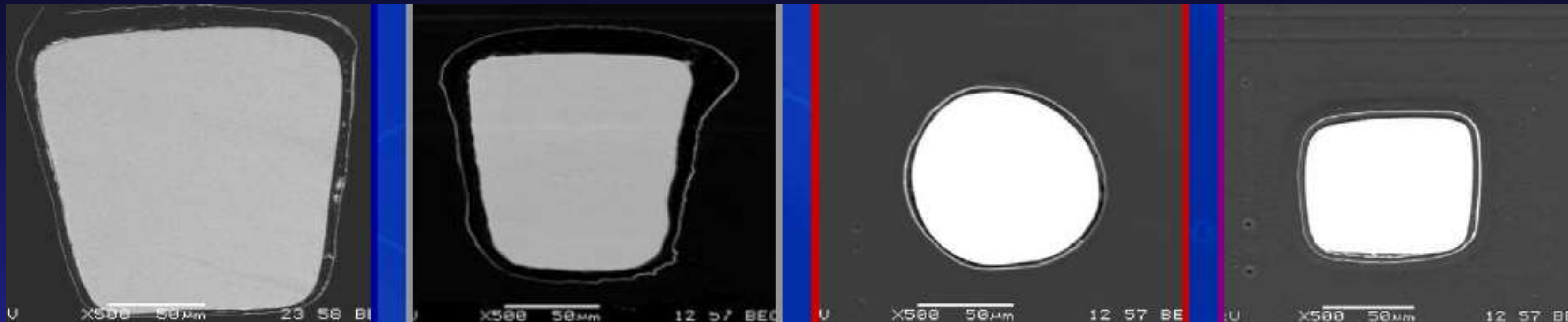
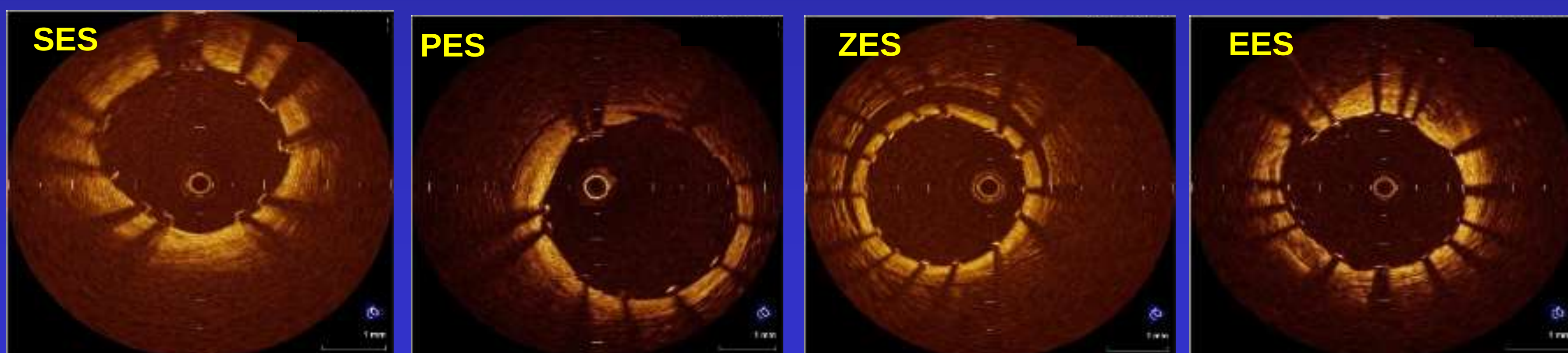
# Definition of incomplete stent appostion (ISA)




**ISA was defined as a ISA distance of >100 μm in EES and >170 μm in SES.**

| | SES | PES | ZES | EES |
|---|---|---|---|---|
| |  | | | |
| Strut thickness | 140 | 132 | 91 | 81 (μm) |
| Polymer thickness | 12.6 | 16.0 | 5.3 | 7.6 |
| Total | 165.2 | 170 | 100.6 | 96.2 |

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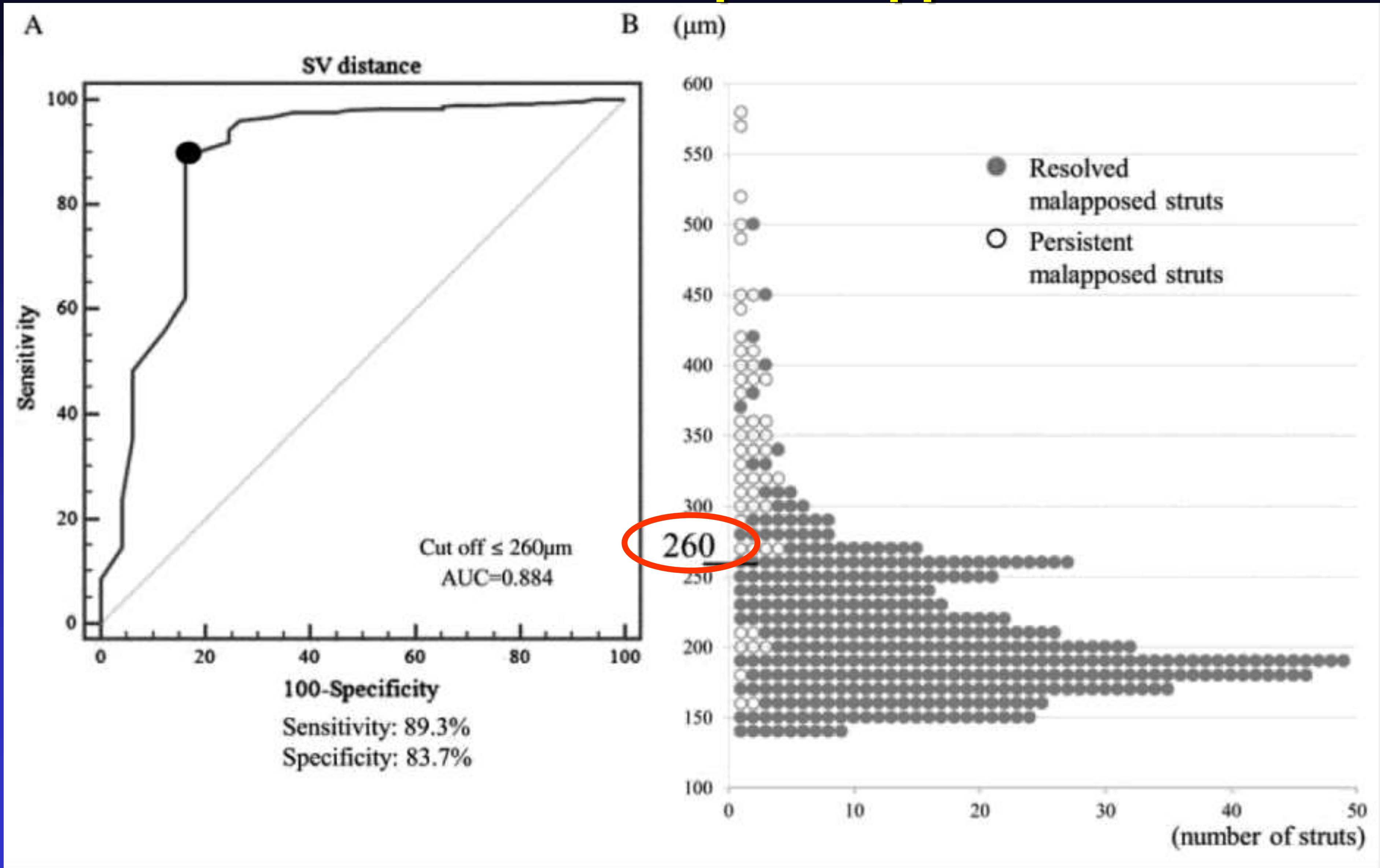
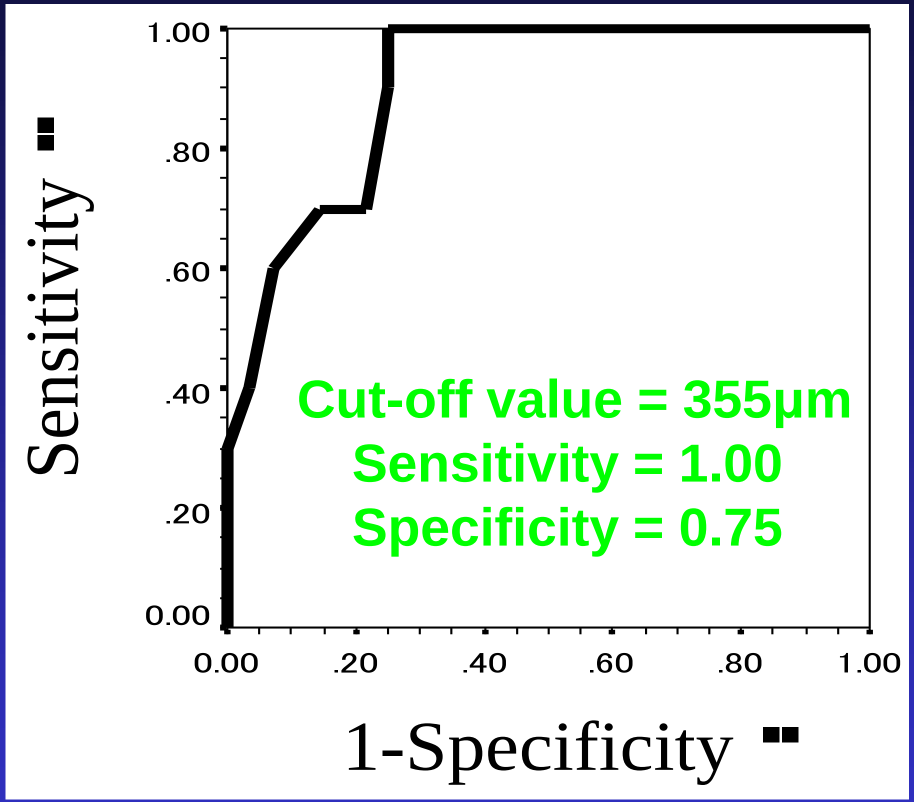
# Persistent incomplete apposition




Kawamori H. et al, Eur Heart J CV Imaging 2013

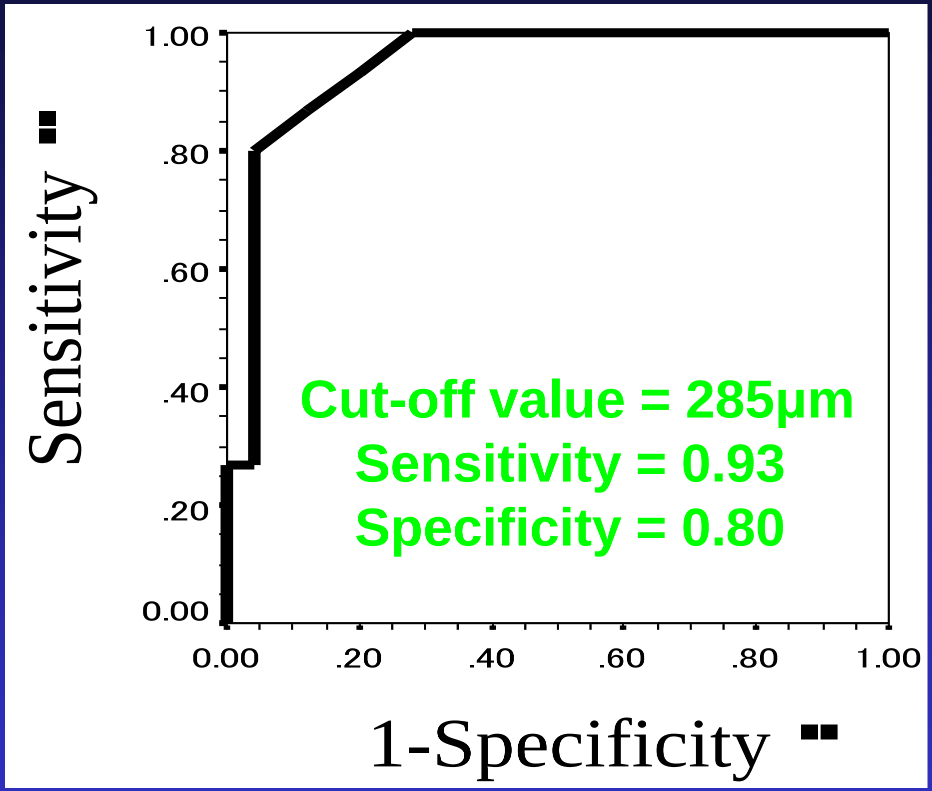
# ROC curve analysis of maximum ISA distance for predicting persistent ISA (Subanalysis of RESET study)

## *EES*




ROC curve analysis identified a maximum ISA distance of EES > 355µm with as separating persistent from resolved ISA (sensitivity 100%, specificity 75%, area under the curve = 0.905; 95%CI, 0.812 to 0.999).

## *SES*




ROC curve analysis identified a maximum ISA distance of SES > 285µm with as separating persistent from resolved ISA (sensitivity 93%, specificity 80%, area under the curve = 0.947; 95%CI, 0.878 to 1.015).

