OCT-Guided Precise PCI for LM Bifurcation Stenting

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Disclosure

Takashi Akasaka, MD, PhD, FAPSC, FESC, FJCS, FJCA, FJACHD

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

Affiliation/Financial Relationship

- **Grant/Research Support : Abbott Medical Japan**
  Boston Scientific Japan
  Terumo Corp.
- **Consulting Fees/Honoraria : Abbott Medical Japan**
  Daiichi-Sankyo Pharmaceutical Corp.
  Nipro Corp.
- **Medical Advisor (Employed) : Terumo Corp.**

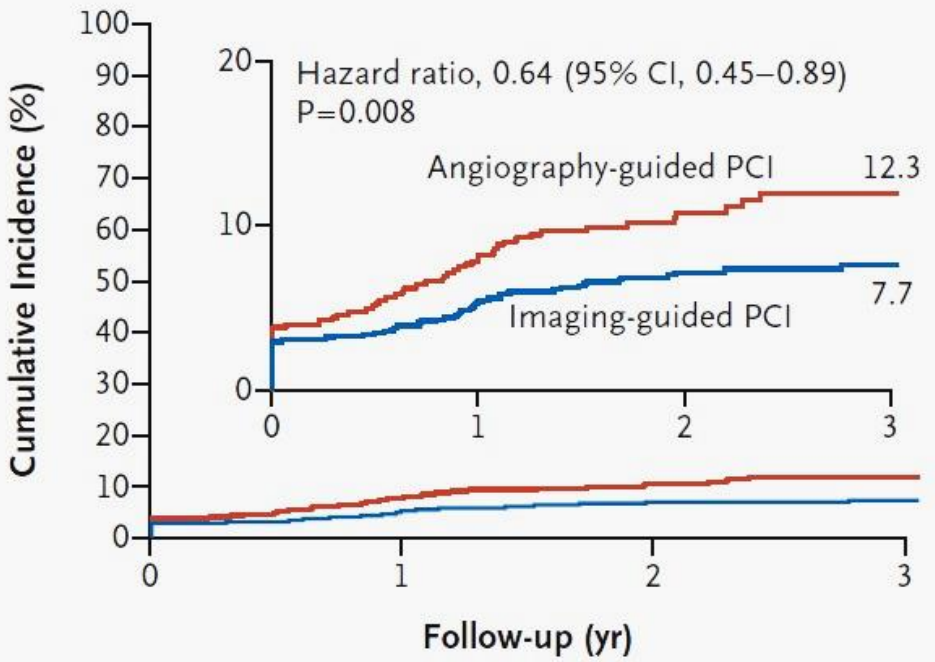
Discussion Points

- **Recent randomized studies data of OCT guided PCI compared with IVUS guided and/or angio-guided PCI, especially for LM bifurcation lesion.**
- **Risk and mechanism of re-stenosis at side branch orifice after bifurcation stenting.**
- **Prediction of side branch occlusion during stenting and how to select ideal cell at the side branch orifice for obtaining optimal stent deployment in the main branch, with enough lumen area without any stent struts at the side branch orifice for maintaining the side branch opening for a long time.**

Intravascular Imaging-guided or Angiography-guided Complex PCI

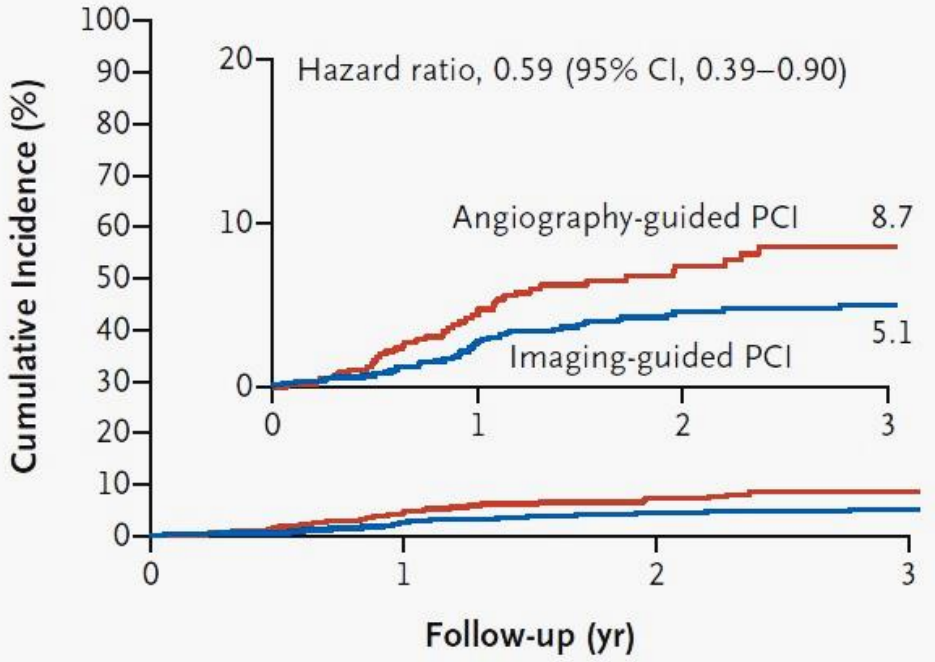
RENOVATE COMPLEX-PCI study

Target Vessel Failure



No. at Risk				
Angiography-guided PCI	547	496	280	120
Imaging-guided PCI	1092	1023	591	255

TVF without Procedure-Related MI



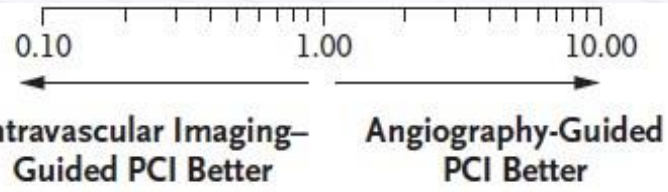
No. at Risk				
Angiography-guided PCI	547	516	284	121
Imaging-guided PCI	1092	1051	596	256

Lee JM, et al. N Engl J Med 2023;388:1668-1679

Intravascular Imaging-guided or Angiography-guided Complex PCI

RENOVATE COMPLEX-PCI study

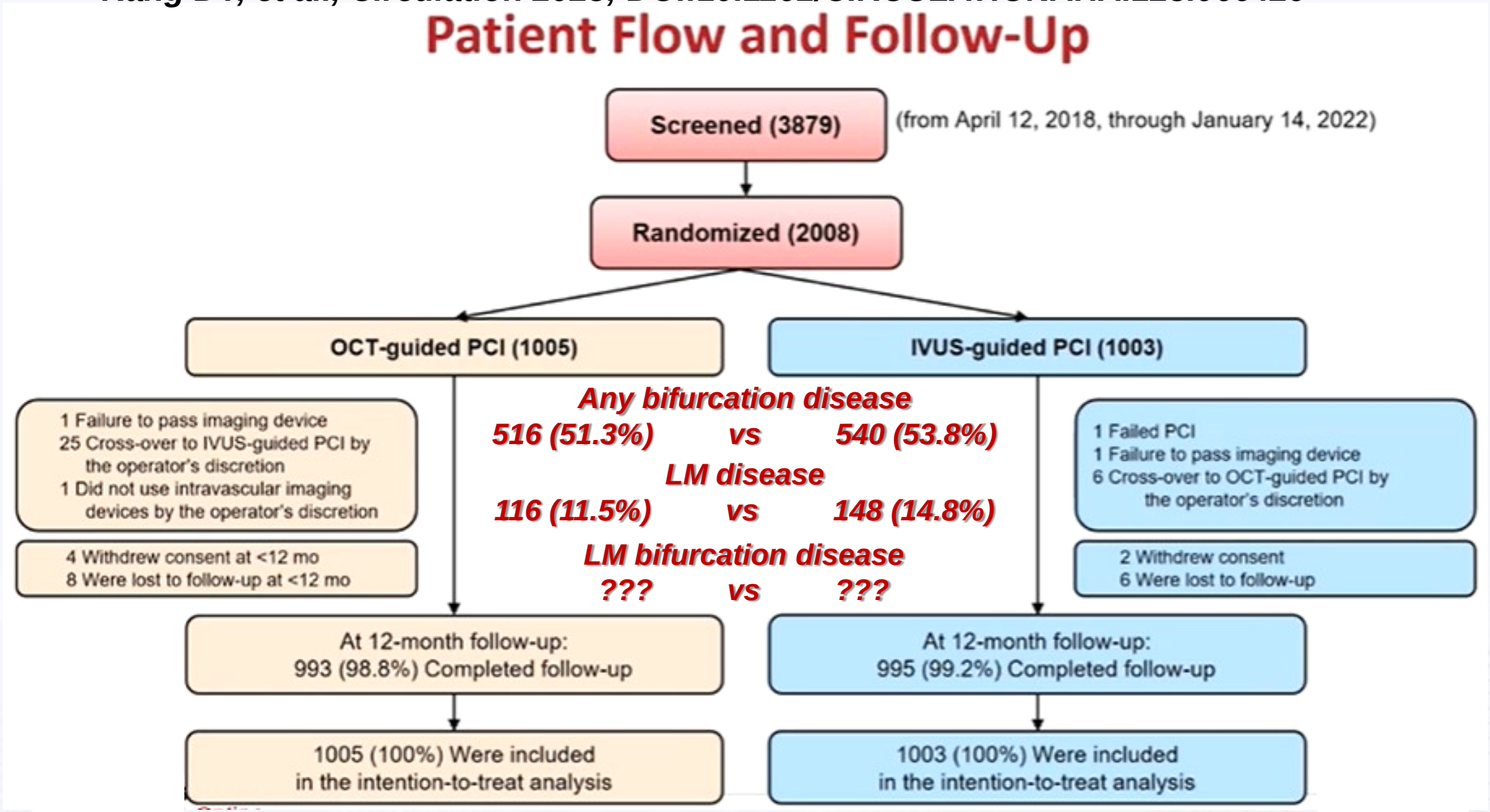
Subgroup	Intravascular Imaging–Guided PCI	Angiography-Guided PCI	Hazard Ratio (95% CI)
	no. of events/total no. of patients (cumulative incidence, %)		
Overall	76/1092 (7.7)	60/547 (12.3)	0.64 (0.45–0.89)
Type of imaging devices			
Intravascular ultrasonography	59/800 (8.0)	60/547 (12.3)	0.66 (0.46–0.95)
Optical coherence tomography	15/278 (5.8)	60/547 (12.3)	0.47 (0.27–0.83)
Type of complex coronary lesions			
True bifurcation	23/233 (10.3)	13/126 (11.8)	0.97 (0.49–1.93)
Chronic total occlusion	9/220 (5.0)	13/99 (14)	0.30 (0.13–0.71)
Unprotected left main coronary artery disease	9/138 (6.8)	11/54 (25)	0.31 (0.13–0.76)
Diffuse long coronary-artery lesion	36/617 (6.5)	31/281 (11.9)	0.52 (0.32–0.83)
Multivessel PCI involving ≥2 major coronary arteries	36/409 (9.5)	22/213 (11.7)	0.84 (0.50–1.44)
Lesion necessitating use of ≥3 stents	16/208 (8.1)	6/97 (6)	1.24 (0.49–3.18)
Lesion with in-stent restenosis	22/158 (15.6)	12/78 (17)	0.90 (0.45–1.82)
Severely calcified lesion	11/157 (7.3)	11/74 (17)	0.46 (0.20–1.06)
Ostial lesions of major coronary artery	8/182 (4.4)	9/69 (16)	0.33 (0.13–0.85)
Initial presentation			
Stable ischemic heart disease	25/532 (5.0)	27/275 (10.4)	0.46 (0.27–0.80)
Acute coronary syndrome	51/560 (10.4)	33/272 (14.6)	0.74 (0.48–1.15)