Shimamura K. et al, Eur Heart J CV Imaging 2015;16:23-28

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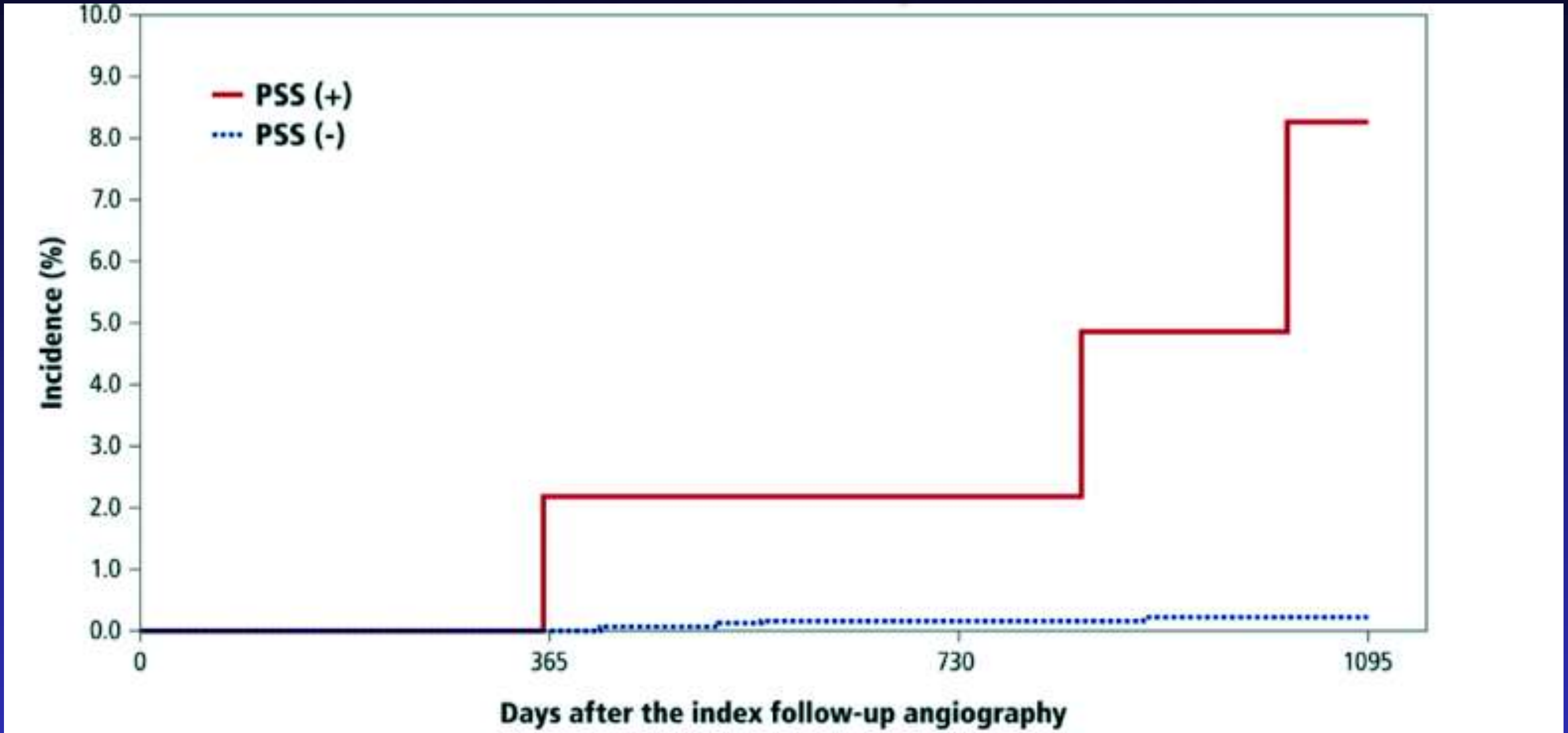
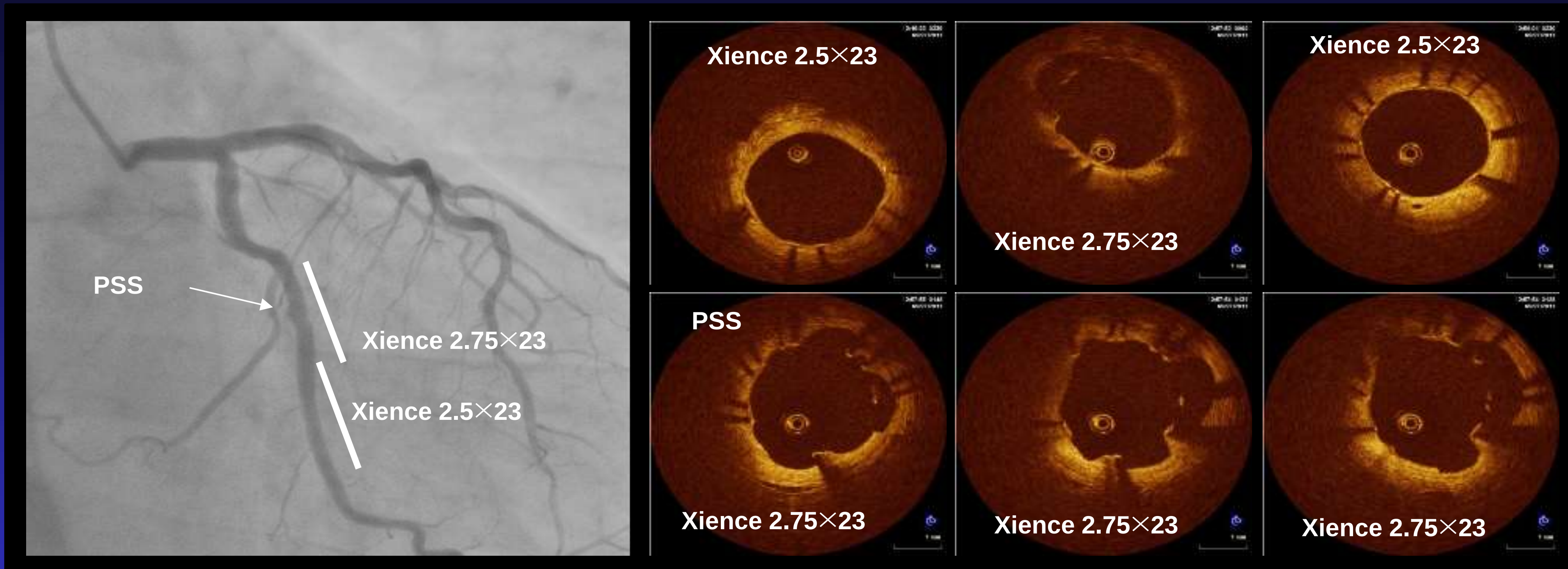
# Cumulative incidence of ST after the index follow-up CAG

**Imai M et al. Circulation 2011;123:2382-2391**




| Days | | 0 | 365 | 730 | 1095 |
|---|---|---|---|---|---|
| PSS (+) | N of lesions at risk | 51 | 46 | 40 | 26 |
| | N of lesions with events | 0 | 1 | 1 | 3 |
| | Cumulative incidence | 0% | 2.1% | 2.1% | 8.2% |
| PSS (-) | N of lesions at risk | 2761 | 2532 | 1847 | 580 |
| | N of lesions with events | 0 | 0 | 3 | 4 |
| | Cumulative incidence | 0% | 0% | 0.13% | 0.2% |

# PSS, #13 CTO (2010/10/26)




**PSS by CAG is demonstrated as mal-apposition by OCT.**

**Persistent incomplete apposition & late acquired mal-apposition should be considered as the cause of mal-apposition in late phase.**

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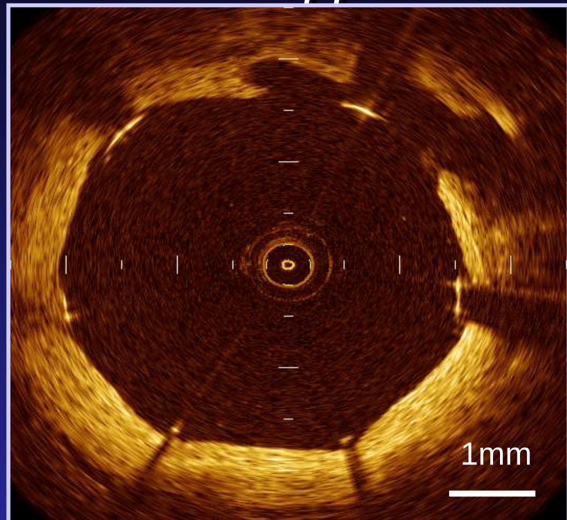
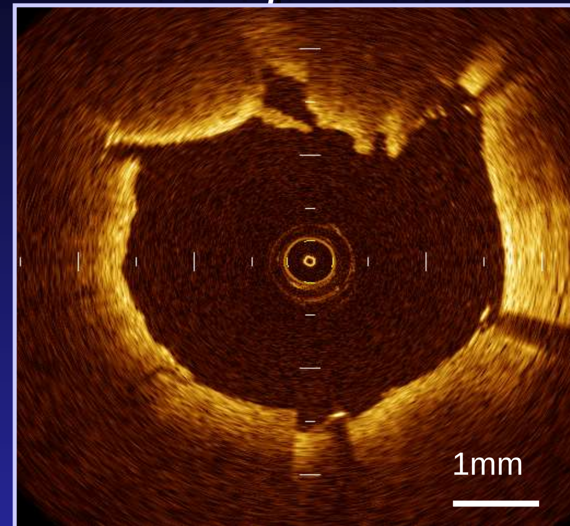
# Inadequate lesion morphologies after stenting