Lee JM, et al. N Engl J Med 2023;388:1668-1679

OCT- or IVUS-guided PCI: The OCTIVUS randomized clinical trial

Kang DY, et al., Circulation 2023; DOI:10.1161/CIRCULATIONAHA.123.066429

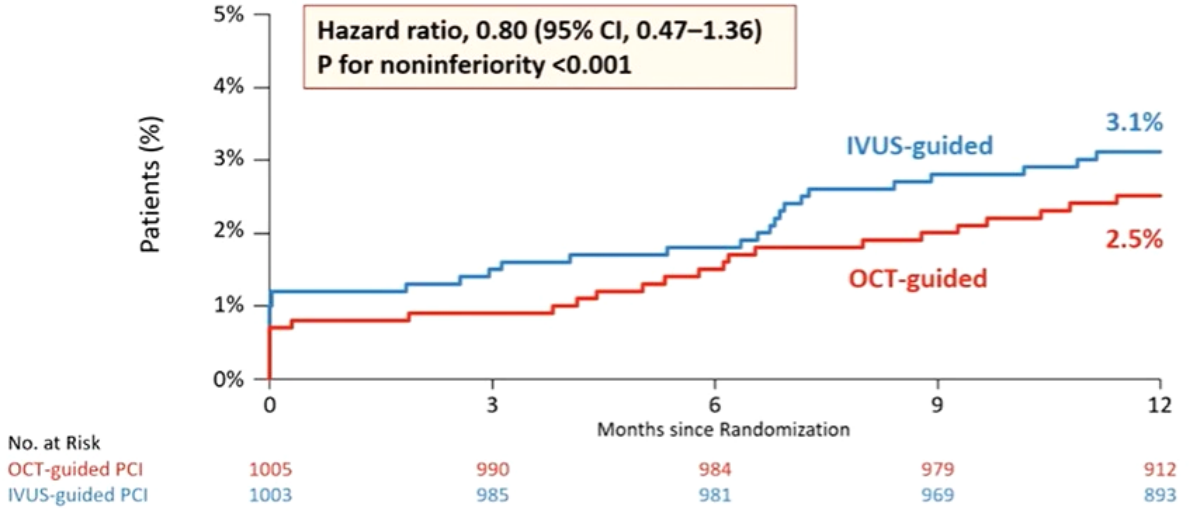


OCT- or IVUS-guided PCI: The OCTIVUS randomized clinical trial

Kang DY, et al., Circulation 2023; DOI:10.1161/CIRCULATIONAHA.123.066429

Bifurcation disease: OCT guide;516 (51.3%), IVUS guide;540 (53.8%)

Primary Endpoint of TVF: Cardiac Death, TV-MI, or TVR



Subgroup	Percent of Patients	Event Rate (%) OCT-guided	Event Rate (%) IVUS-guided	Hazard Ratios (95% CI)	P-for-Interaction
Left main disease					0.868
Yes	13.2	5.3	6.8	0.78 (0.28 to 2.16)	
No	86.9	2.2	2.5	0.87 (0.47 to 1.61)	
Bifurcation disease					0.901
Yes	52.6	3.1	3.7	0.83 (0.43 to 1.61)	
No	47.4	1.9	2.4	0.78 (0.32 to 1.87)	
Diffuse long coronary artery lesion					0.077
Yes	58.2	3.3	2.9	1.15 (0.60 to 2.22)	
No	41.8	1.4	3.4	0.41 (0.16 to 1.05)	
Severely calcified lesion					0.149
Yes	7.6	7.9	8.1	1.36 (0.60 to 3.07)	
No	92.4	2.1	2.7	0.61 (0.31 to 1.23)	
Multivessel disease					0.547
Yes	61.6	3.2	4.2	0.75 (0.42 to 1.36)	
No	38.4	1.5	1.4	1.13 (0.35 to 3.71)	
SYNTAX score					0.096
Low	79.0	1.5	2.9	0.52 (0.26 to 1.04)	
Intermediate	15.6	5.7	3.5	1.63 (0.57 to 4.70)	
High	5.4	9.9	5.3	1.93 (0.46 to 8.06)	

OCT- vs angio-guided PCI for complex bifurcation lesions

OCT or Angiography Guidance for PCI in Complex Bifurcation Lesions

N.R. Holm, L.N. Andreasen, O. Neghabat, P. Laanmets, I. Kumsars, J. Bennett, N.T. Olsen, J. Odenstedt, P. Hoffmann, J. Dens, S. Chowdhary, P. O'Kane, S.-H. Bülow Rasmussen, M. Heigert, O. Havndrup, J.P. Van Kuijk, S. Biscaglia, L.J.H. Mogensen, L. Henareh, F. Burzotta, C. H. Eek, D. Mylotte, M.S. Llinas, L. Koltowski, P. Knaapen, S. Calic, N. Witt, I. Santos-Pardo, S. Watkins, J. Lønborg, A.T. Kristensen, L.O. Jensen, F. Calais, J. Cockburn, A. McNeice, O.A. Kajander, T. Heestermans, S. Kische, A. Eftekhari, J.C. Spratt, and E.H. Christiansen, for the OCTOBER Trial Group*

Holm NR, et al. N Engl J Med 2023
DOI: 10.1056/NEJMoa2307770

Clinical criteria

Inclusion

- 18 years old
- Stable angina, unstable angina or NSTEMI

Exclusion

- STEMI < 72h
- Cardiogenic shock
- Prior or planned CABG
- eGFR < 50mL/min/1.73²
- Life expectency < 2 years
- EF < 30%
- NYHA>II

Angiographic criteria

Inclusion

- Main vessel: Reference size ≥ 2.75mm
- Side branch: Reference size ≥ 2.5mm
- ≥50% stenosis in both vessels
- Left-main or non left-main bifurcations

Exclusion

- Severe tortuosity
- Chronic total occlusion
- Large thrombus in the Left-main artery

Full list of in-and exclusion criteria are listed in the published supplementary appendix to the main publication

Patients with stable angina, unstable angina or NSTEMI.
True bifurcation lesion. Side branch reference size ≥ 2.5mm

↓

1200 patients

↓

OCT guiding
Stepwise guiding protocol

1:1

Angiographic guiding
IVUS not encouraged, but allowed in LM lesions

↓

Primary endpoint: MACE at median two years*

MACE: Cardiac death, target lesion MI, ischemia-driven target lesion revascularisation

* At least one year of follow-up
Follow-up: 1 month, 1 year, annually through 5 years. All-cause mortality at 10 years

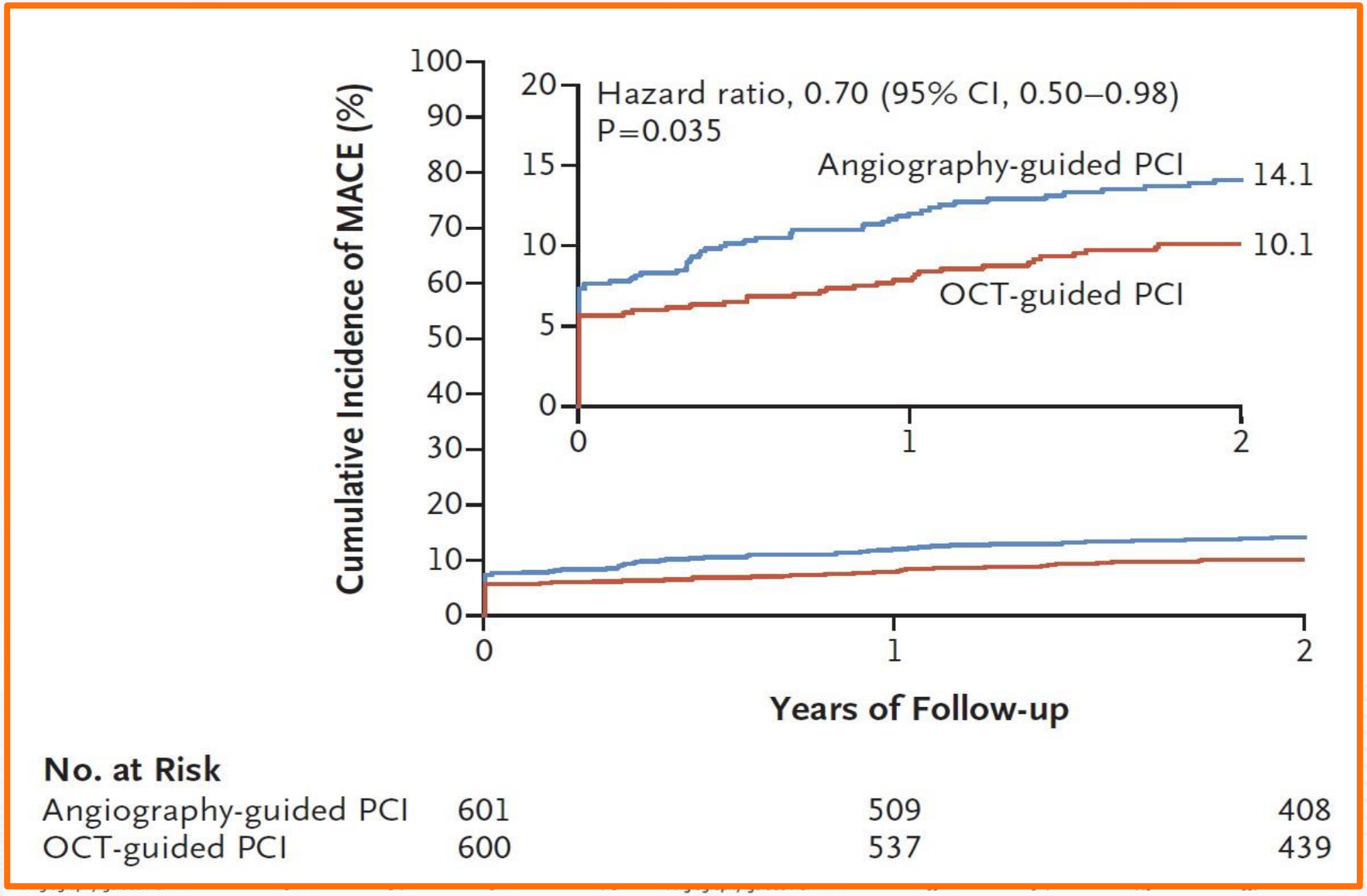
- Investigator-initiated study
- Open label design
- 38 heart centers in Europe
- On-site training in OCT-guided PCI
- Feedback on OCT-guided cases

Funding: Abbott and Aarhus University

CVRF

OCT- vs angio-guided PCI for complex bifurcation lesions

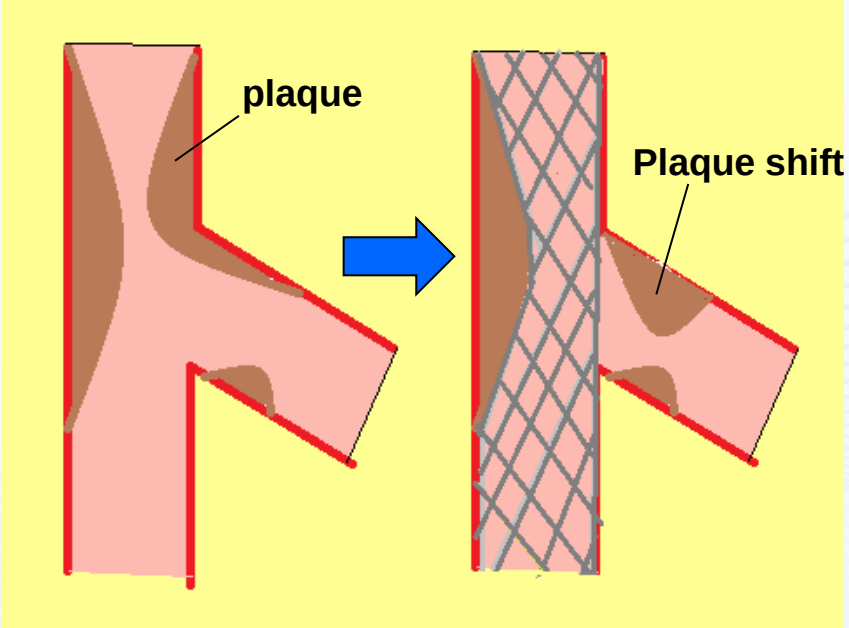
Primary End Point; MACE (cardiac death, target-lesion MI, ischemia-driven TLR)



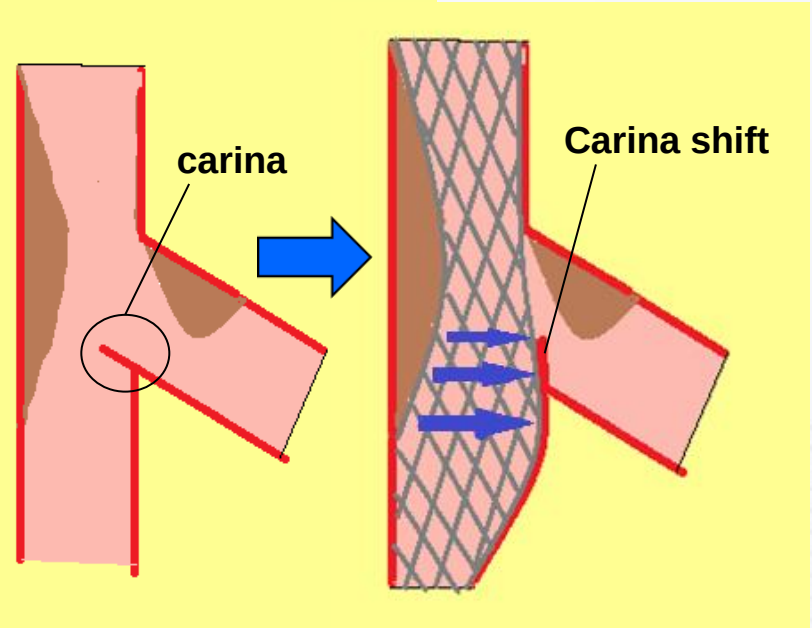
Holm NR, et al. N Engl J Med 2023; DOI: 10.1056/NEJMoa2307770

Mechanism of side branch occlusion after stenting

Although plaque shift, carina shift, side branch dissection, spasm, thrombus formation, etc. have been proposed as the cause of side branch occlusion, plaque shift and carina shift are thought to be main mechanisms of side branch occlusion .



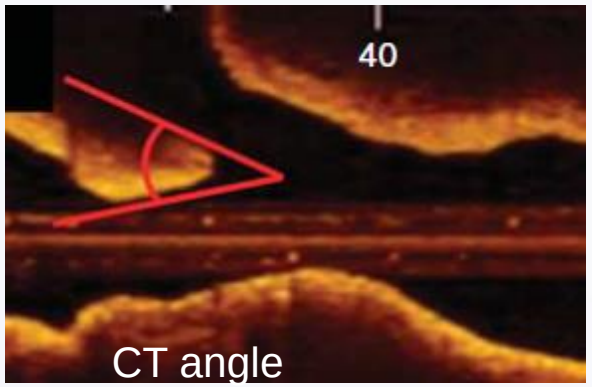
Plaque shift

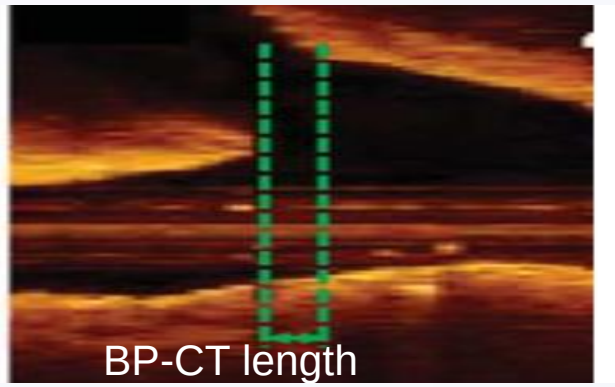


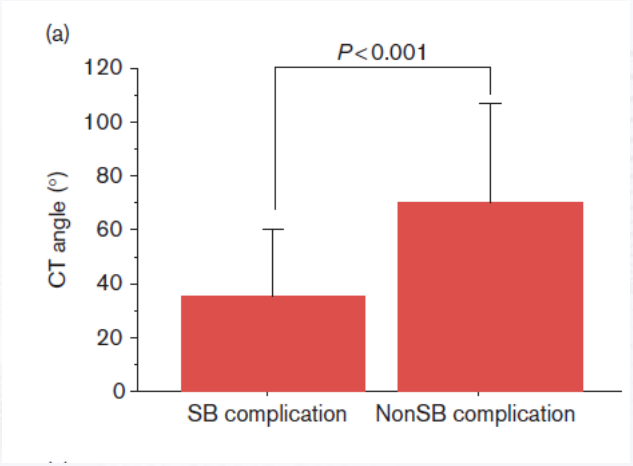
Carina shift

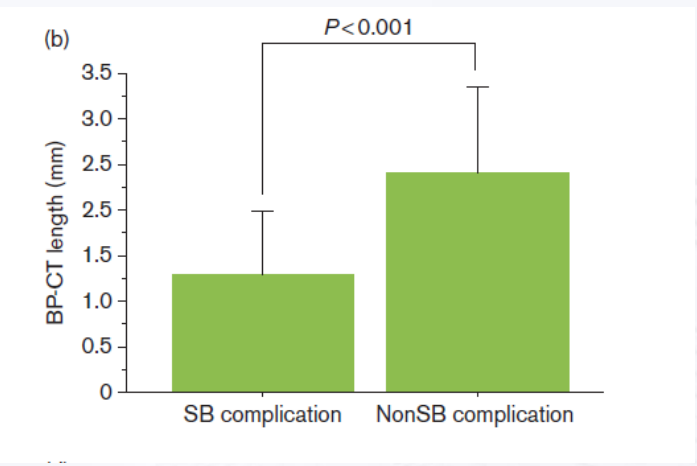
Prediction of side branch occlusion by carina shift using OCT

Side branch occlusion might be occurred less frequently in cases with carina tip (CT) angle≧50 degree and branch point to carina tip (BP-CT) length≧1.7mm.









Watanabe M et al. Coron Artery Dis 2014; 25: 321-329

Case; 85y.o, Male

Clinical Diagnosis

Effort AP

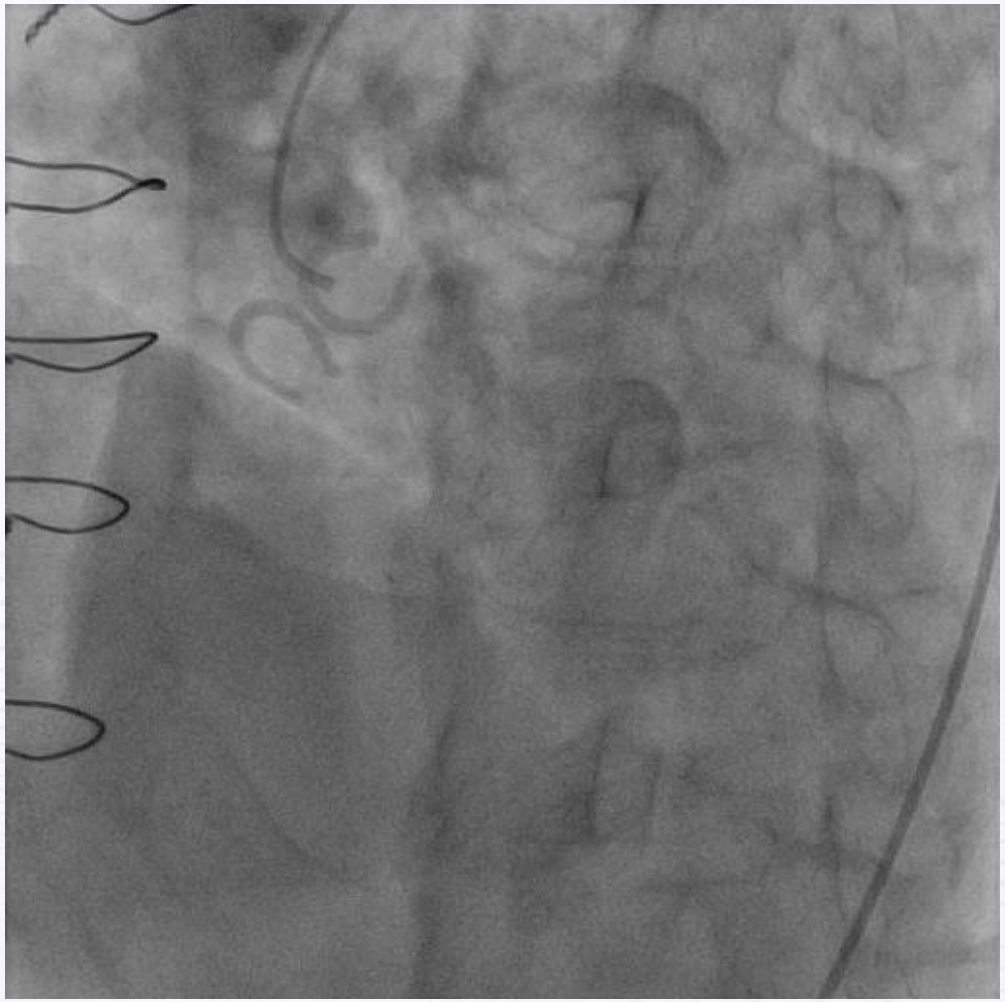
History

2012: CABG（SVG-LAD, SVG-DG） for unstable AP

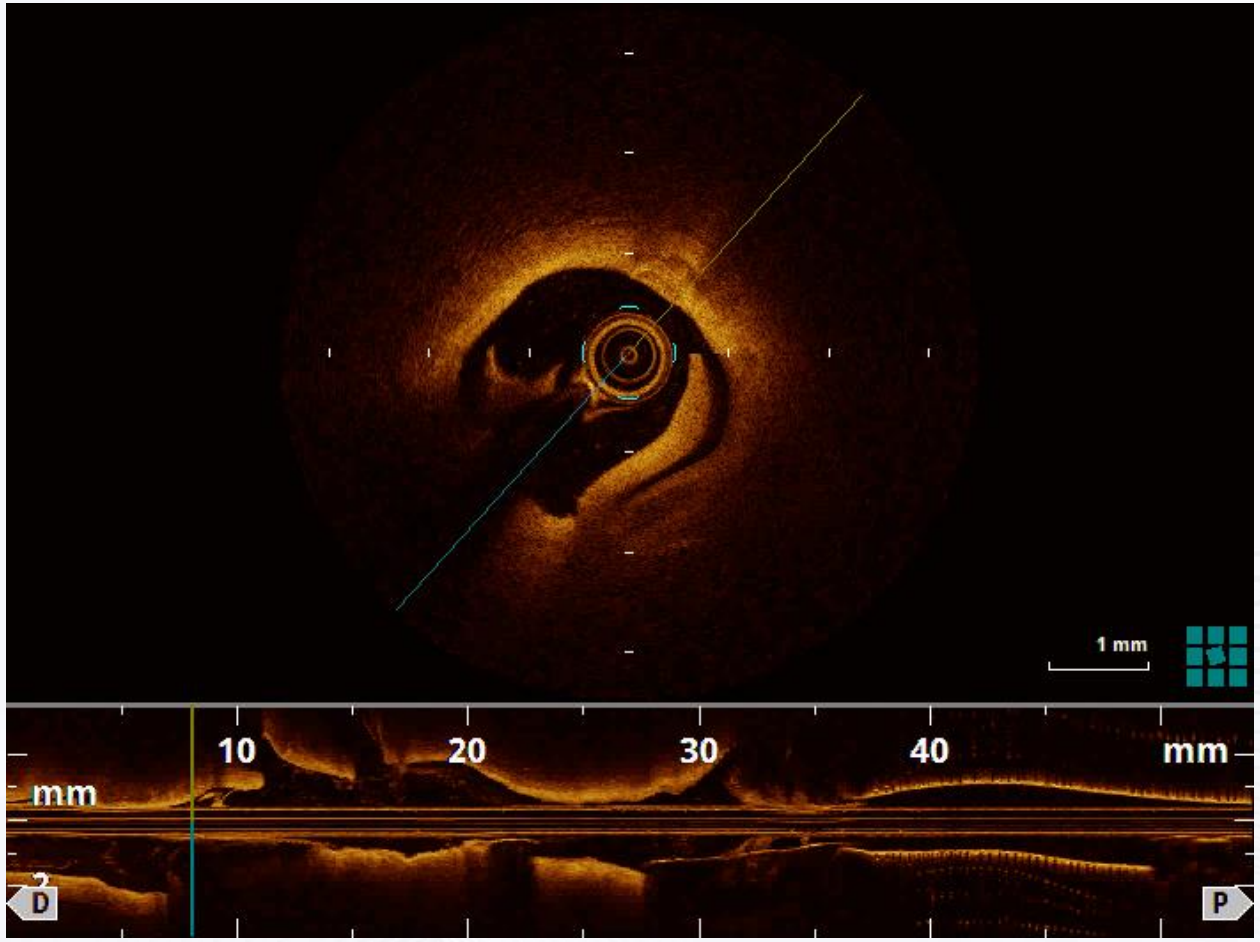
2014: Graft (SVG to LAD) stenosis by MDCT.