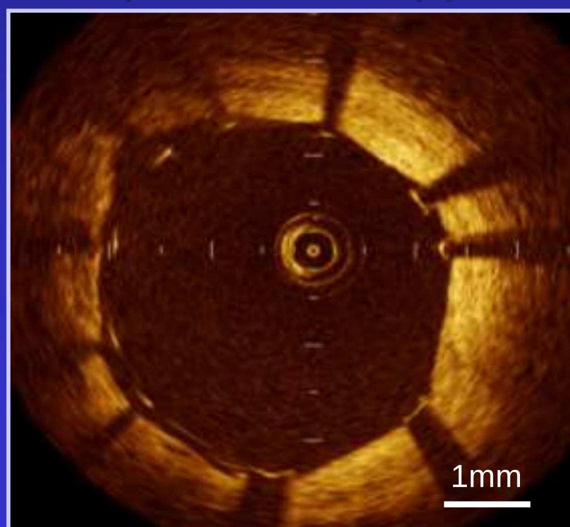
*Stent malapposition*



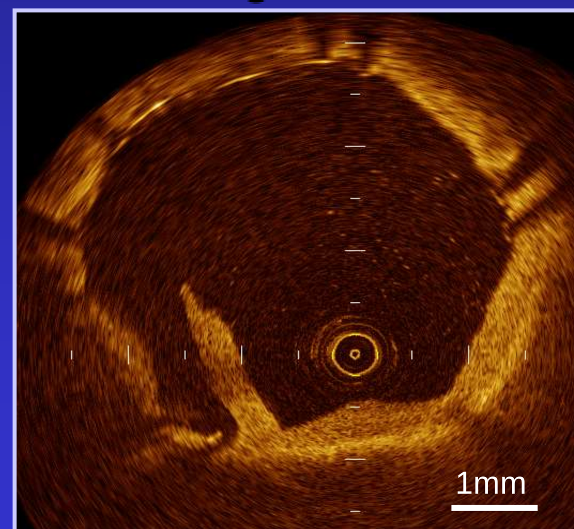

*Tissue protrusion*




*Incomplete stent apposition*



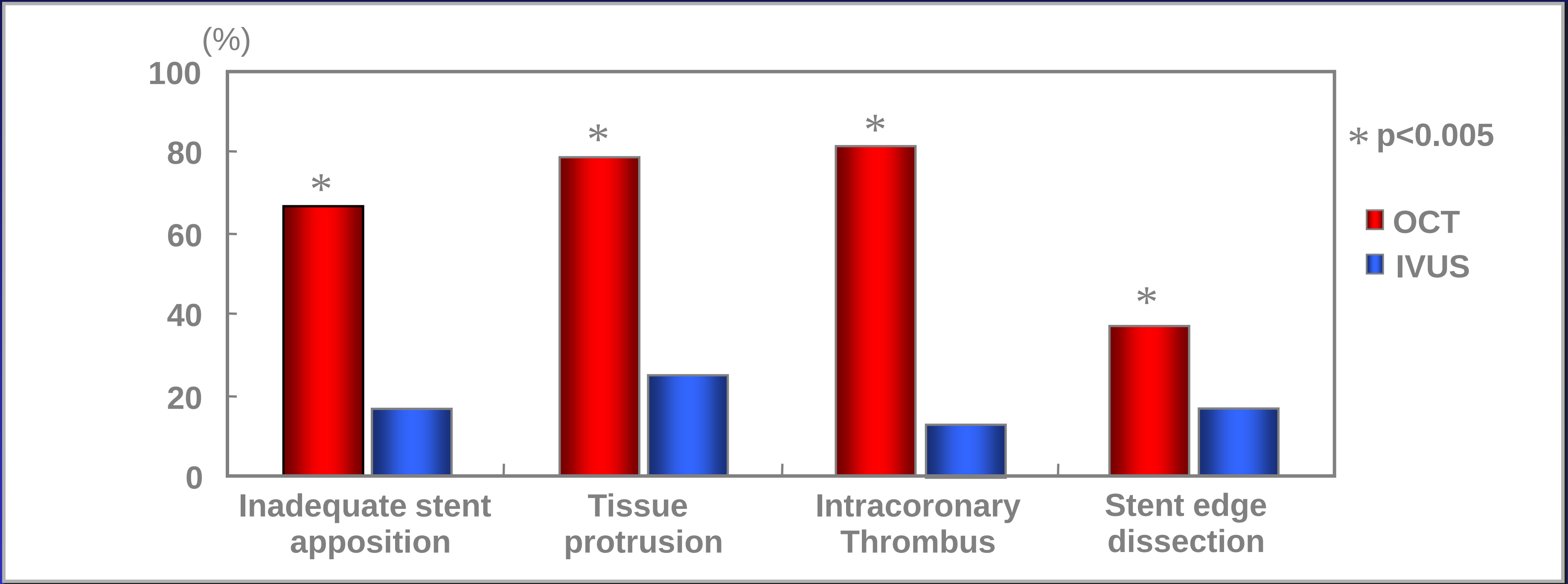

*Stent edge dissection*




***Kubo T, et al, JACC Img. 2008 1:475–84***

# Comparison of the ability for monitoring stent deployment between OCT and IVUS

**55 patients were examined by OCT and IVUS to evaluate lesion morphologies after stent implantation.**




**Conclusion: OCT can provide more detailed morphological information after stenting than IVUS.**

*Kubo T, et al, JACC Img. 2008 1:475–84*

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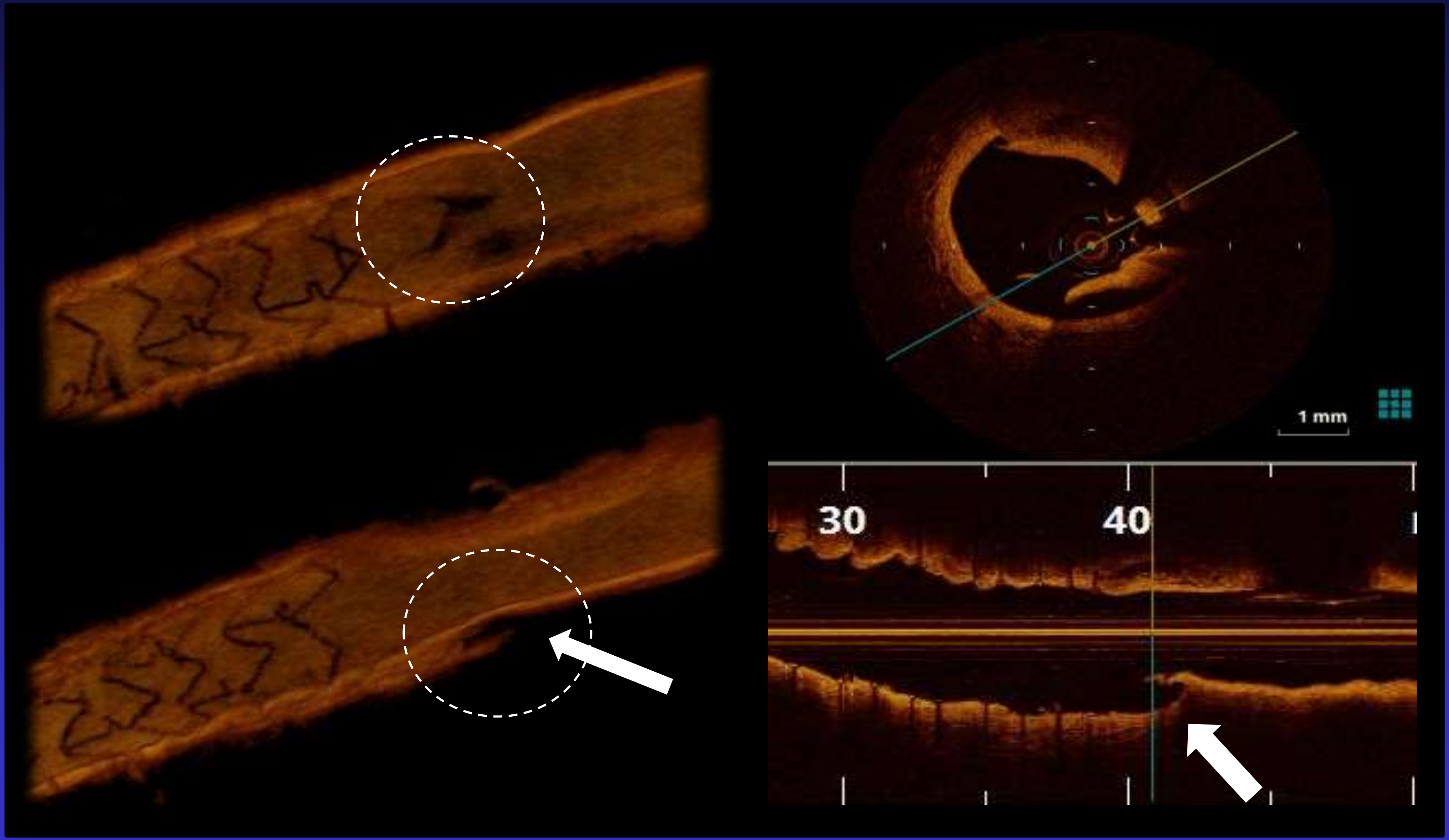
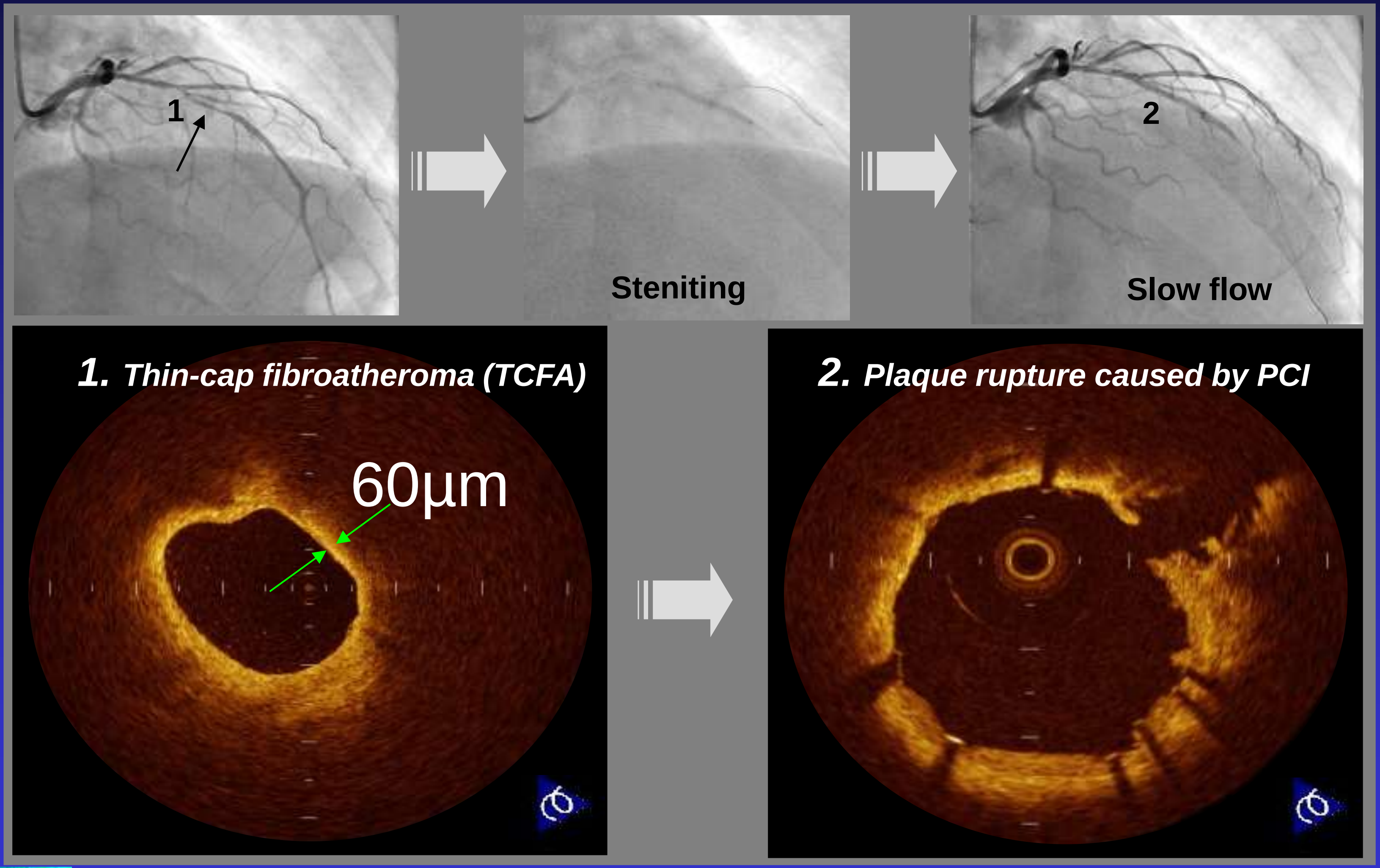
# SAP, #6 99% Xience 2.75x18, Dissection



# Prediction of angiographic slow flow




A 73-year-old male underwent PCI for the treatment of mid-LAD lesion (arrow).

In OCT image at pre-intervention, the culprit lesion presented lipid-rich plaque with thin-fibrous cap (TCFA).

After stenting, angiogram showed slow flow, and OCT disclosed plaque rupture behind stent.

TCFA is easy to be ruptured by PCI and has a high risk for coronary slow flow.

# Prediction of No-reflow Post-PCI

| | No-reflow n=14 | Reflow n=69 | *p*-Value |
|---|---|---|---|
| Plaque rupture, % | 71 | 48 | 0.053 |
| Thrombus, % | 79 | 80 | 0.567 |
| TCFA, % | 50 | 16 | 0.034 |
| Lipid-arc, degree* | 166 | 44 | 0.012 |

*Tanaka A, Kubo T, Akasaka T et al. Eur Heart J 2009;30:1348-55*

# Prediction of Microvascular Obstruction

| | OR | 95% CI | *P* |
|---|---|---|---|
| ST-elevation myocardial infarction | 48.05 | 2.85–809.11 | 0.007 |
| TCFA at culprit | 5.43 | 1.27–23.32 | 0.023 |
| Thrombectomy | 0.014 | 0.001–0.35 | 0.009 |
| Diameter stenosis, % | 1.1 | 1.02–1.19 | 0.011 |

*Ozaki, Kubo, Akasaka et al. Circulation Img 2011;4:620-7*

**There is not enough data demonstrating the efficacy of distal protection during PCI.**

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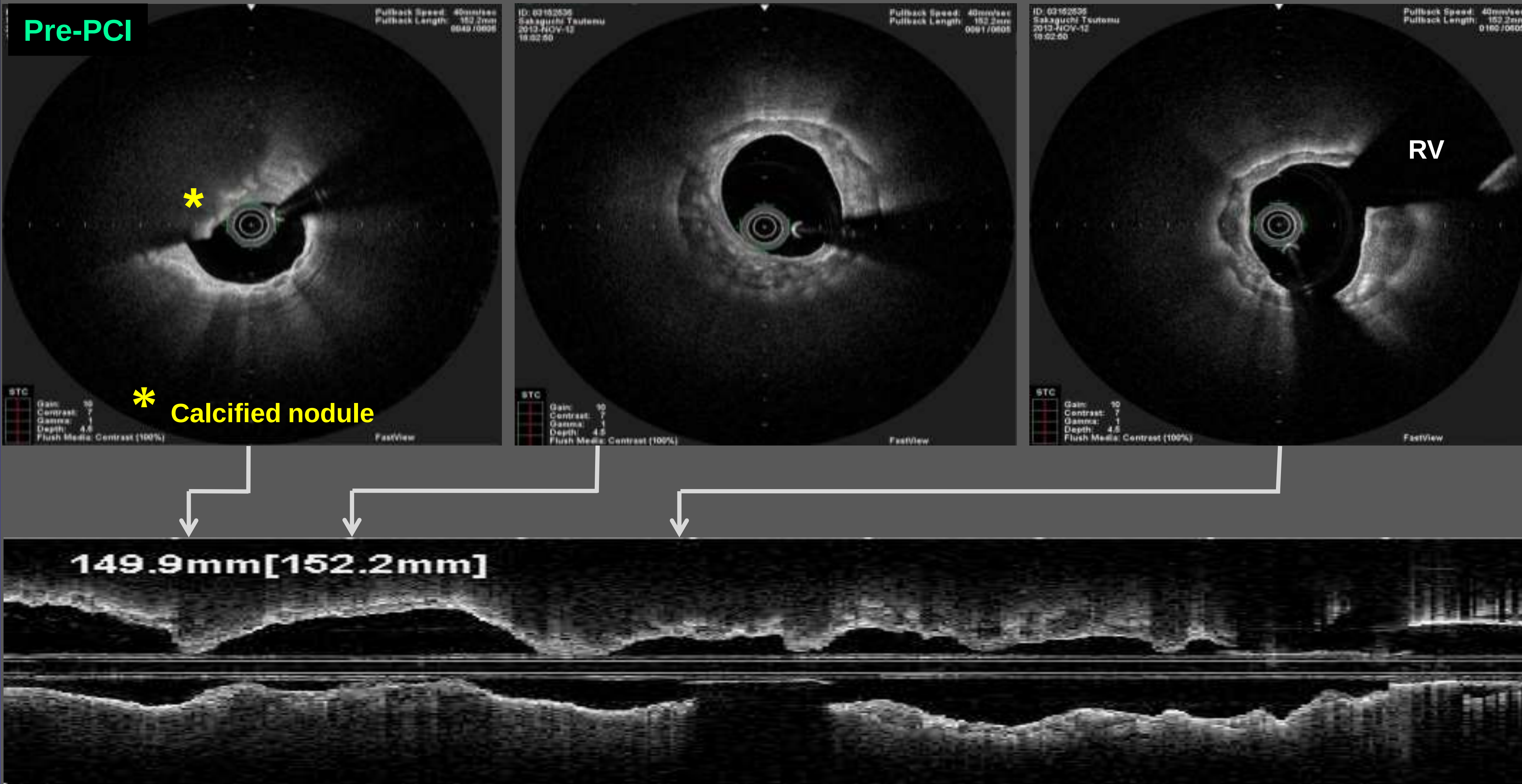
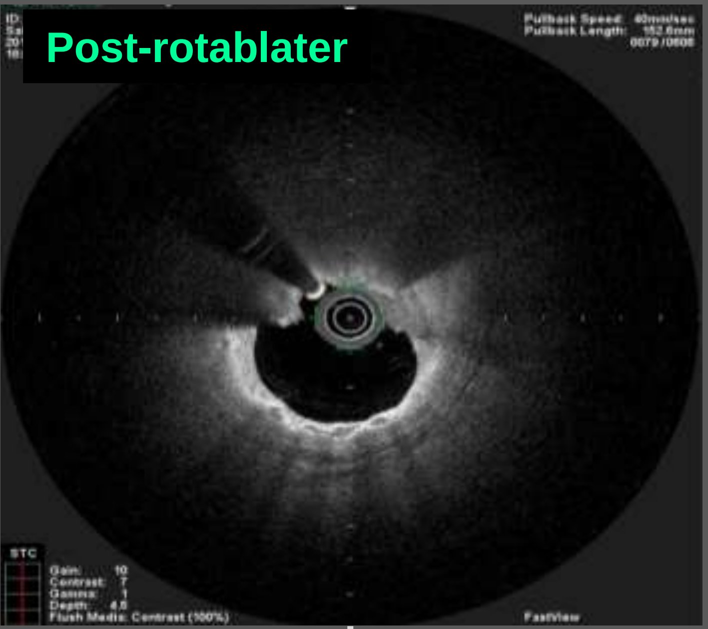
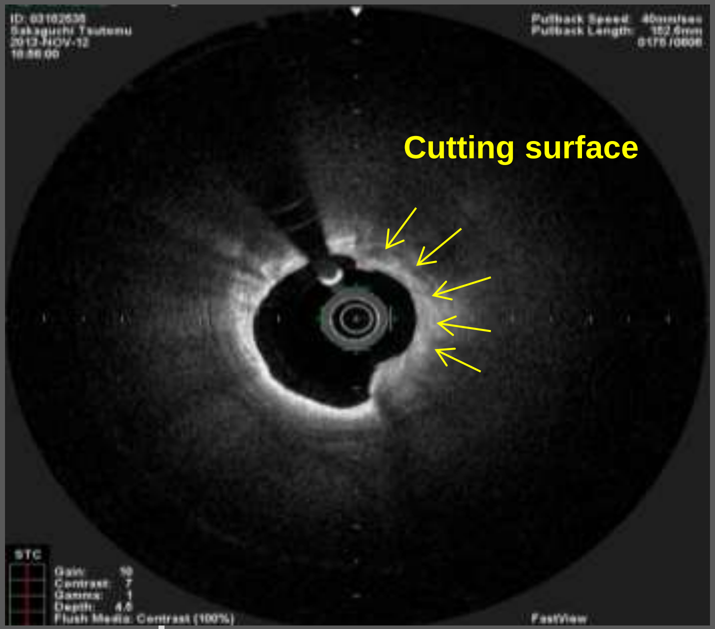
# Pre-PCI FD-OCT (Markedly calcified lesion)