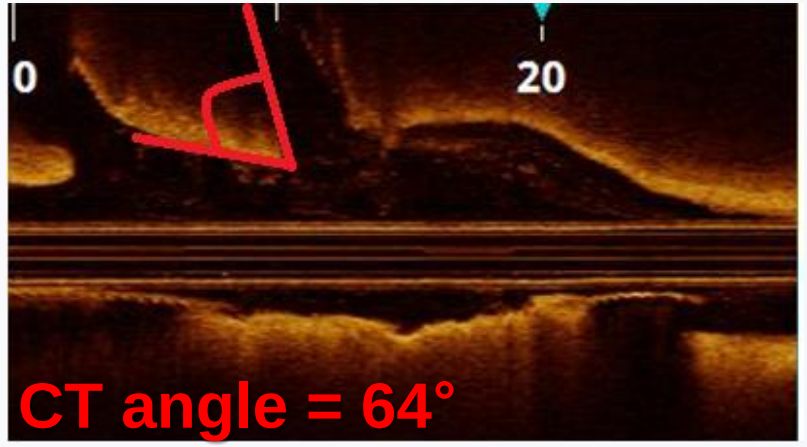
2016: Effort AP for 2-5 min during exercise

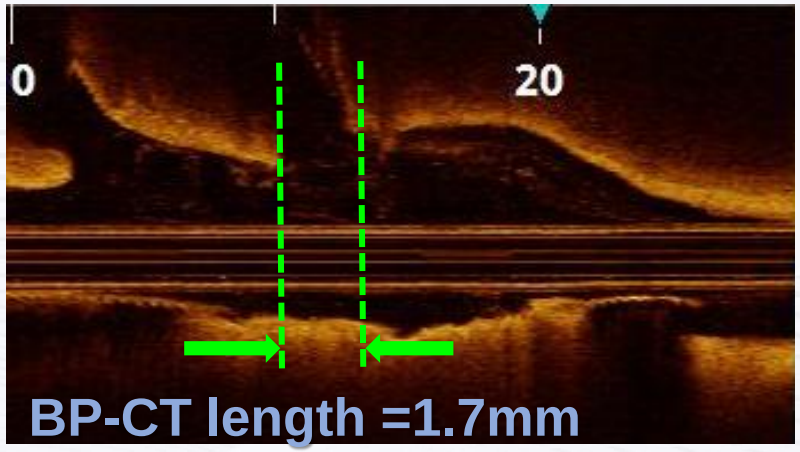
Coronary Angiography



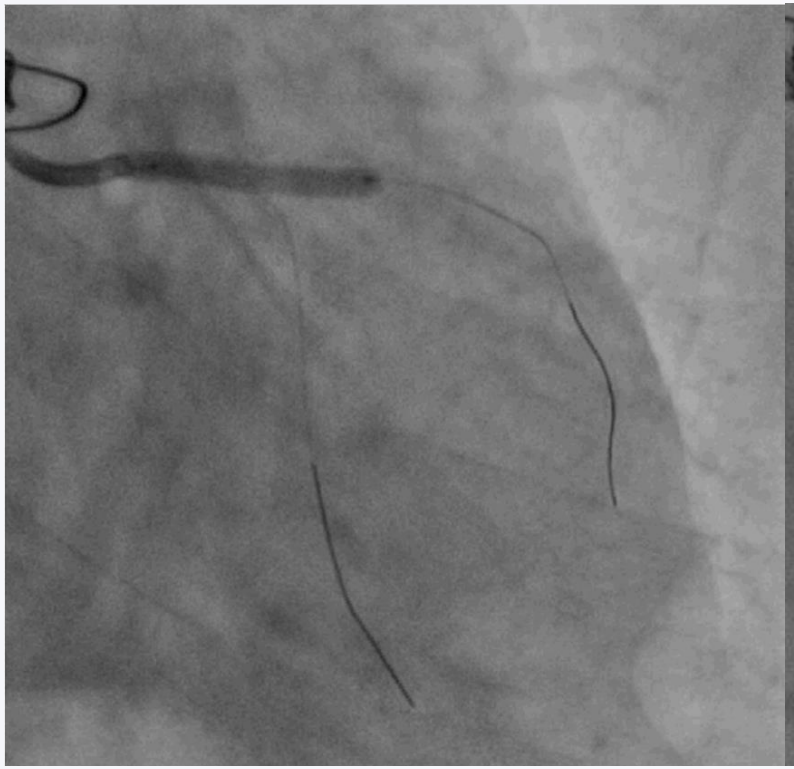
OCT before stenting for LM bifurcation

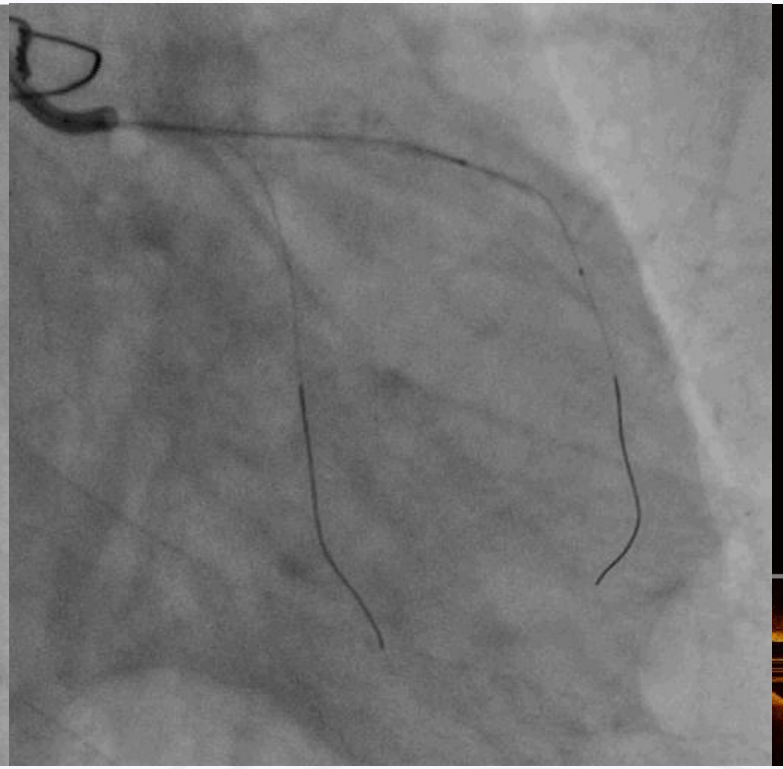


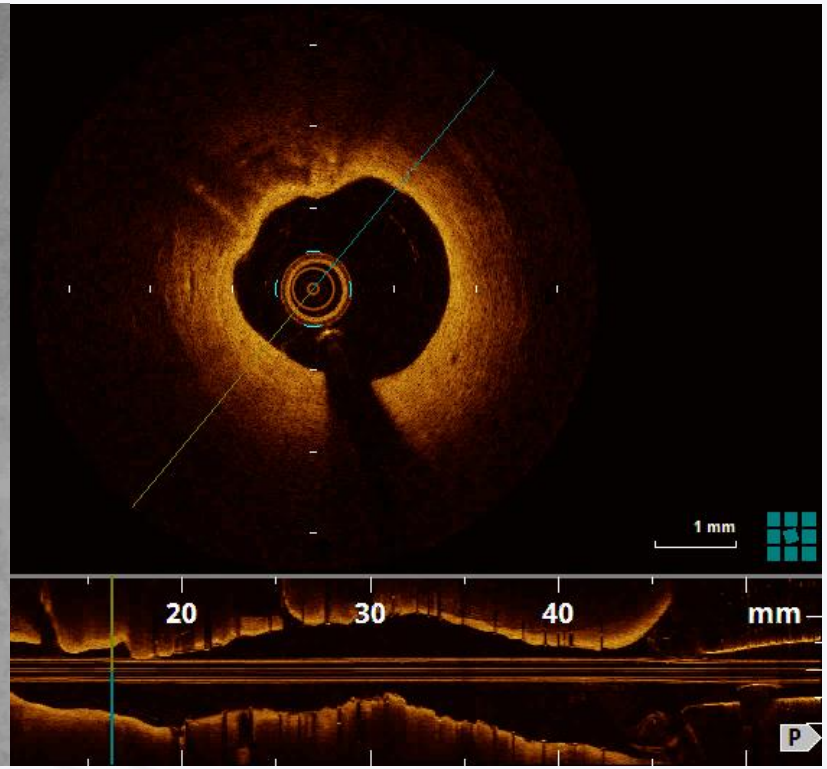


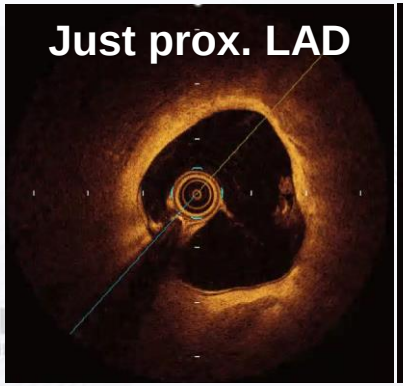


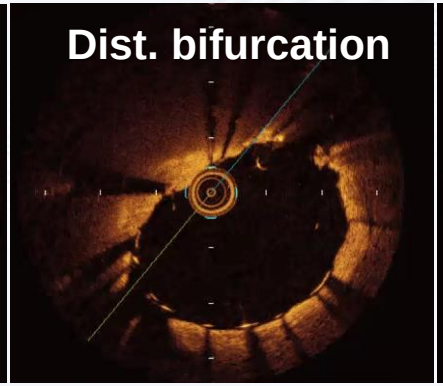
Angio. & OCT After Crossover Stenting

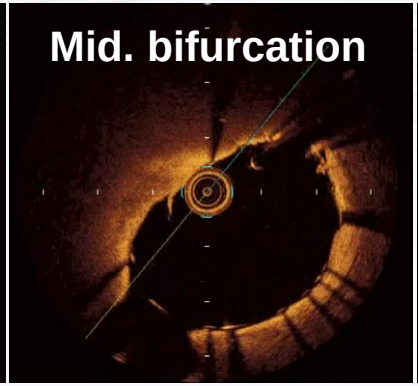


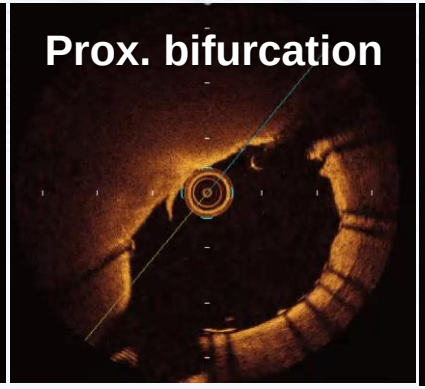