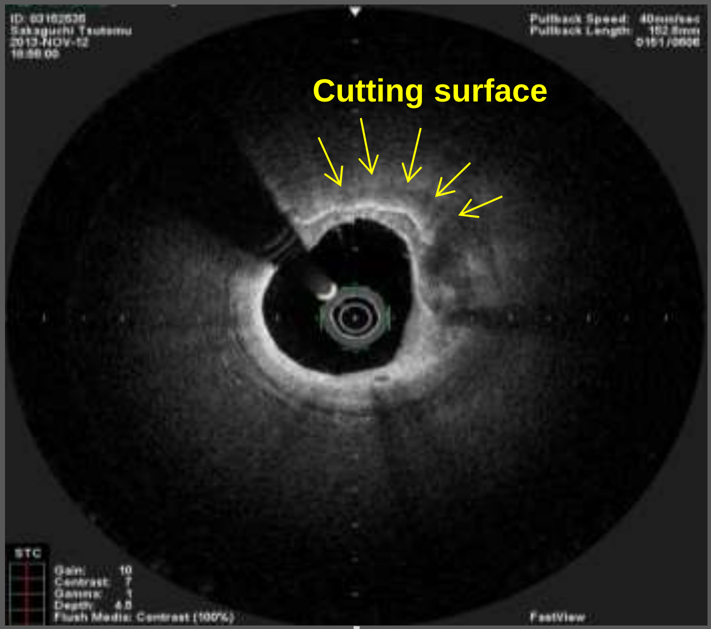
*Minimum lumen area site* | *Severe calcification* | *Severe calcification*

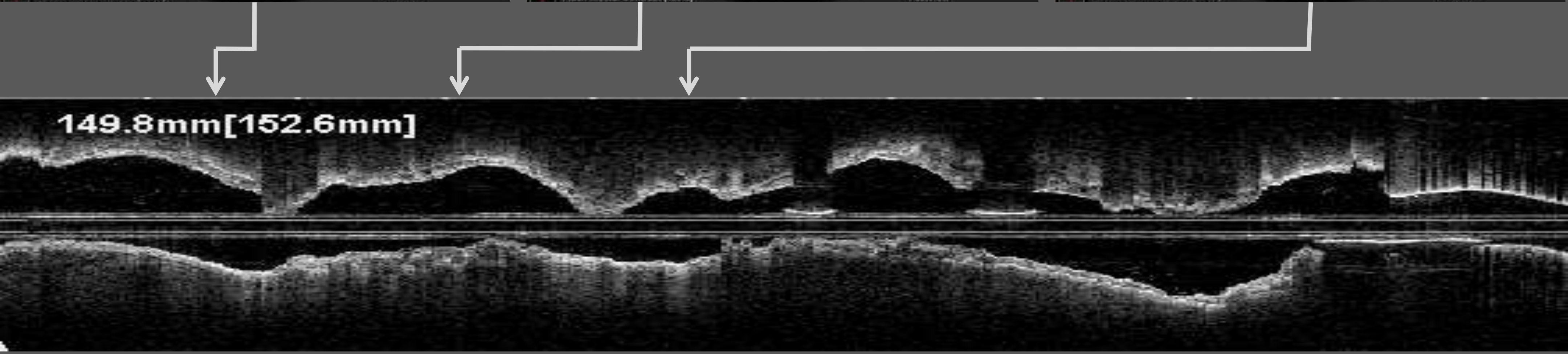


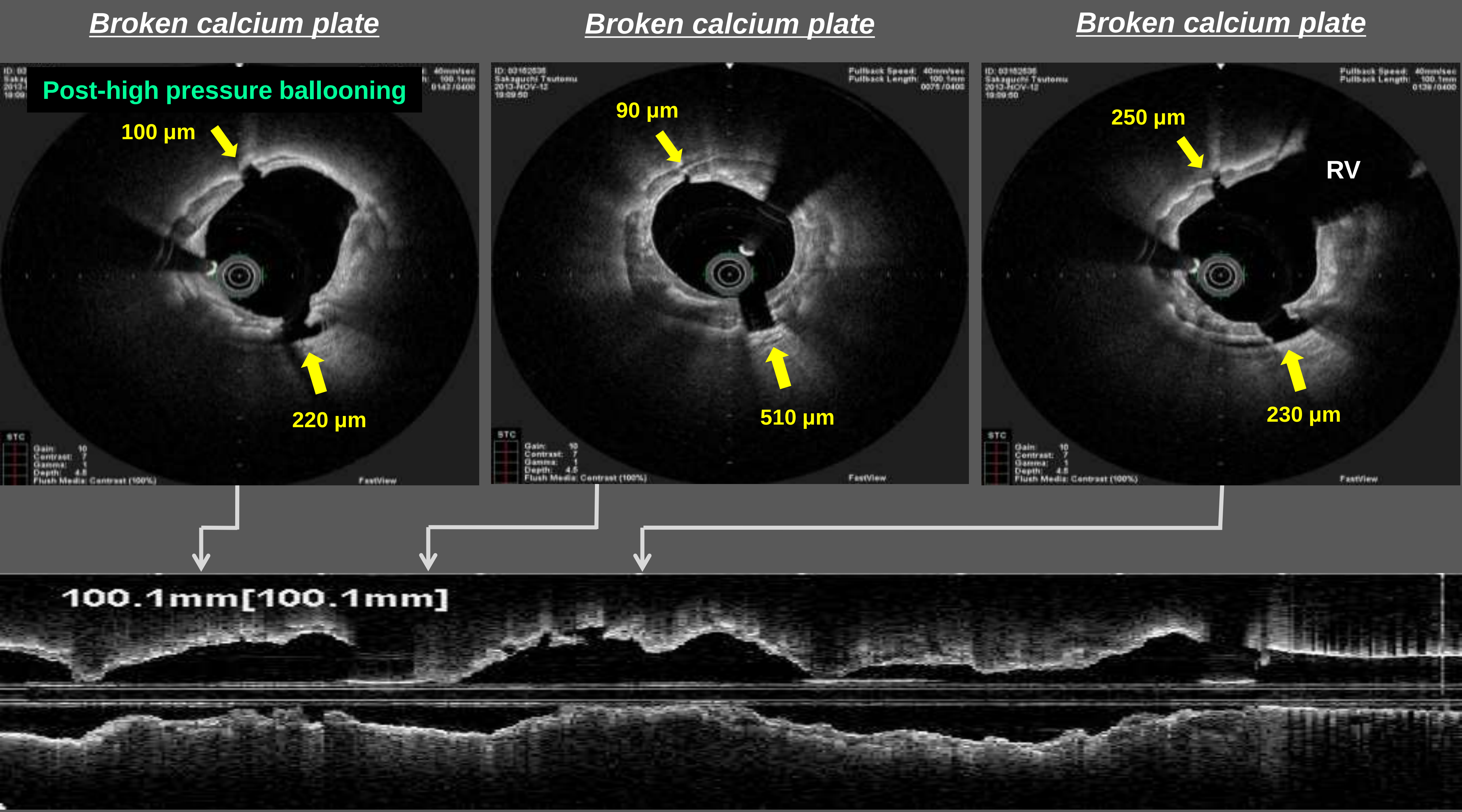
***Minimum lumen area site*** ***Calcification*** ***Calcification***



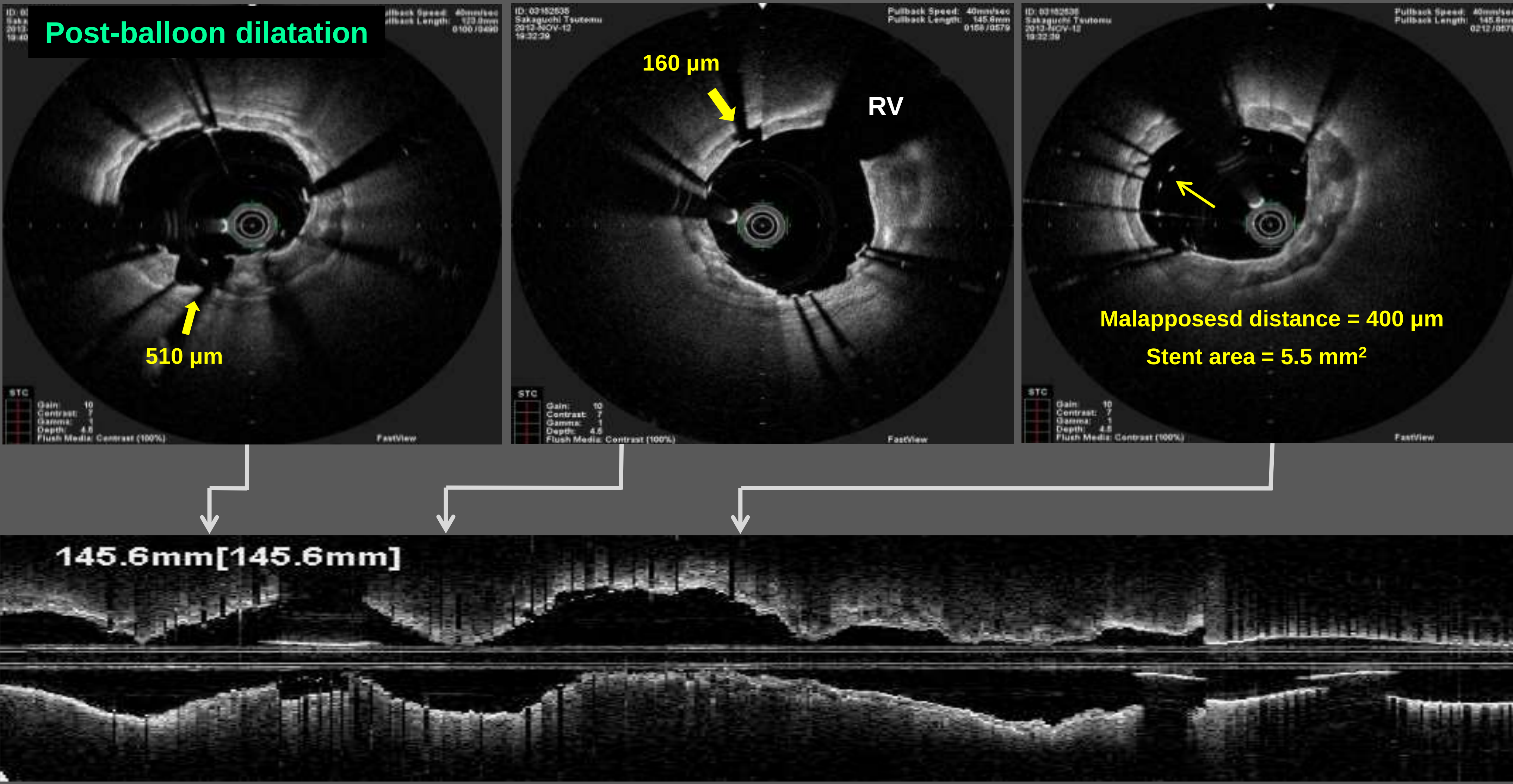



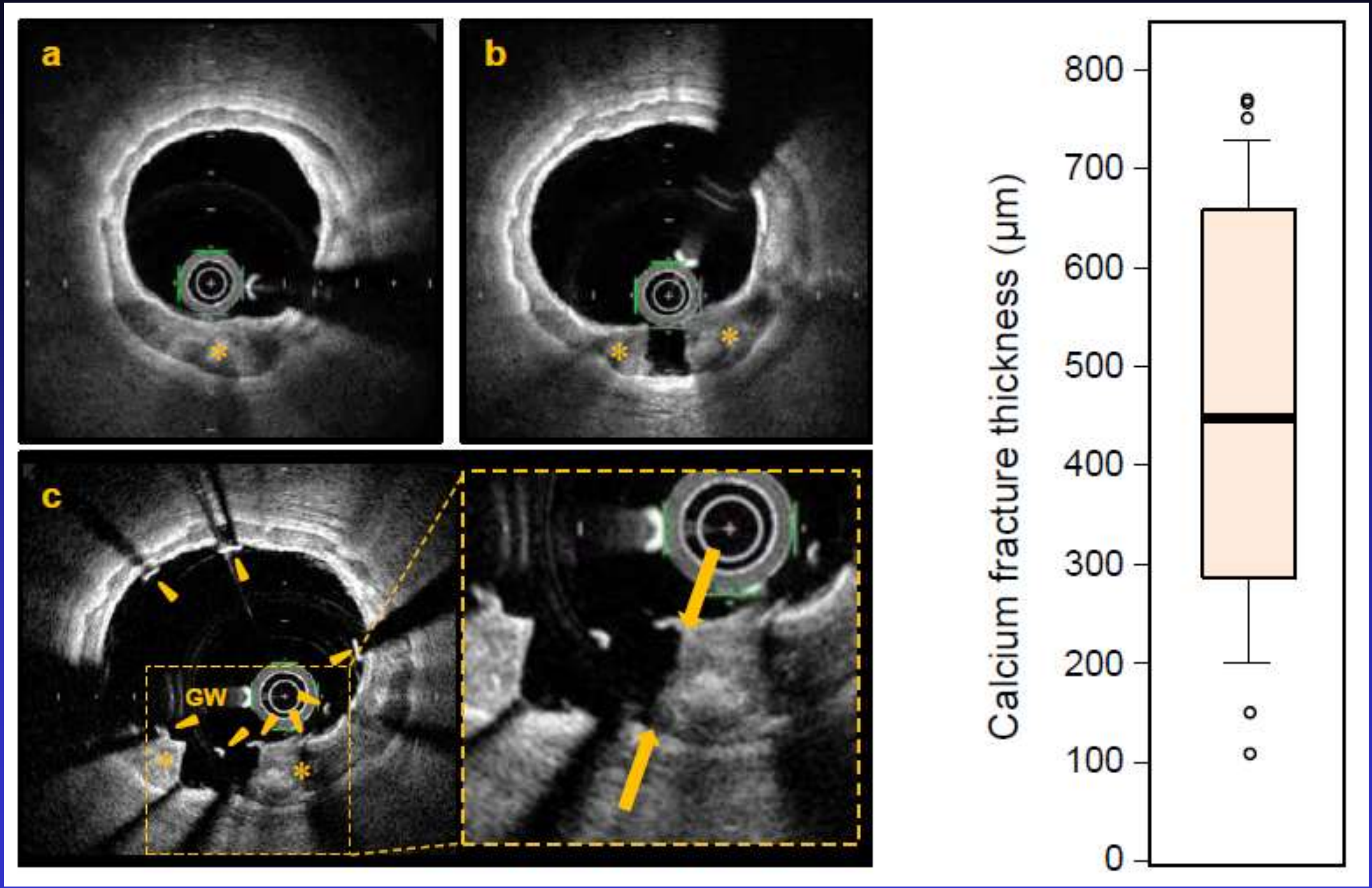





Broken calcium plate
Broken calcium plate
Broken calcium plate
Post-high pressure ballooning
100 µm
220 µm
90 µm
510 µm
250 µm
RV
230 µm
100.1mm[100.1mm]

***Broken calcium plate*** | ***Broken calcium plate*** | ***Stent malappsoition***



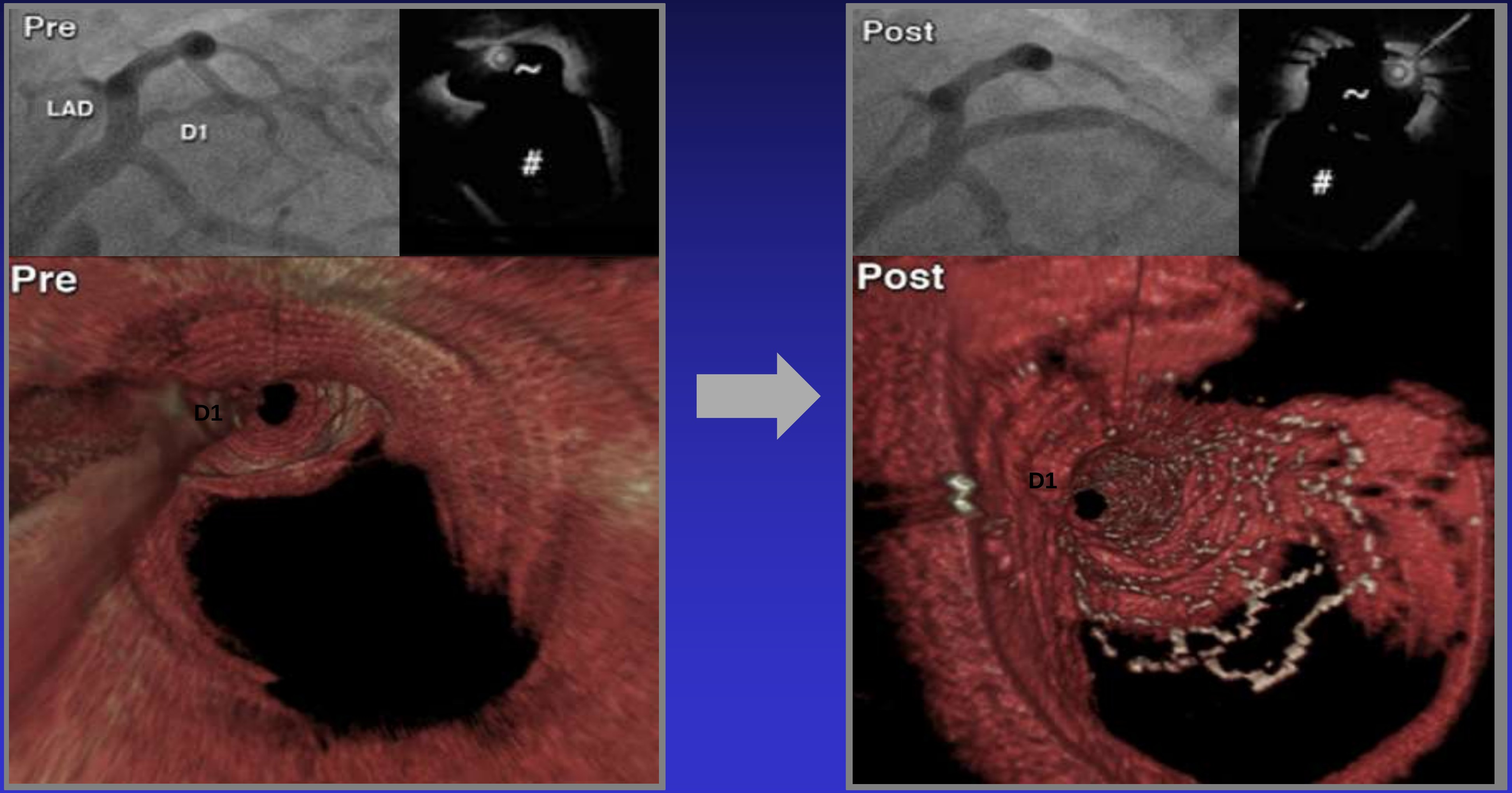



Kubo T. et al, J Am Coll Cardiol Cardiovasc Imag 2015 (in press)

# Agenda

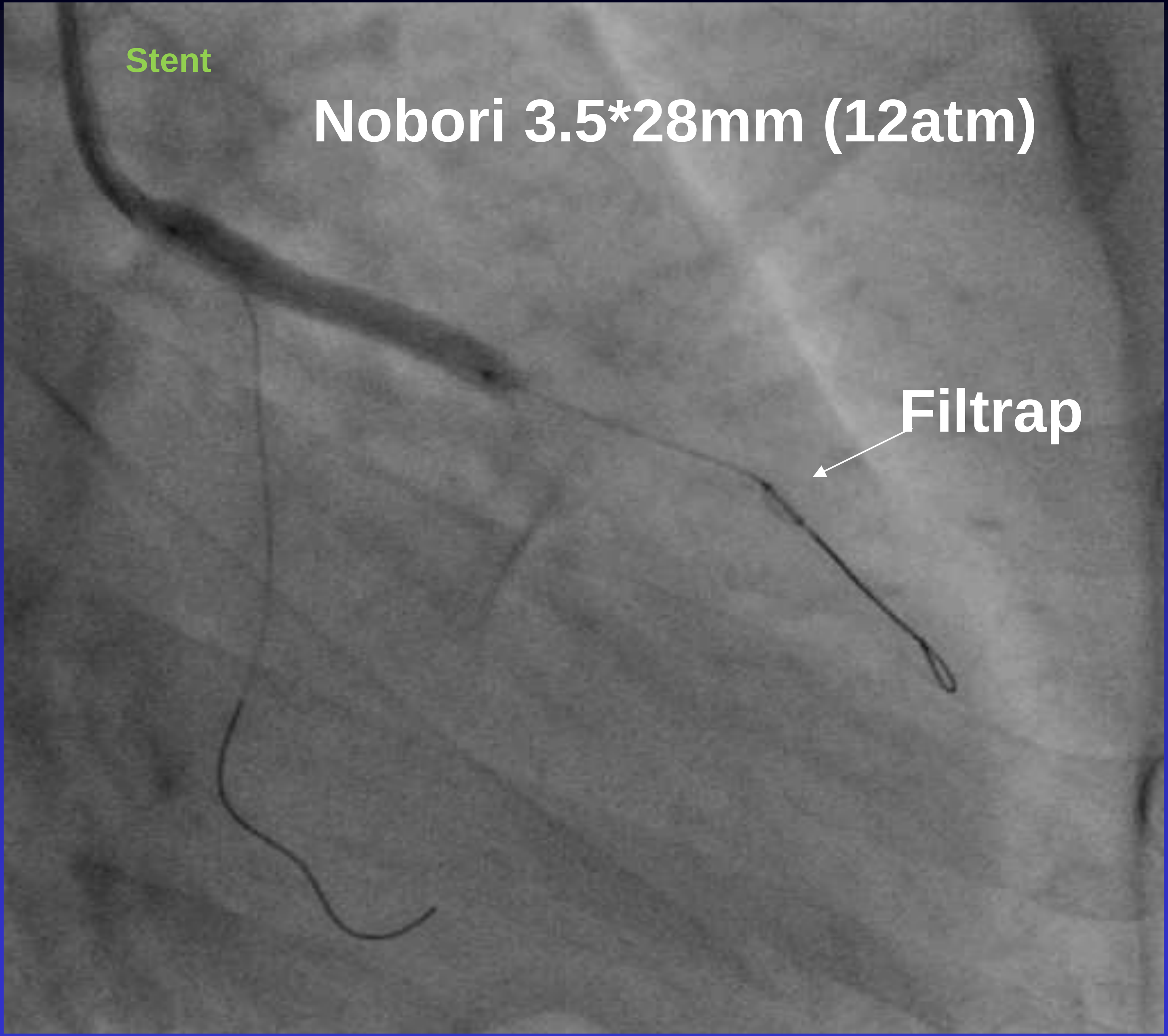
- How to obtain FD-OCT image
- How to select stent size & length
- How to treat stent under-expansion
- How to decide stent apposition
- How to manage other complication
- How to deal calcified lesion
- **How to care bifurcation lesion**
- How to treat instent restenosis

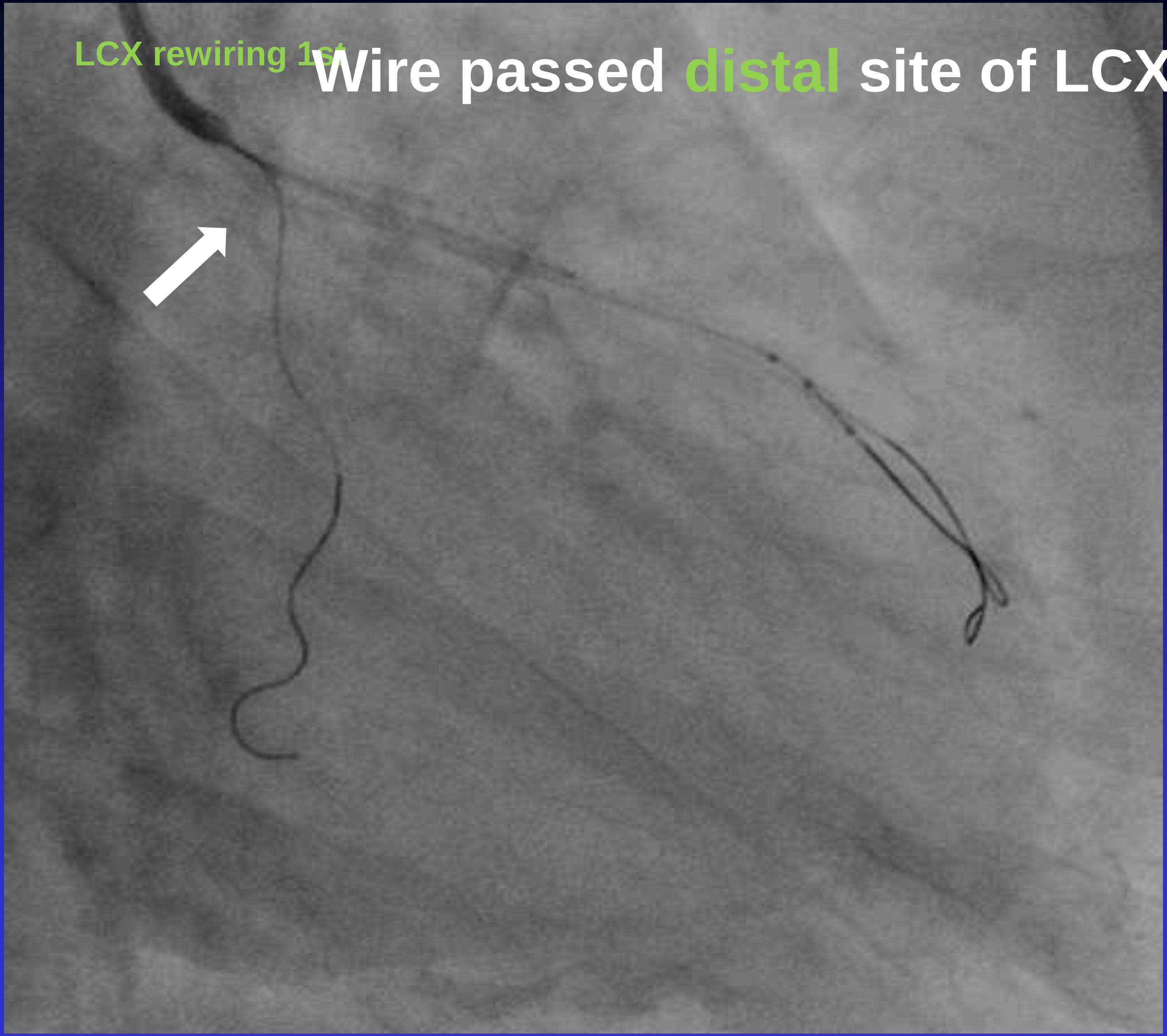
# “Overhanging” struts of the D1 stent into the LAD orifice