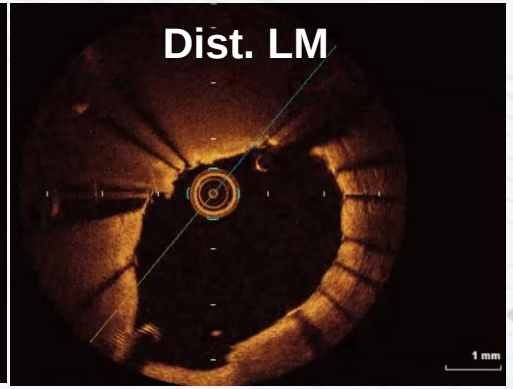








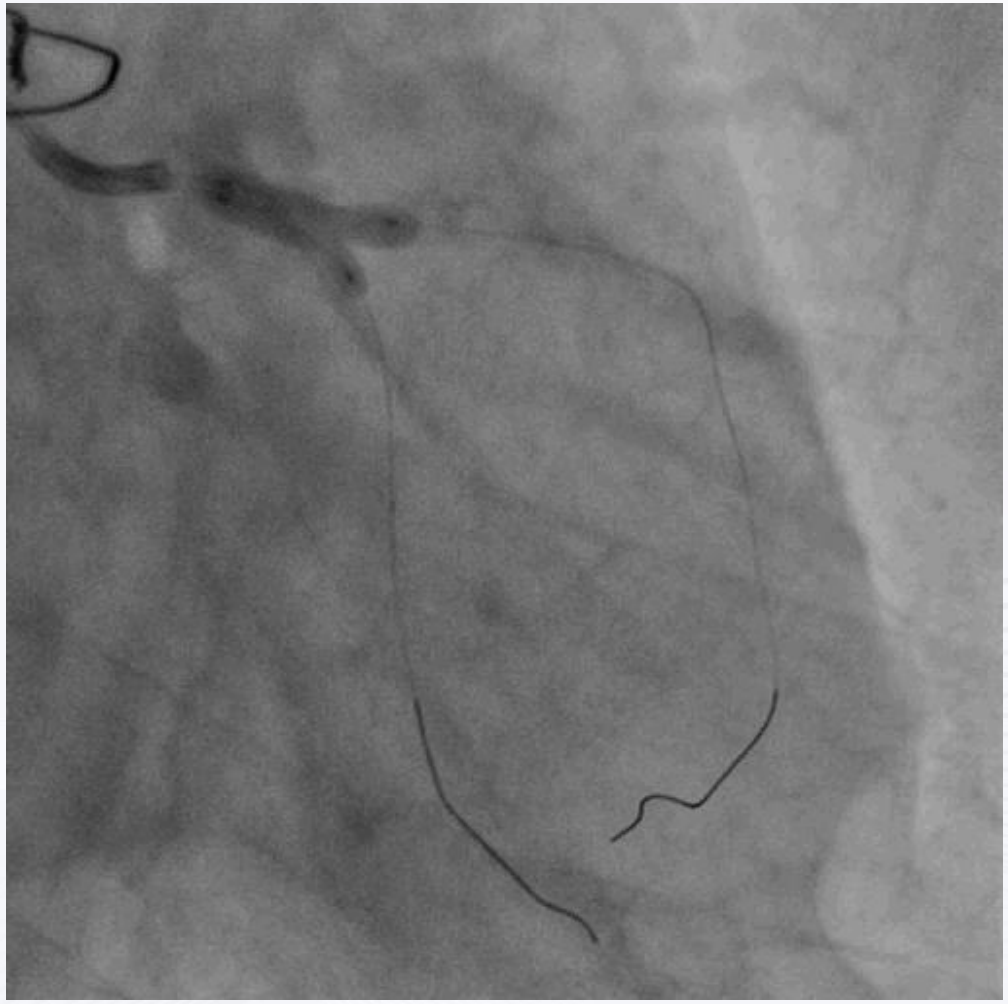


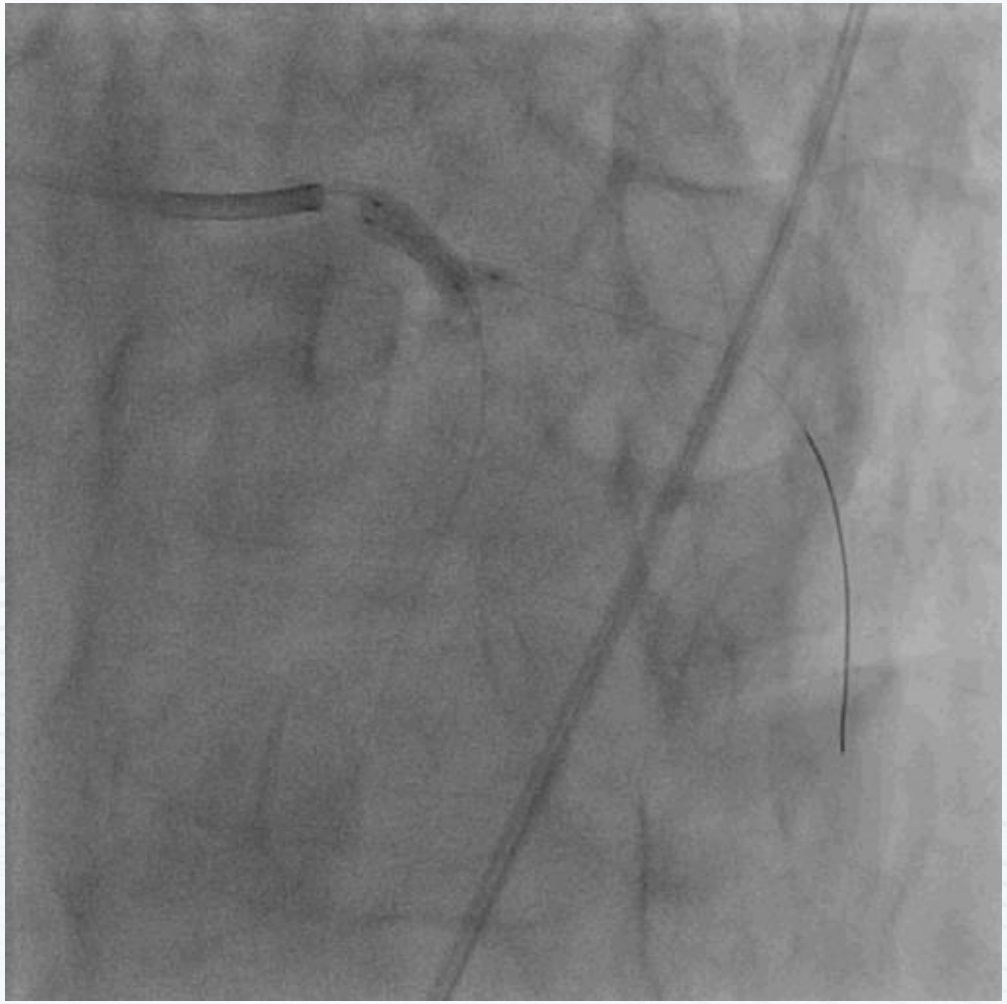


3D-OCT following to rewiring after crossover stenting & POT

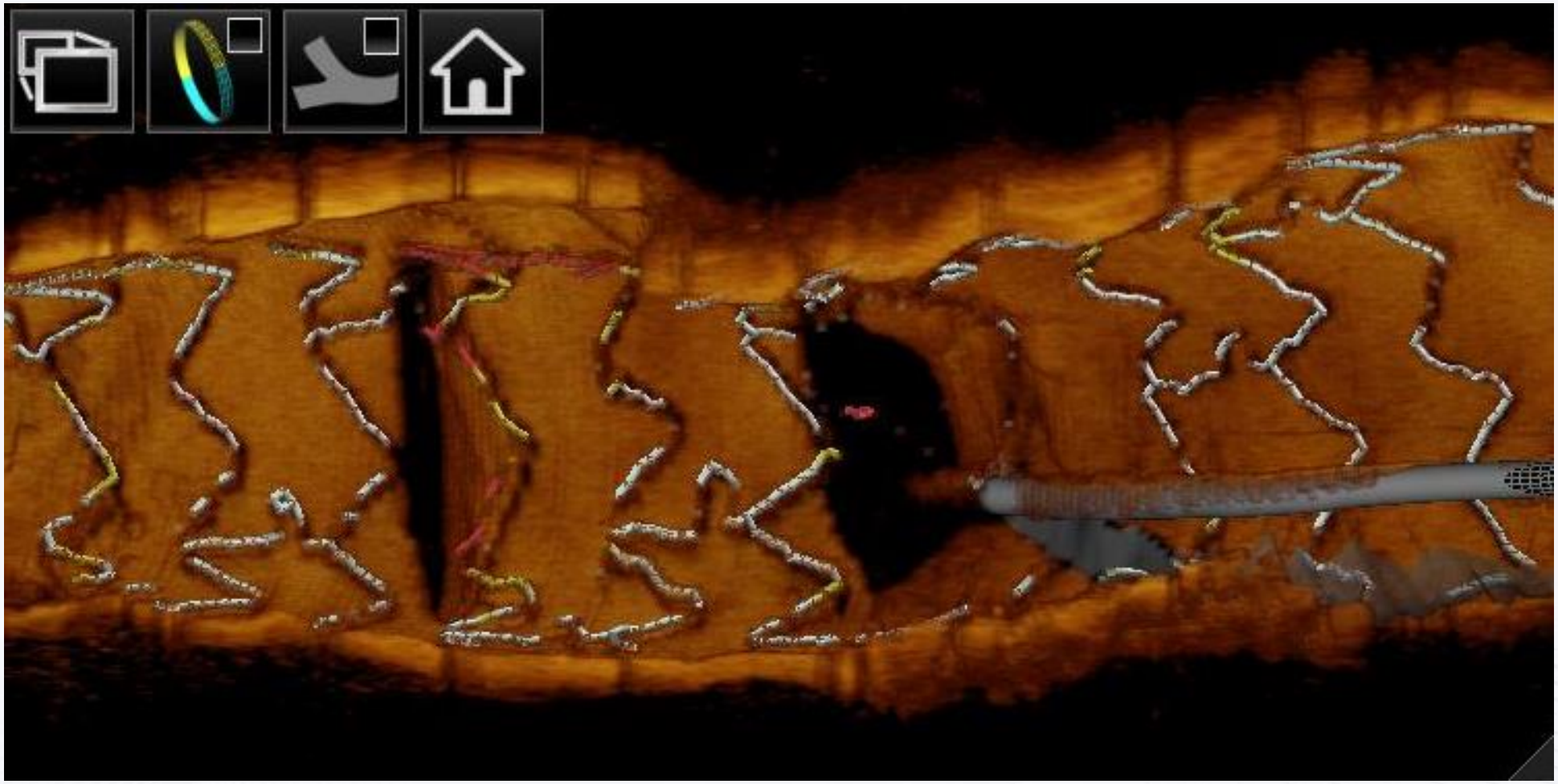
Link free type

KBT after POT

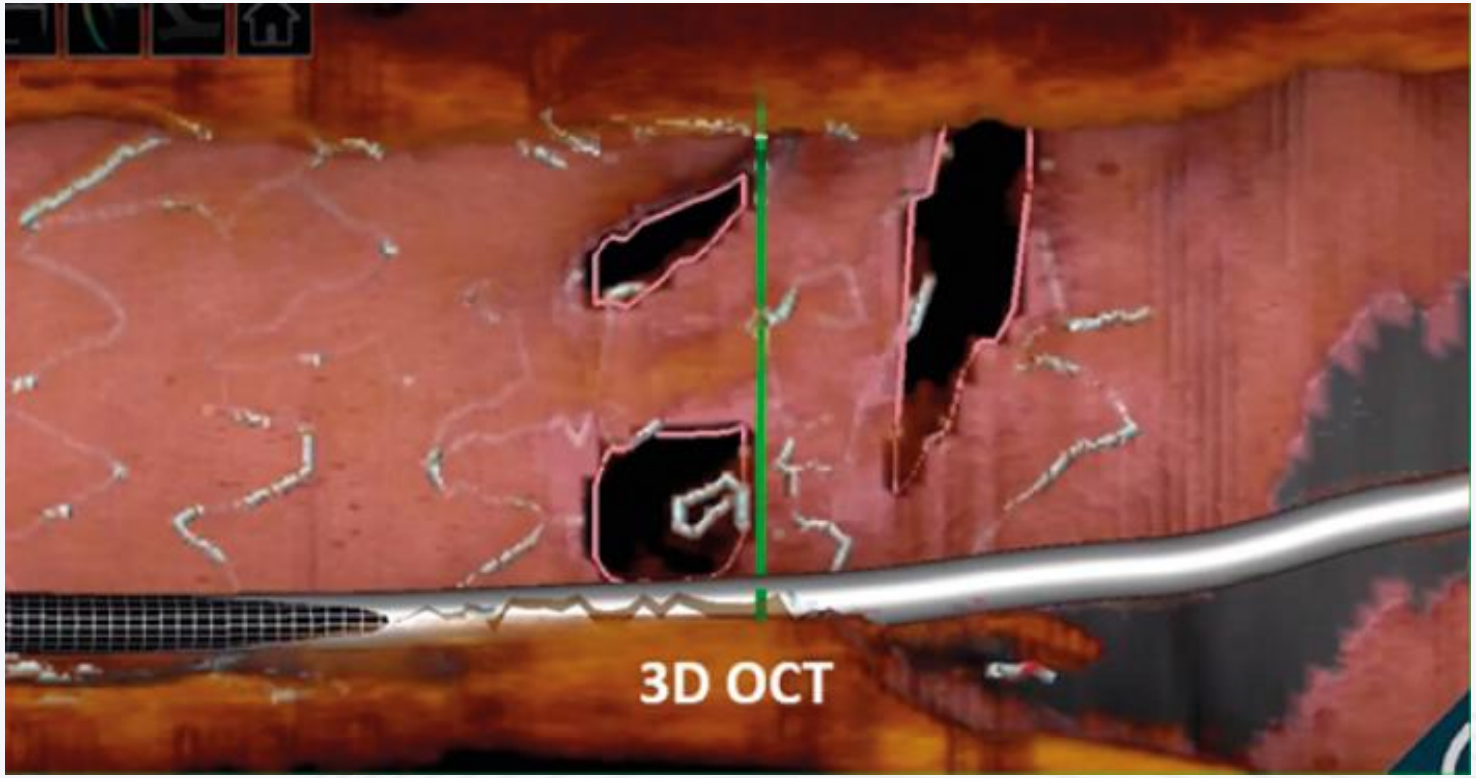




3D-OCT after POT & KBT



Representative 3D-OCT image of LCx restenosis after LM bifurcation stenting

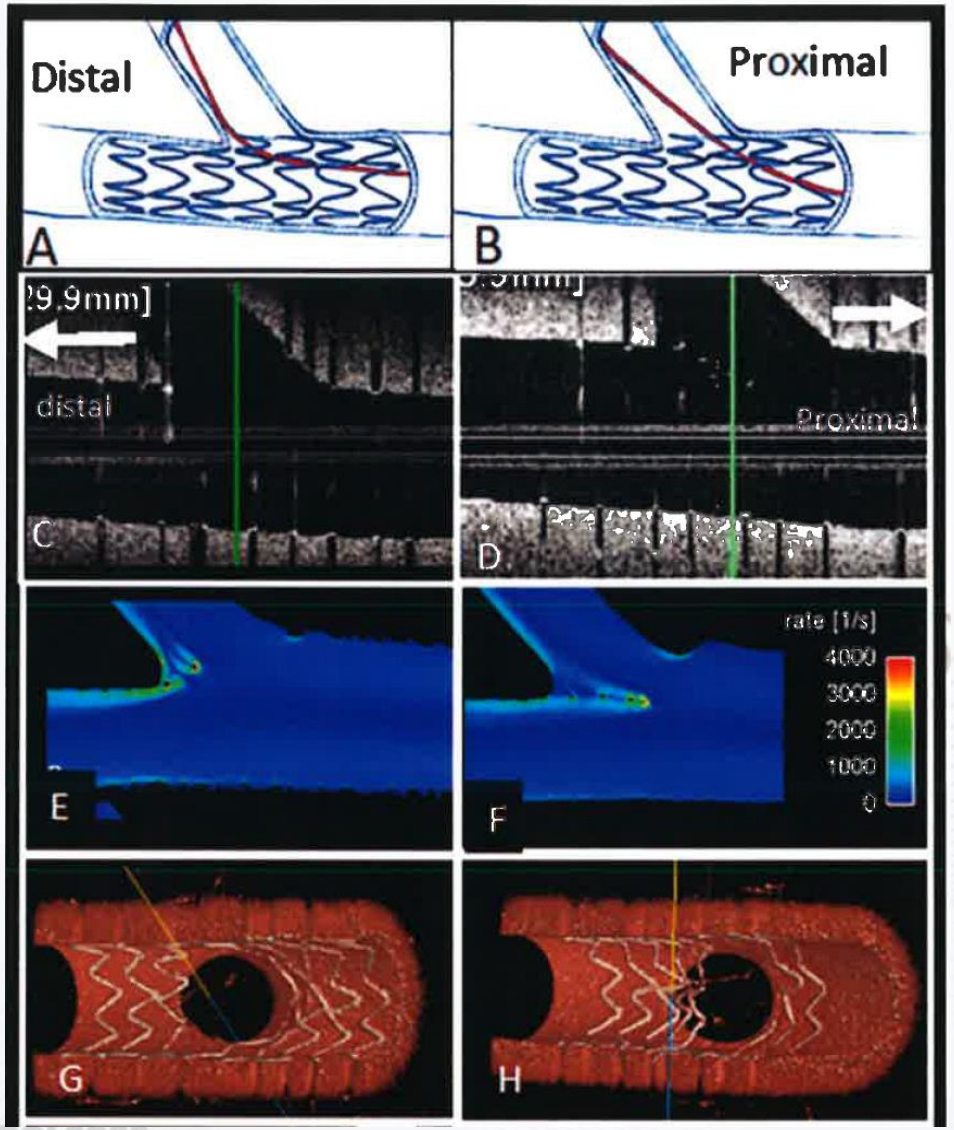


3D-OCT clearly demonstrates restenosis by the neointimal proliferation at the LM bifurcation with 3 LCx different orifices (1 proximal and 2 distal).