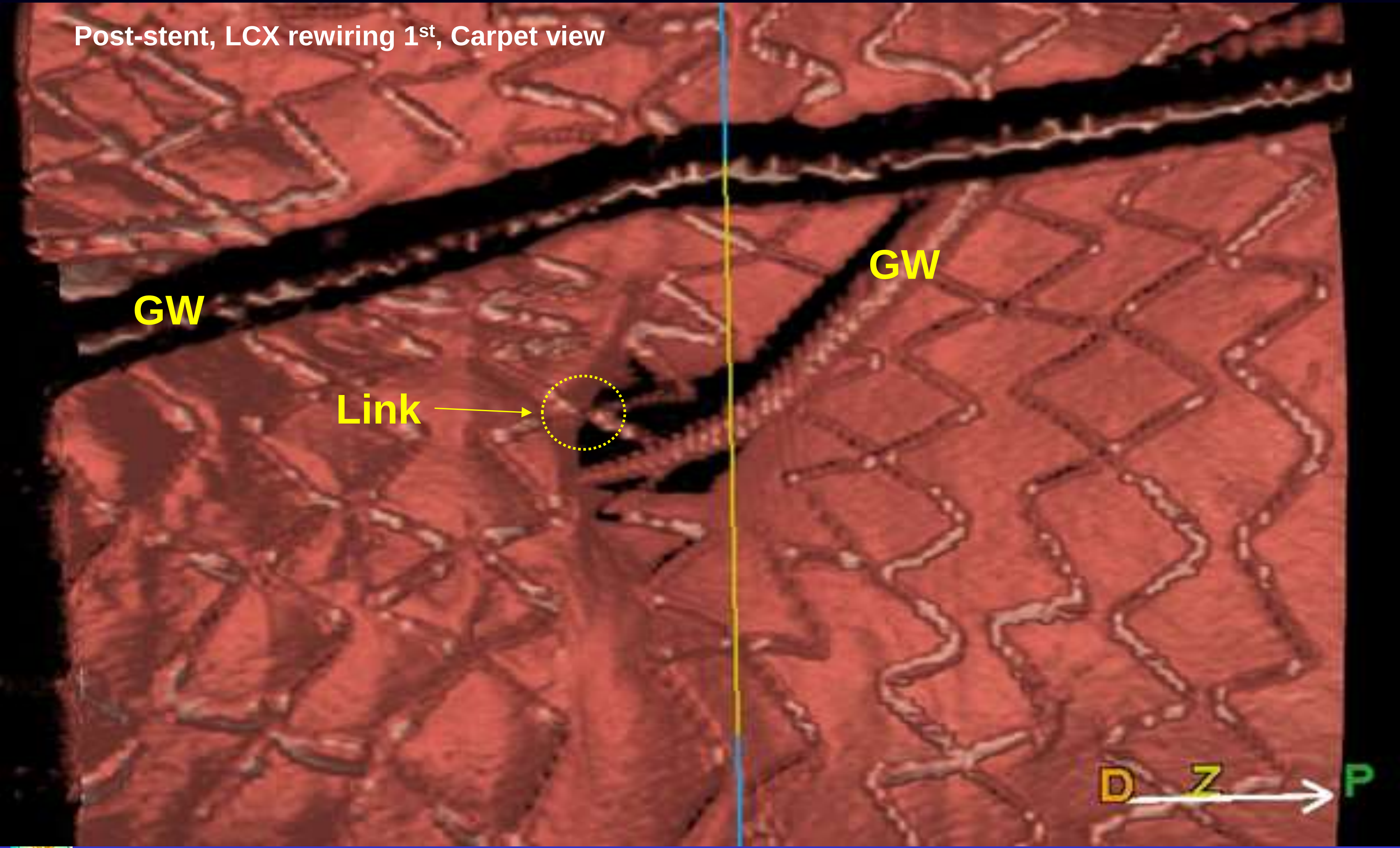



*Farooq et al. JACC int 2011;9:1044-6*

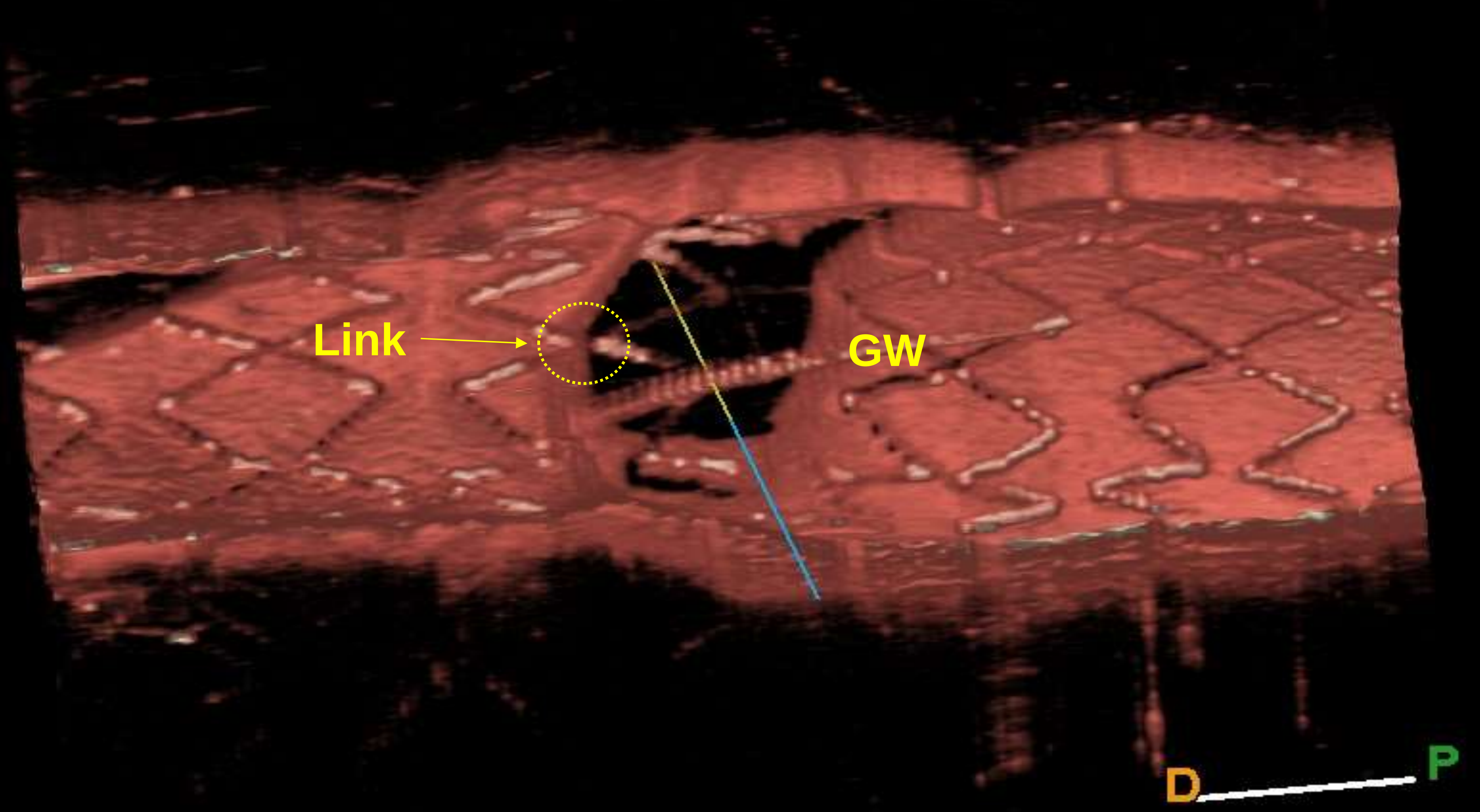
Wakayama Medical University


Stent
Nobori 3.5*28mm (12atm)
Filtrap

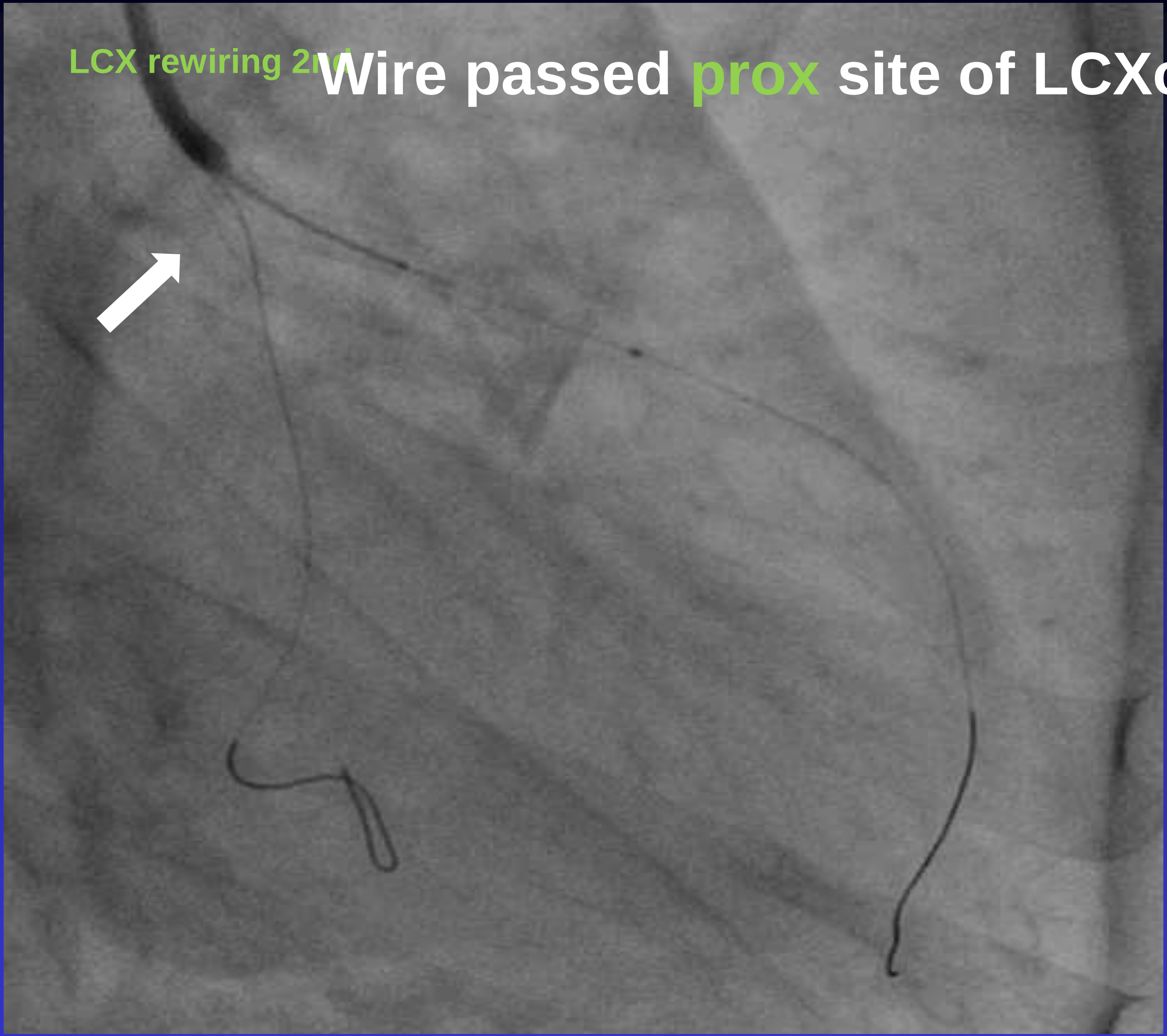

LCX rewiring 1st
Wire passed distal site of LCXos.


Post-stent, LCX rewiring 1st, Carpet view
GW
GW
Link
D
Z
P

Post-stent, LCX rewiring 1st, Cut-away view

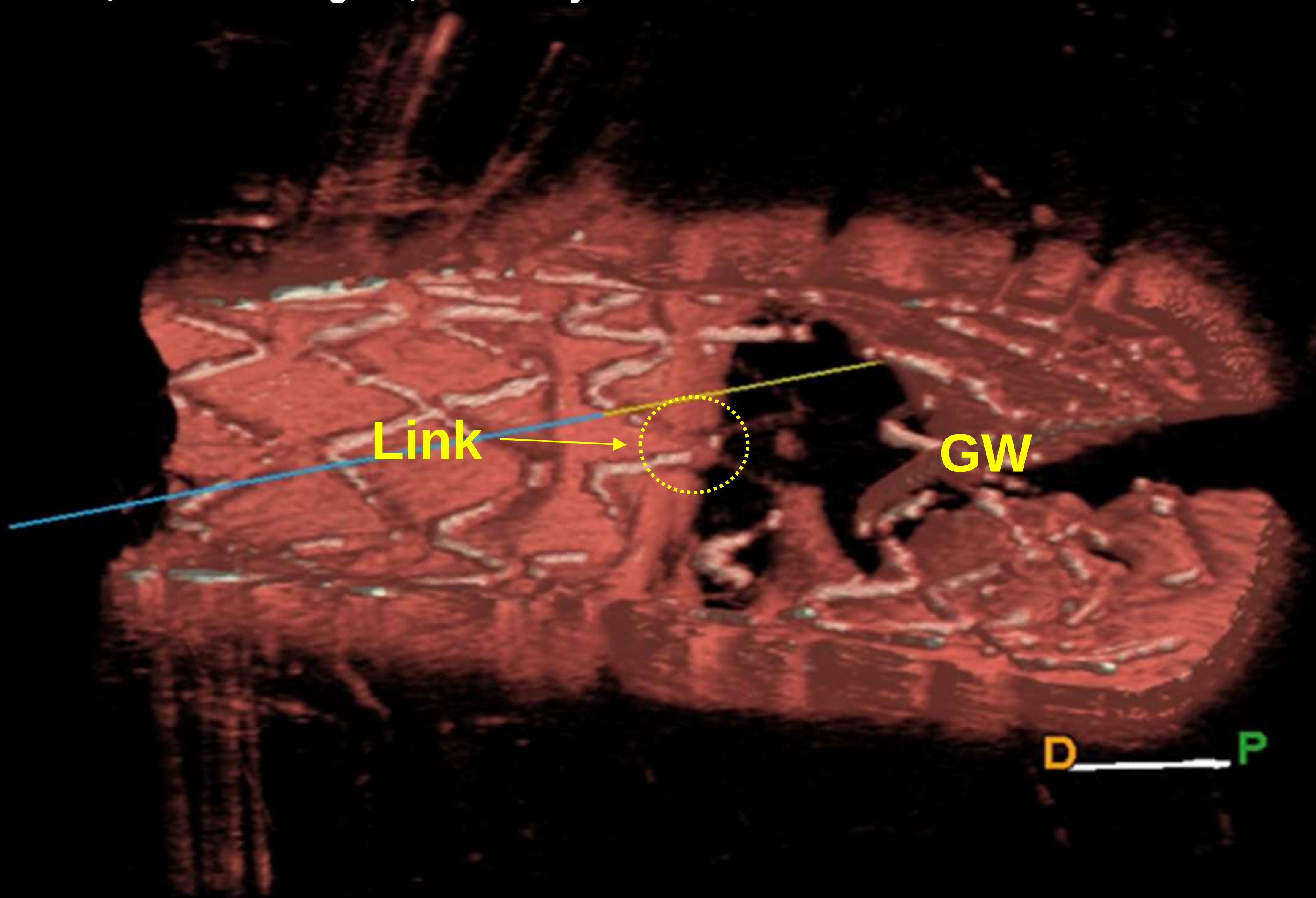


# Wire passed prox site of LCXos.



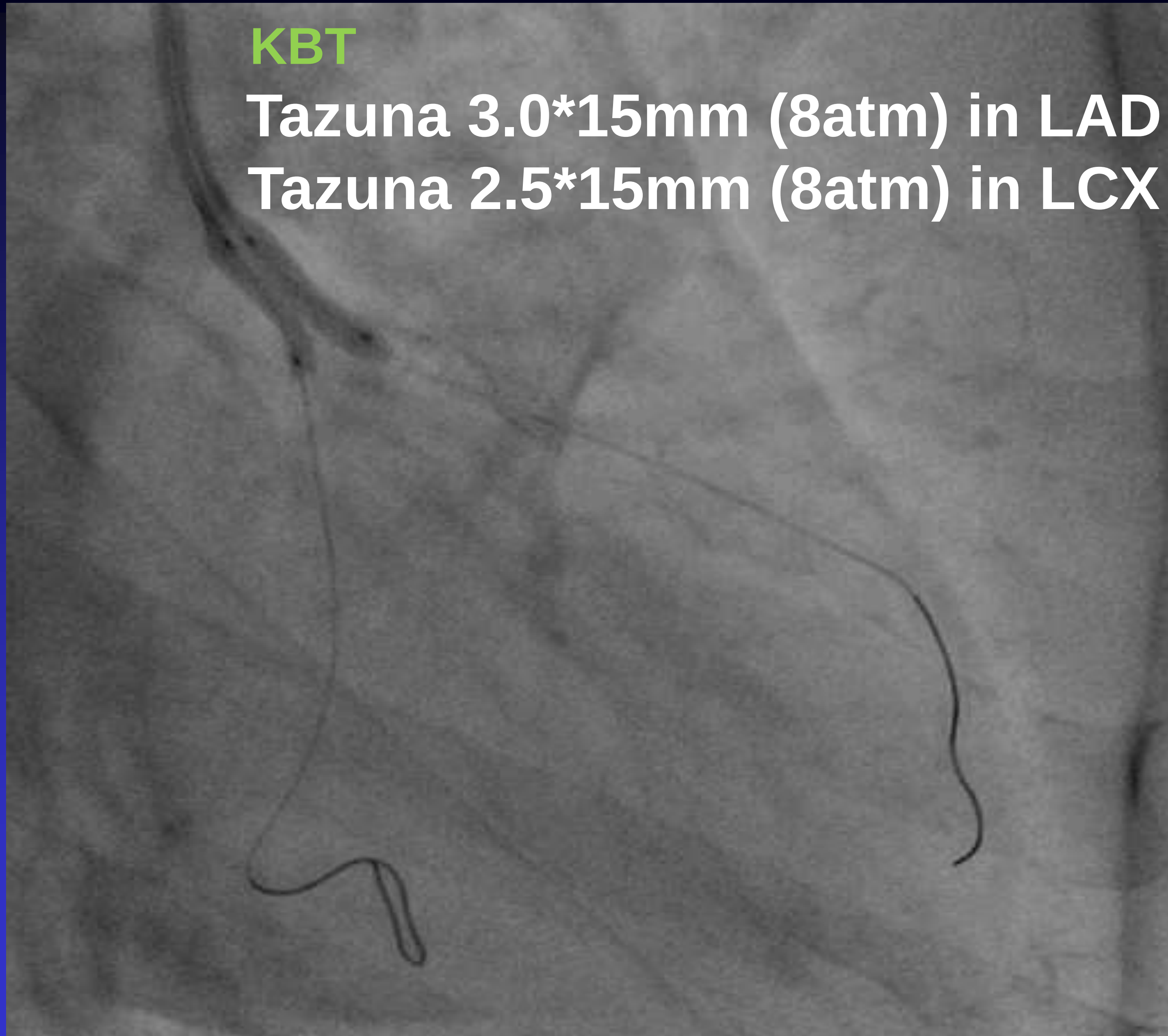

GW
Post-stent, LCX rewiring 2nd, Carpet view
Link
GW
D
Z

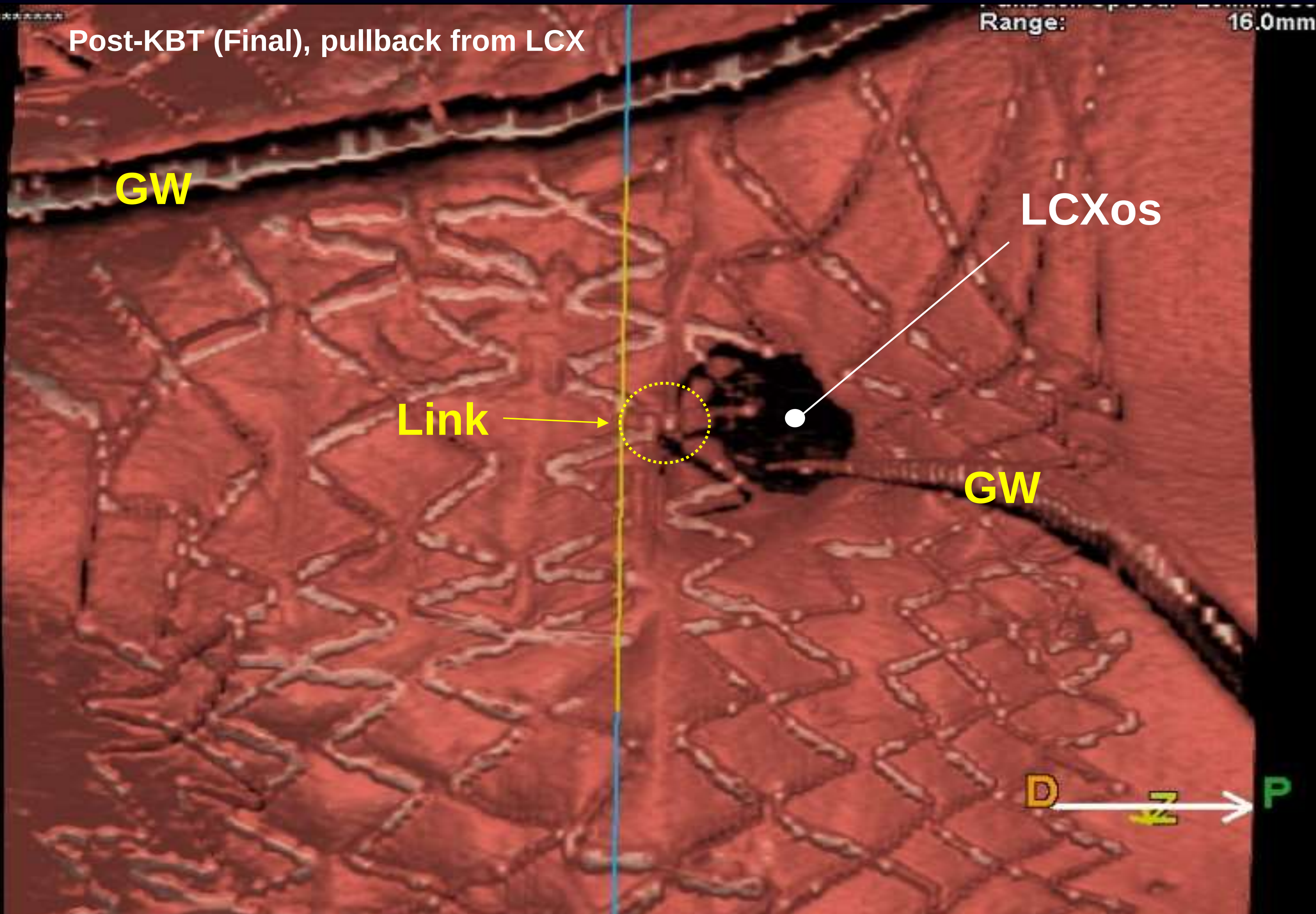
Post-stent, LCX rewiring 2nd, Cut-away view



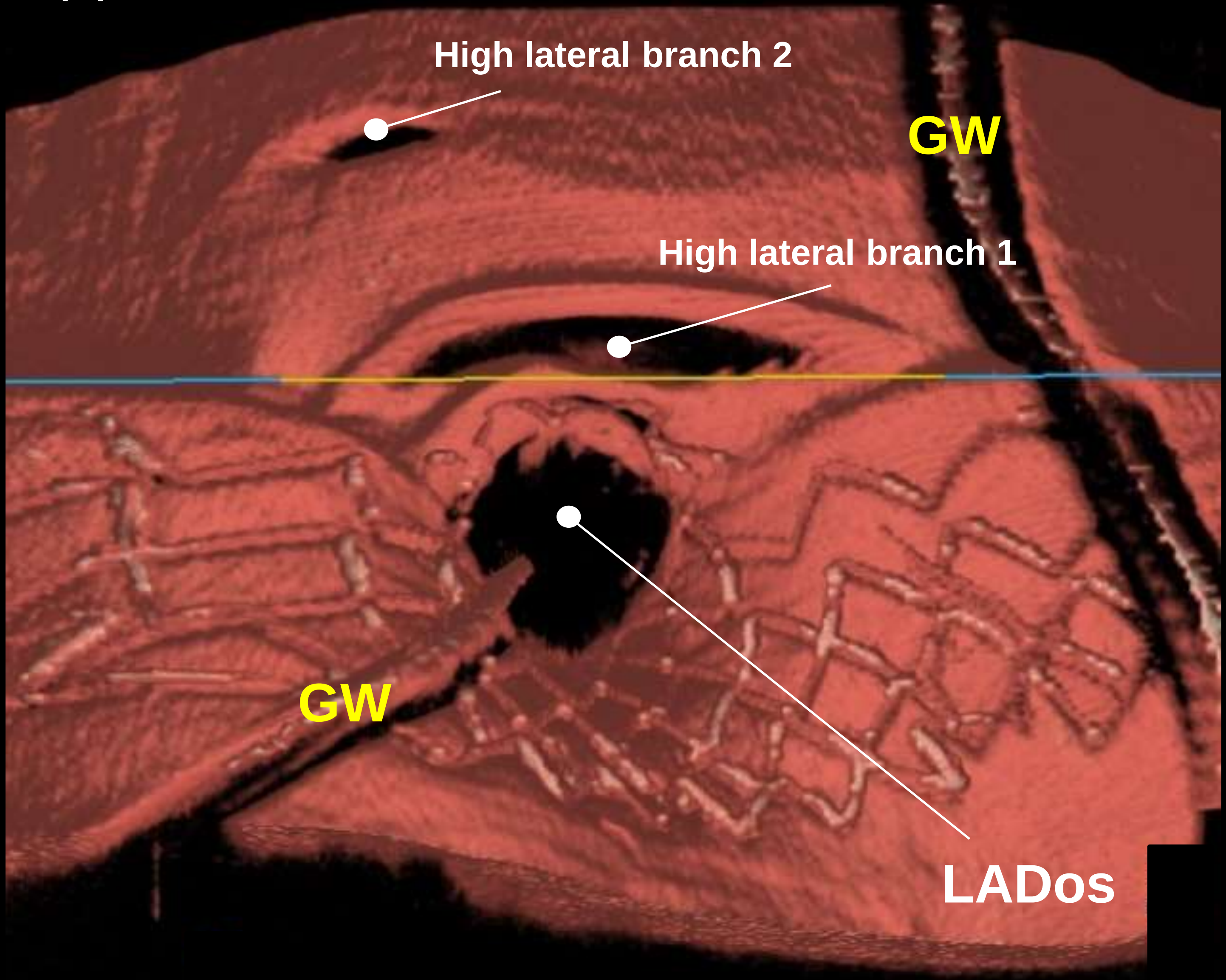
## KBT

**Tazuna 3.0*15mm (8atm) in LAD**
**Tazuna 2.5*15mm (8atm) in LCX**

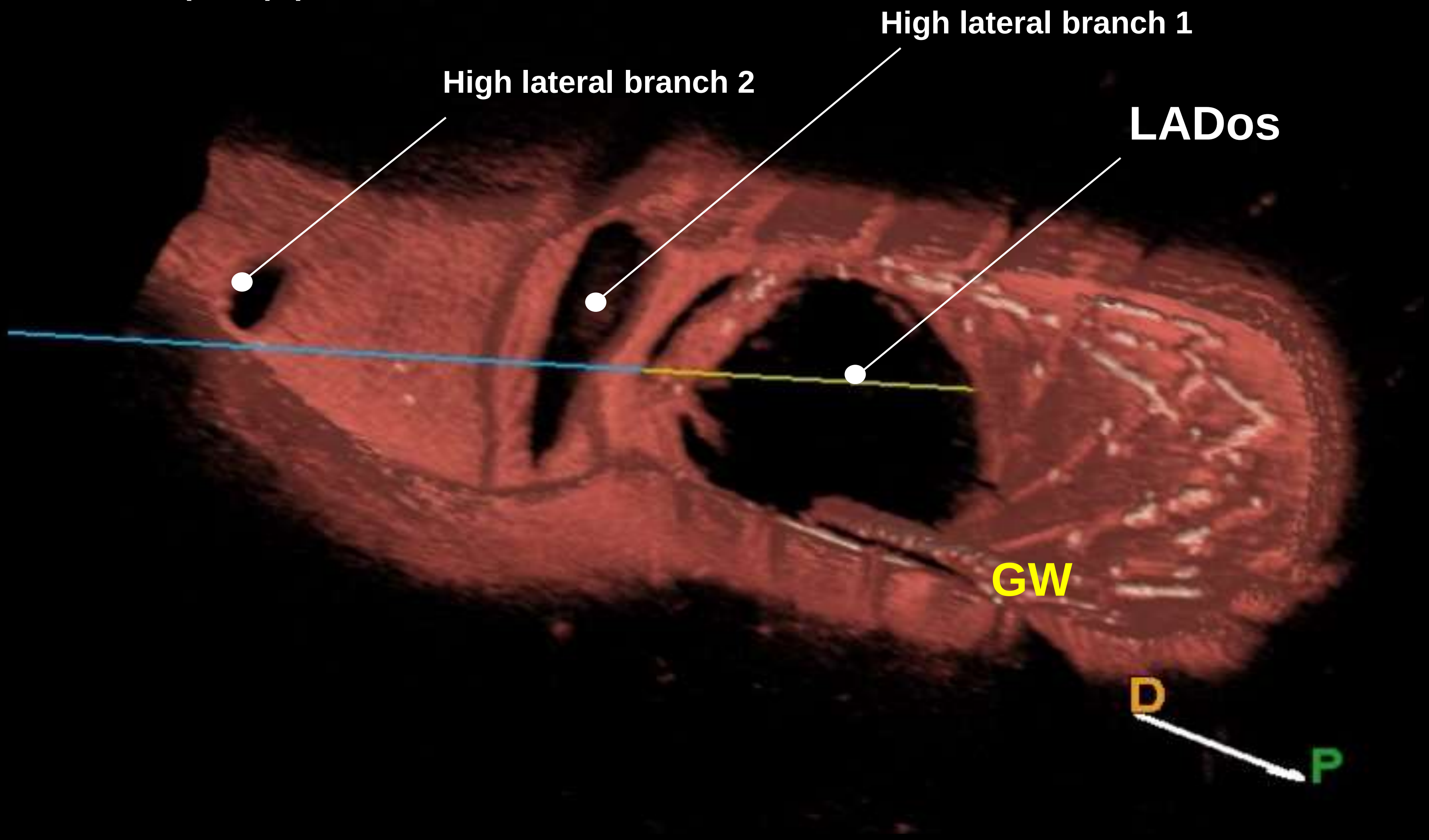



Range:
16.0mm
Post-KBT (Final), pullback from LCX
GW
LCXos
Link
GW
D
P

## Post-KBT (Final), pullback from LCX



Post-KBT (Final), pullback from LCX



# 3D optical coherence tomography: new insights into the process of optimal rewiring of side branches during bifurcational stenting