Impact of the rewiring position

Strut malapposition & shear stress

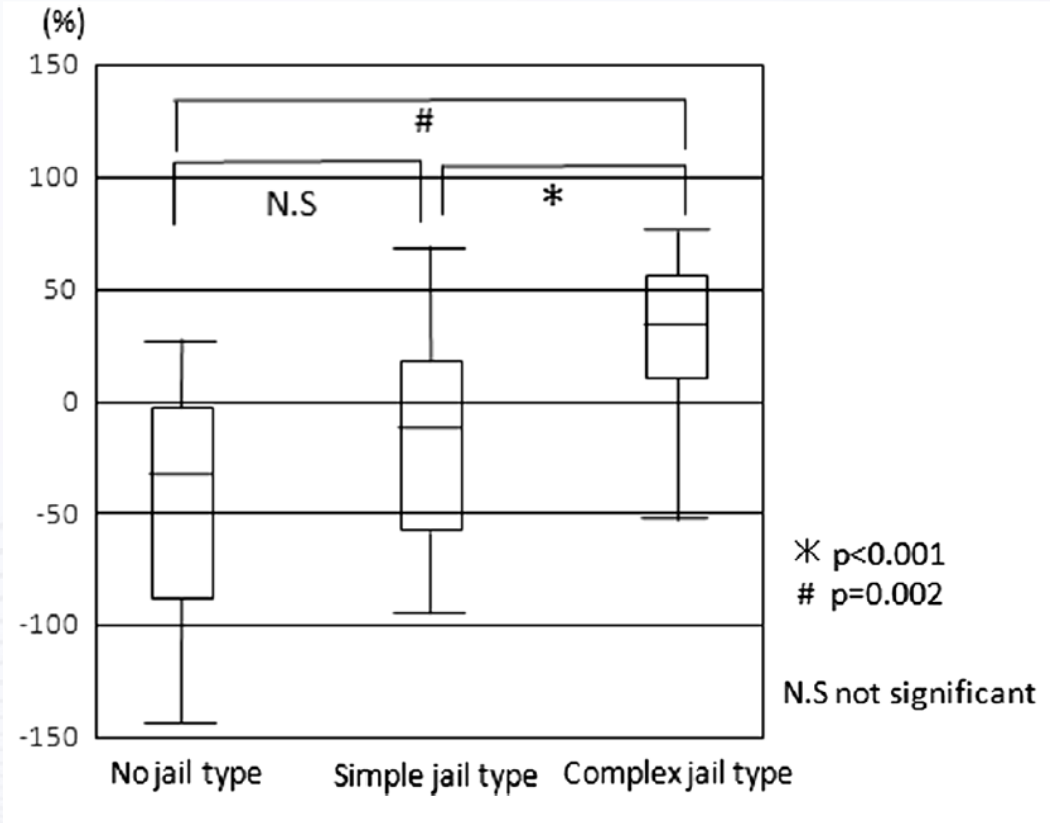
Onuma Y, et al. EuroInterv 2018, doi: 10.4244/EIJ-D-18-00391



Comparison of % reduction of the side branch flow area

Comparison among each jailed type

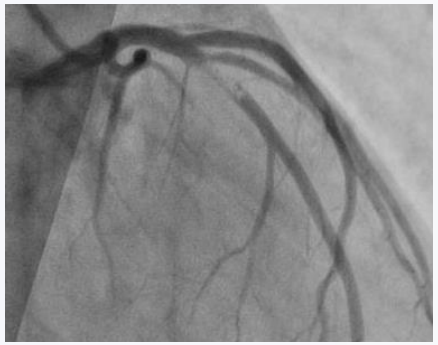
Nakamura T, et al. Int J CV Imag 2017;33: 797 – 806



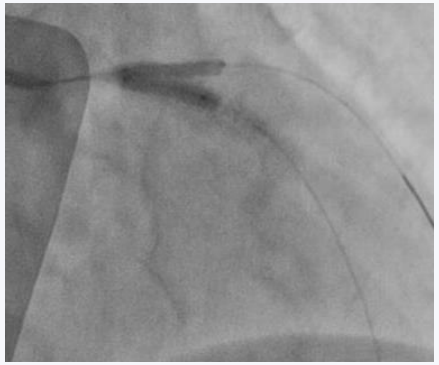
Residual stent strut on the surface of bifurcation orifice may reduce the side branch flow area during follow up.

3D OCT images for bifurcation PCI

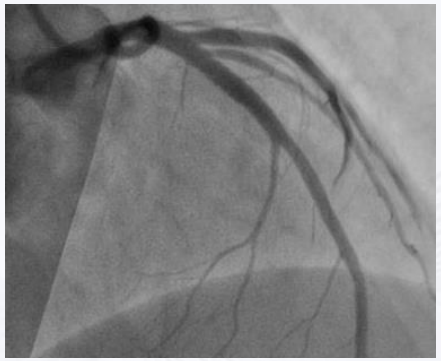
Before PCI



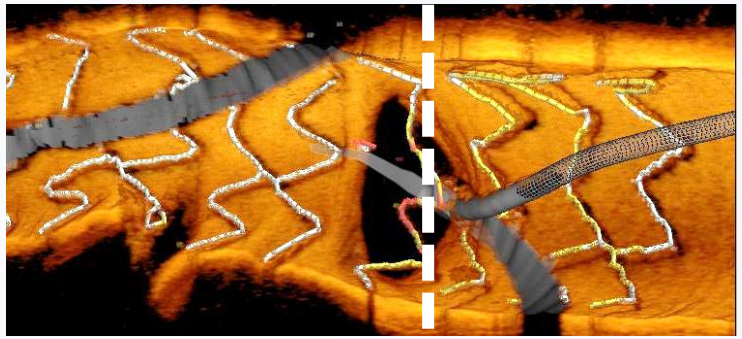
During KBT



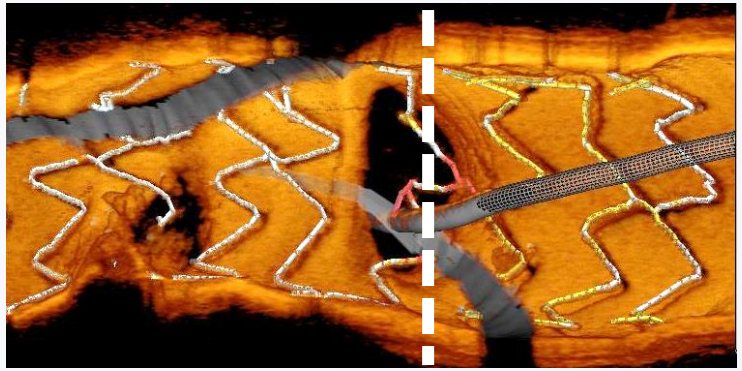
After PCI



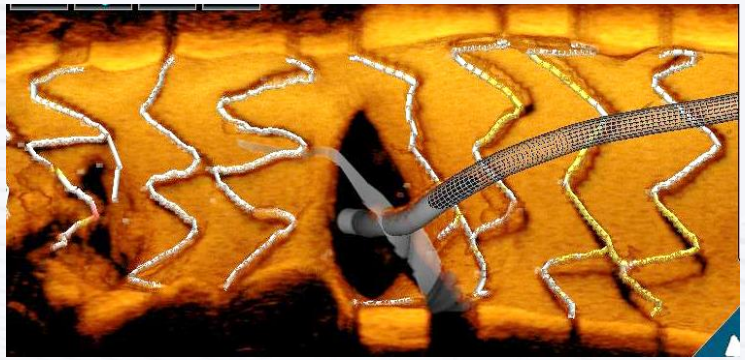
Before re-wiring

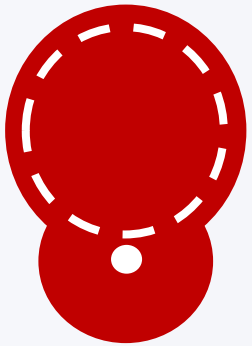


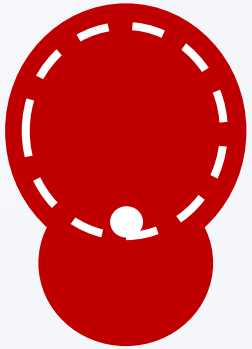
After re-wiring before KBT



After KBT

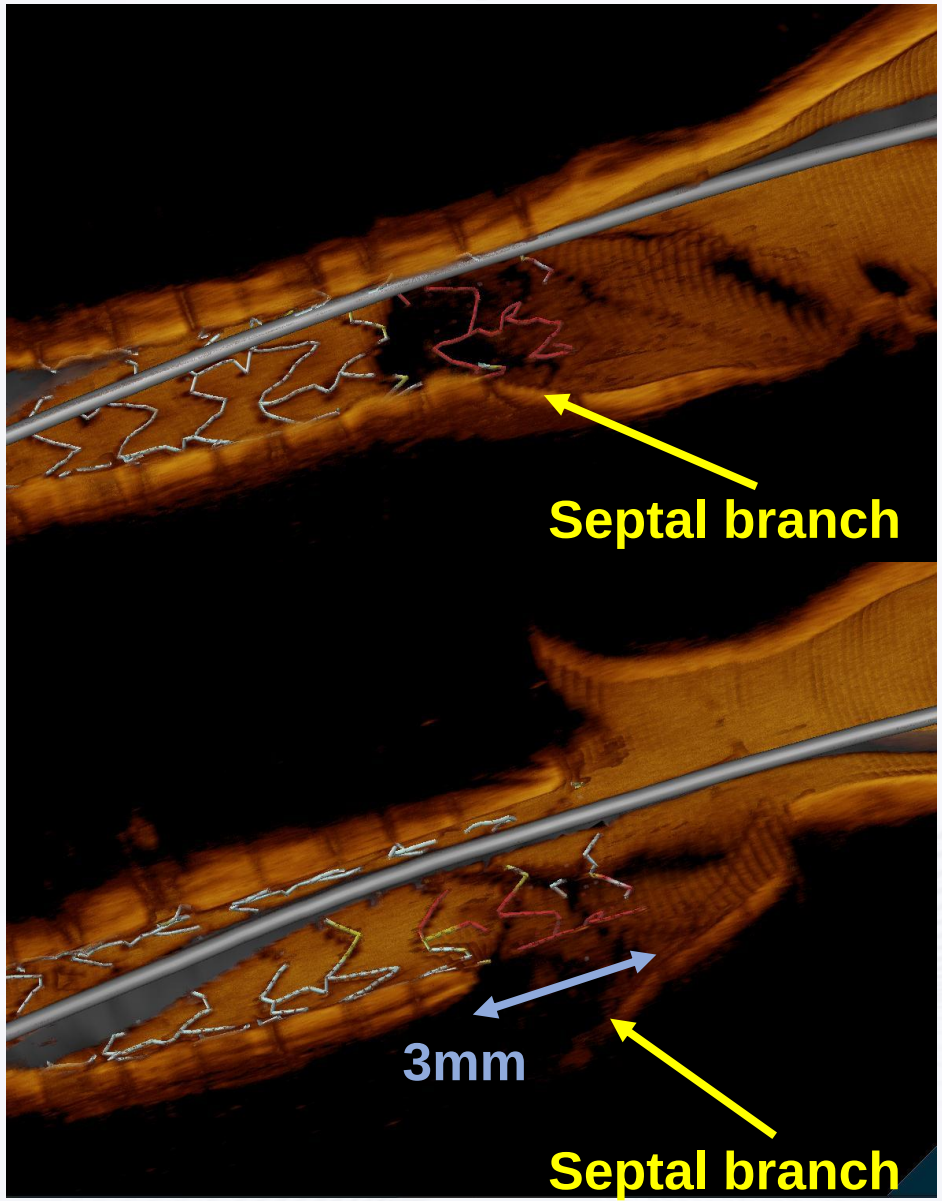


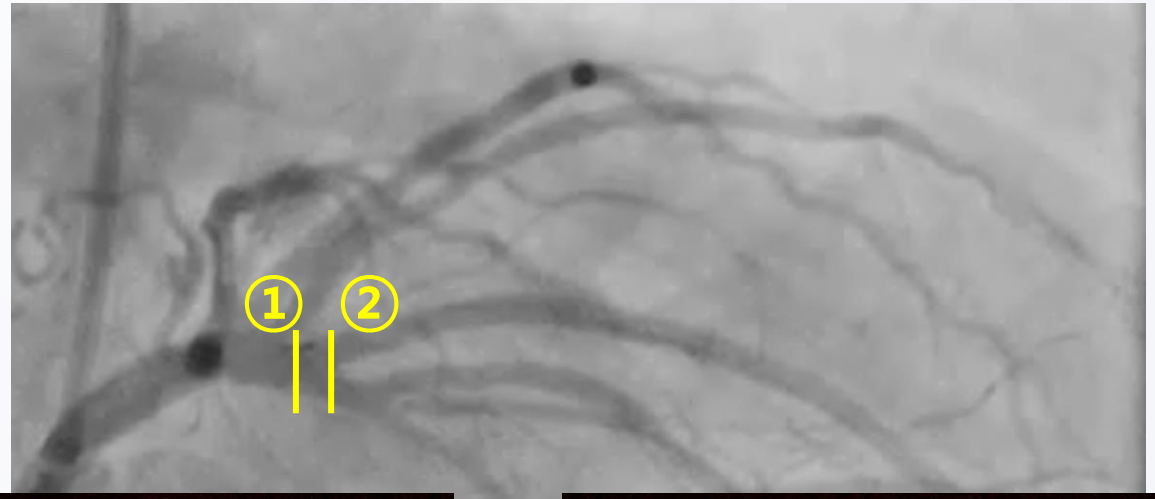


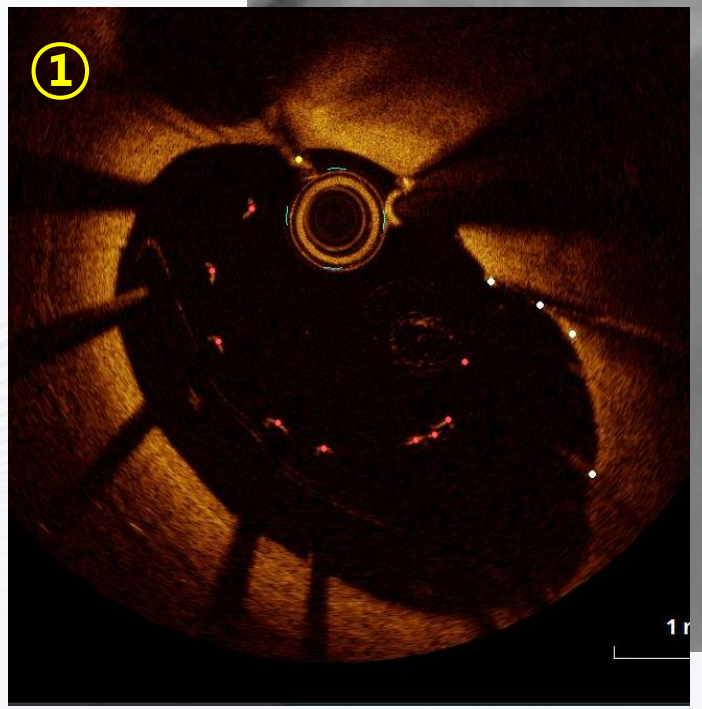


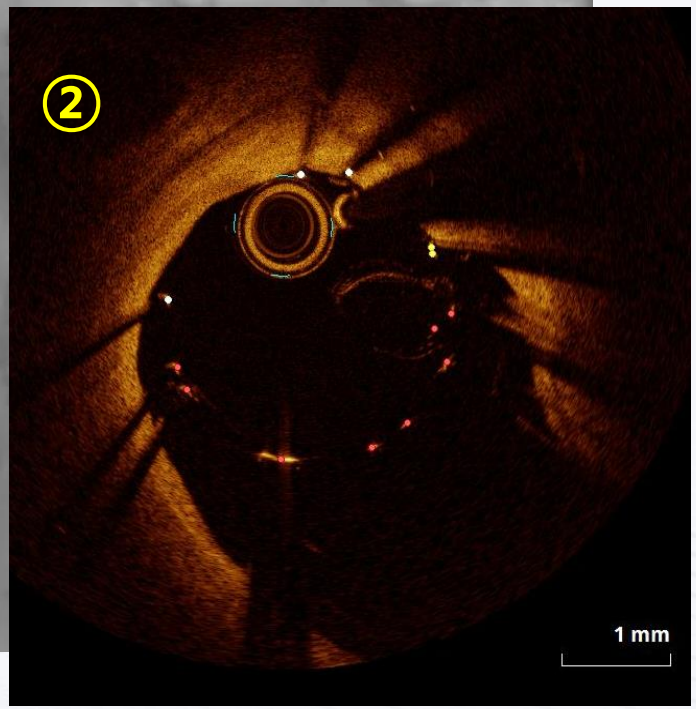
Stent strut & wire position around the side branch can be easily assessed and improvement of side branch KBT procedure could be expected by the guidance of newly developed OCT.