Takayuki Okamura[1]*, MD, PhD; Yoshinobu Onuma[2], MD; Jutaro Yamada[1], MD, PhD;
Javaid Iqbal[2], MRCP, PhD; Hiroki Tateishi[1], MD, PhD; Tomoko Nao[1], MD, PhD; Takamasa Oda[1], MD;
Takao Maeda[1], MD; Takeshi Nakamura[1], MD; Toshiro Miura[1], MD, PhD; Masafumi Yano[1], MD, PhD;
Patrick W. Serruys[2], MD, PhD, FESC, FACC

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*Ube, Japan; 2. Thoraxcenter, Erasm*

*T. Okamura and Y. Onuma have co*

GUEST EDITOR: Carlo Di Mario
*Brompton Hospital, London, United*


## Abstract

**Aims:** We describe three-dimensional optical coherence tomography (3D-OCT) guided bifurcation stenting and the clinical utility of 3D-OCT.

**Methods and results:** Twenty-two consecutive patients who underwent OCT examination to confirm the recrossing position after stent implantation in a bifurcation lesion were enrolled. Frequency domain OCT images were obtained to check the recrossing position and 3D reconstructions were performed off-line. The recrossing position was clearly visualised in 18/22 (81.8%) cases. In 13 cases, serial 3D-OCT could be assessed both before and after final kissing balloon post-dilation (FKBD). We divided these cases into two groups according to the presence of the link between hoops at the carina: free carina type (n=7) and connecting to carina type (n=6). All free carina types complied with the distal rewiring. The percentage of incomplete stent apposition (%ISA) of free carina type at the bifurcation segment after FKBD was significantly smaller than that of the connecting to carina type (0.7±0.9% vs. 12.2±6.5%, p=0.0074).

**Conclusions:** 3D-OCT confirmation of the recrossing into the jailed side branch is feasible during PCI and may help to achieve distal rewiring and favourable stent positioning against the side branch ostium, leading to reduction in ISA and potentially better clinical outcomes.

# Agenda

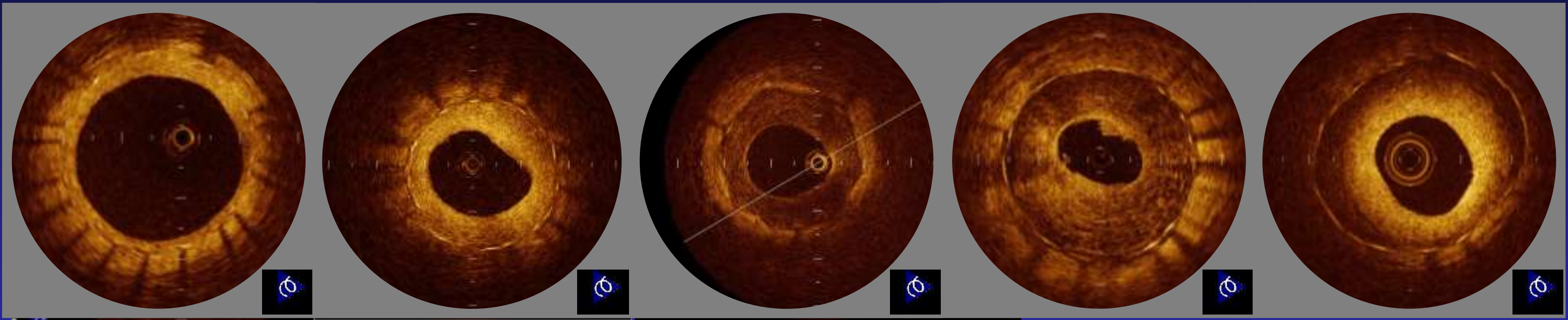
- How to obtain FD-OCT image
- How to select stent size & length
- How to treat stent under-expansion
- How to decide stent apposition
- How to manage other complication
- How to deal calcified lesion
- How to care bifurcation lesion
- How to treat instent restenosis

# Neointimal tissue characterization by OCT

**No restenosis**

**Restenosis**

*Homogeneous* *Heterogeneous* *Layered*



Neointimal tissue has very thin & uniform optical properties with backscattering pattern.

Restenotic tissue has uniform optical properties and dose not show focal variations in backscattering pattern.

Restenotic tissue has focally changing optical properties and show various backscattering patterns.

Restenotic tissue consists of concentric layers with different optical properties: an adluminal high scattering layer & adluminal low scattering layer.

**Although no data showing the relation between OCT-findings & histology in detail, there is a data demonstrating the effect of DCB according to OCT finding.**

European Heart Journal – Cardiovascular Imaging (2014) **15**, 307–315
doi:10.1093/ehjci/jet165

# Association between tissue characteristics evaluated with optical coherence tomography and mid-term results after paclitaxel-coated balloon dilatation for in-stent restenosis lesions: a comparison with plain old balloon angioplasty

**Takeshi Tada[1*], Kazushige Kadota[1], Shingo Hosogi[2], Koshi Miyake[1], Hideo Amano[1], Michitaka Nakamura[1], Yu Izawa[1], Shunsuke Kubo[1], Tahei Ichinohe[1], Yusuke Hyoudou[1], Haruki Eguchi[1], Yuki Hayakawa[1], Suguru Otsuru[1], Daiji Hasegawa[1], Yoshikazu Shigemoto[1], Seiji Habara[1], Hiroyuki Tanaka[1], Yasushi Fuku[1], Harumi Kato[1], Tsuyoshi Goto[1], and Kazuaki Mitsudo[1]**

[1]Department of Cardiovascular Medicine, Kurashiki Central Hospital, 1-1-1 Miwa, Kurashiki 710-8602, Japan; and [2]Department of Cardiovascular Medicine, Kochi Health Sciences Center, Kochi, Japan

*Received 14 May 2013; revised 13 August 2013; accepted after revision 16 August 2013; online publish-ahead-of-print 15 September 2013*

**Aims** Morphological assessment of neointimal tissue using optical coherence tomography (OCT) is important for clarifying the pathophysiology of in-stent restenosis (ISR) lesions. The aim of this study was to determine the impact of OCT findings on recurrence of ISR after paclitaxel-coated balloon (PCB) dilatation compared with plain old balloon angioplasty (POBA).

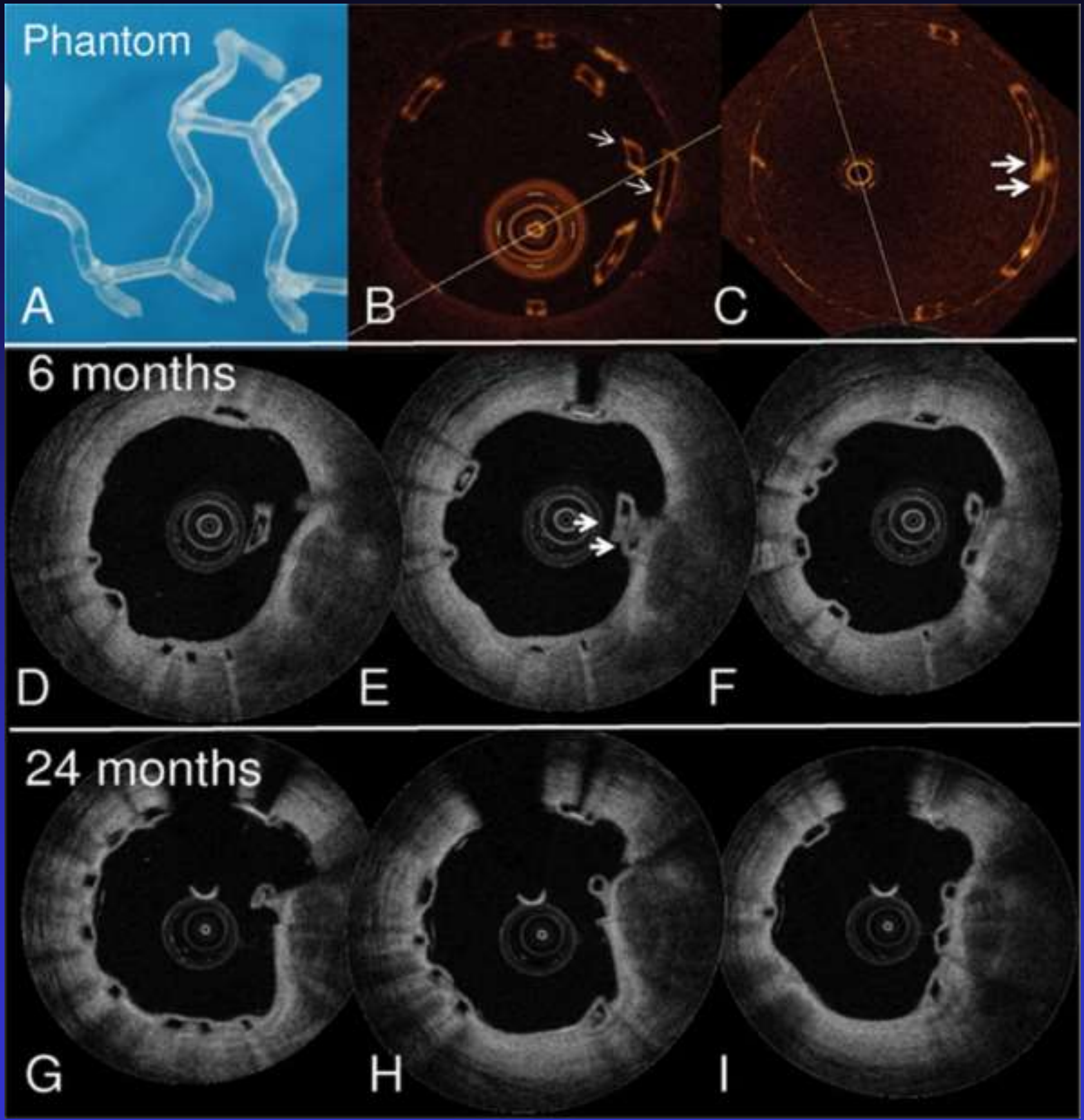
**Methods and results** Between July 2008 and May 2012, we performed percutaneous coronary intervention for 214 ISR lesions using POBA + PCB (146 lesions, PCB group) or POBA only (68 lesions, POBA group). Morphological assessment of neointimal tissue using OCT, including assessment of restenotic tissue structure and restenotic tissue backscatter, was performed. We examined the association between lesion morphologies and mid-term (6–8 months) results including ISR and target lesion revascularization (TLR) rates. Both ISR and TLR rates of lesions with a homogeneous structure were significantly lower in the PCB group than those in the POBA group (ISR: 20.0 vs. 55.6%, $P = 0.002$, TLR: 12.7 vs. 37.0%, $P = 0.019$), but there was no difference between the two groups in ISR and TLR rates of lesions with a heterogeneous or layered structure. Both ISR and TLR rates of lesions with high backscatter were significantly lower in the PCB group than those in the POBA group (ISR: 19.8 vs. 52.5%, $P < 0.001$, TLR: 13.6 vs. 42.5%, $P = 0.001$), but there was no difference between the two groups in ISR and TLR rates of lesions with low backscatter.

**Conclusion** Morphological assessment of ISR tissue using OCT might be useful for identifying ISR lesions favourable for PCB dilatation.

**Keywords** optical coherence tomography • in-stent restenosis lesion • paclitaxel-coated balloon

*Wakayama Medical University*

# Assessment of BVS by OFDI




Ormiston J A et al. Circ Cardiovasc Interv 2012;5:620-632

# How to use OCT-guided PCI in DES Era

- **Pre PCI Assessment**
  - Image acquisition is very fast and easy.
  - Precise measurements might be possible automatically.
  - Lesion morphology can be assessed in detail.
    Easy to plan PCI strategies, easy to decide stent landing zone, easy to identify unexpected lesions, etc.
- **During and after PCI.**
  - Results of PCI such as tissue protrusion, incomplete apposition, mal-apposition, small dissection, etc. can be assessed precisely.
  - Much more delicate treatment may be expected to bifurcation lesion stenting by 3D-OCT.
  - Pathophysiology of LST & VLST could be demonstrated in detail and ideal treatment could be expected by OCT-guided PCI using PCB.
  - OCT-guided PCI should be essential for BVS.

# Summary
# OCT-guided PCI in DES Era

- Pre- & post-PCI lesion morphology can be assessed easily & precisely by OCT because of higher resolution with high frame rate, auto-pullback & auto-measurement systems, etc.

- Improvement of clinical outcomes can be expected in PCI by the guidance of OCT, although there are not enough data to support the reduction of the adverse clinical events by OCT guided PCI.

- Randomized prospective studies should be planned to demonstrate the improvement of clinical outcome by OCT-guided PCI in the near future.