An example of incomplete apposition at the bifurcation



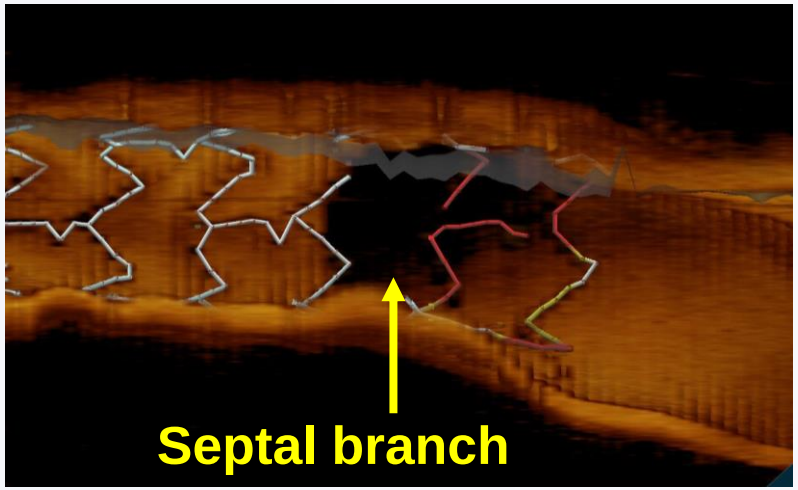


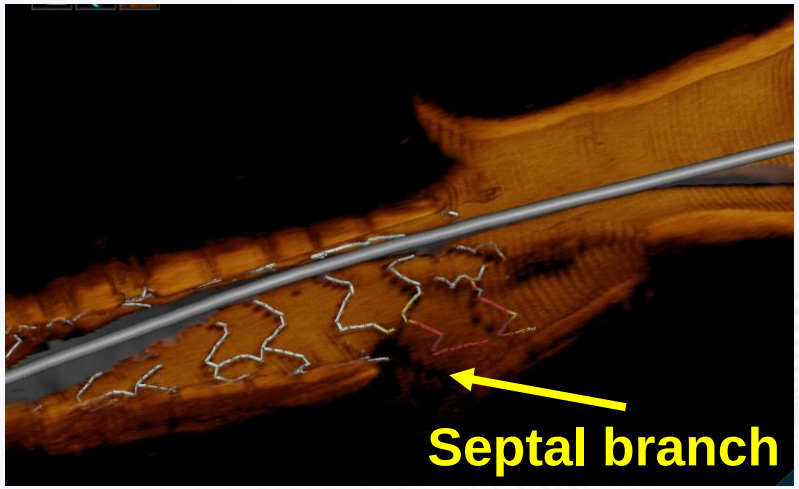




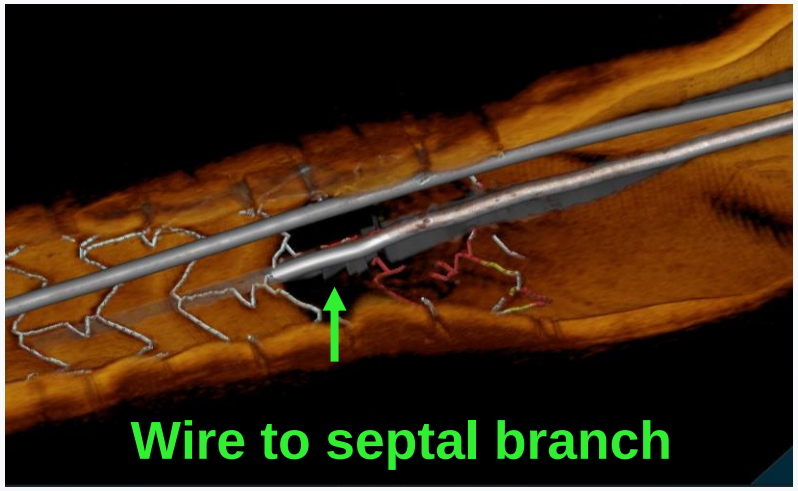
3D-OCT after POT, Wire Re-cross & Final KBT

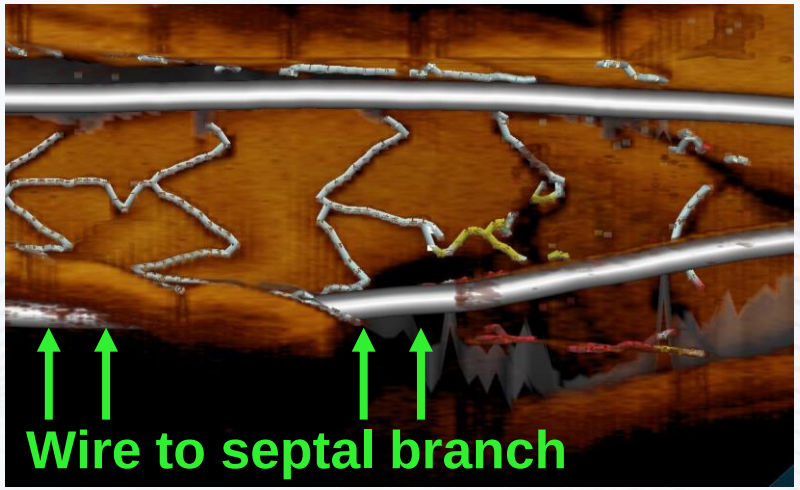
After POT



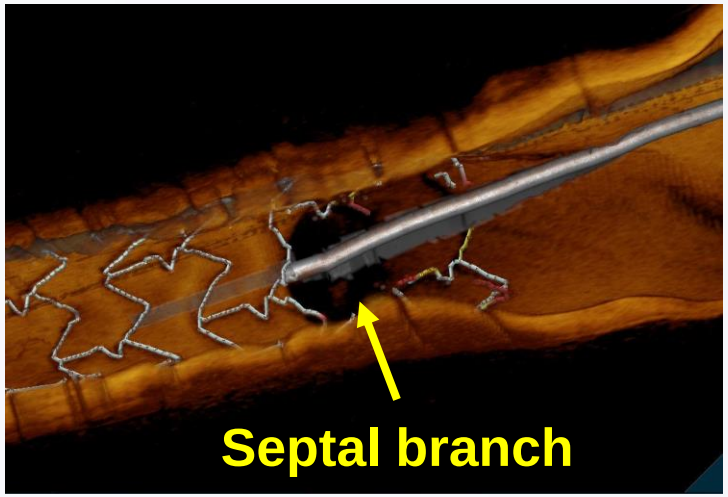


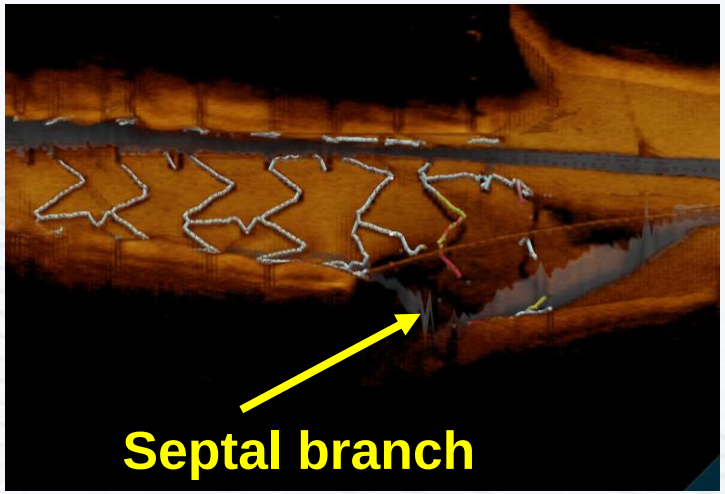
After wire re-cross





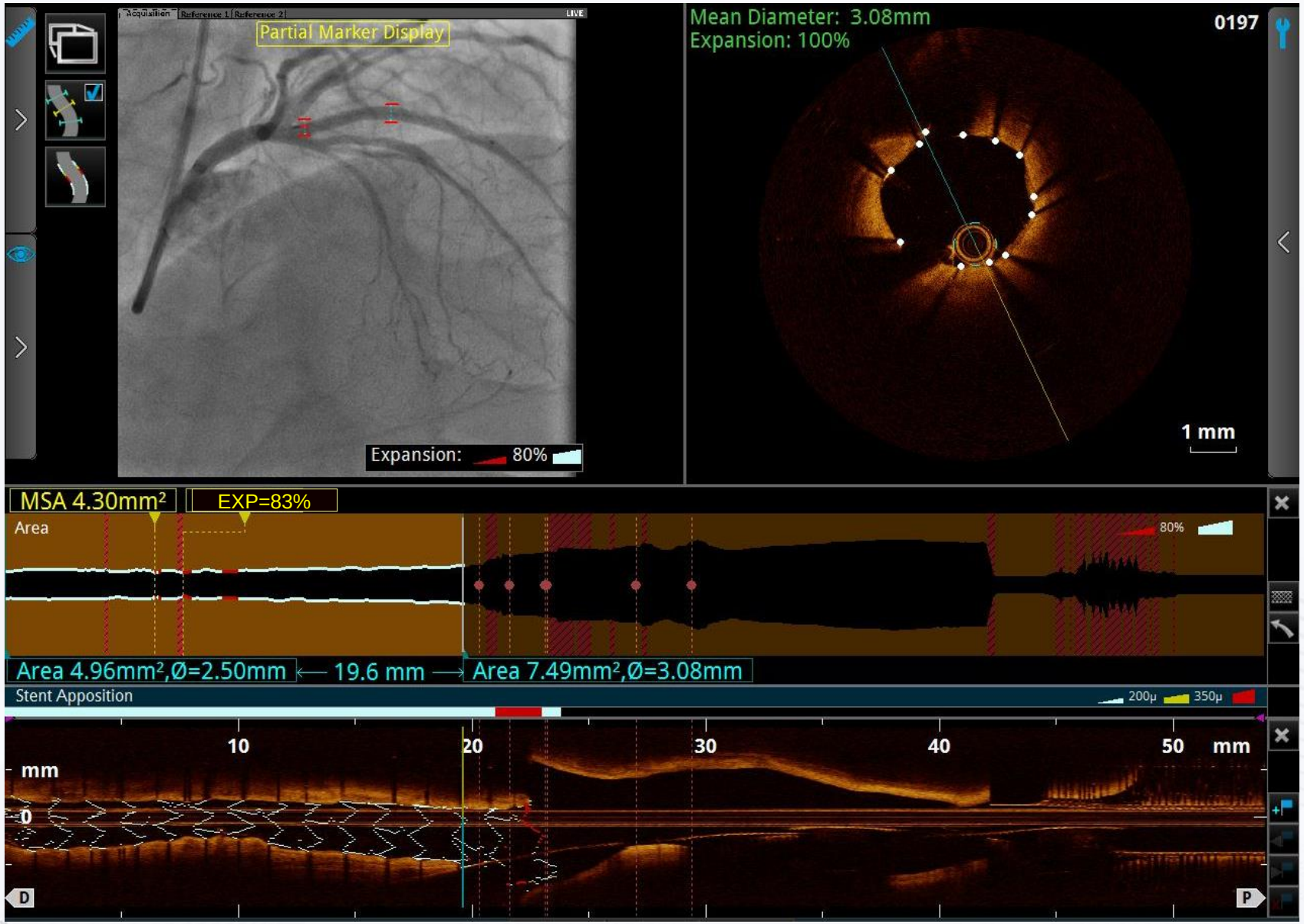
After final KBT

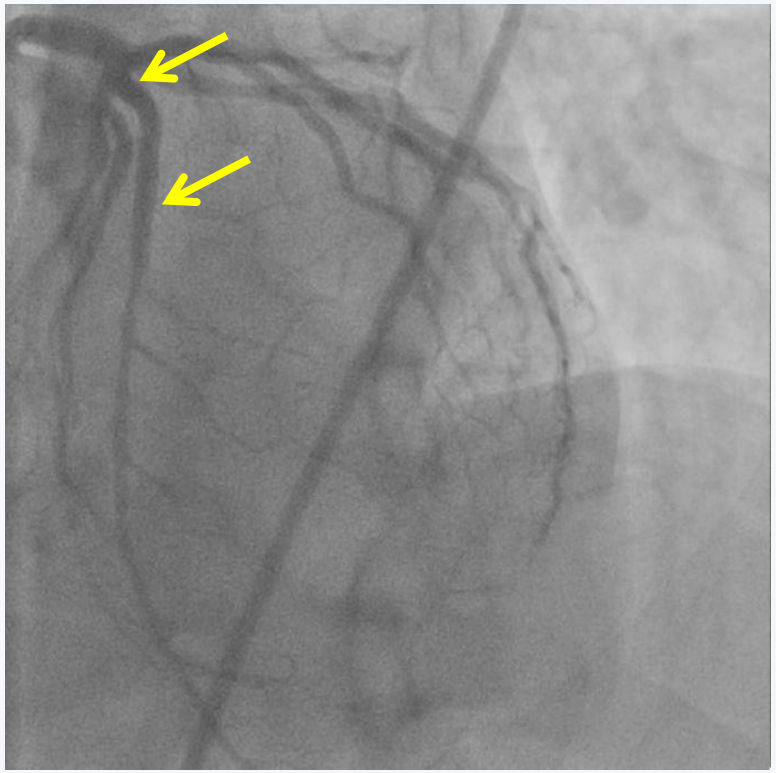




After POT, a link free stent cell can be identified clearly at the distal site of the side branch, and it seems to be easy to recross the wire through this cell.

Angiography & Angio-corregistration OCT after KBT

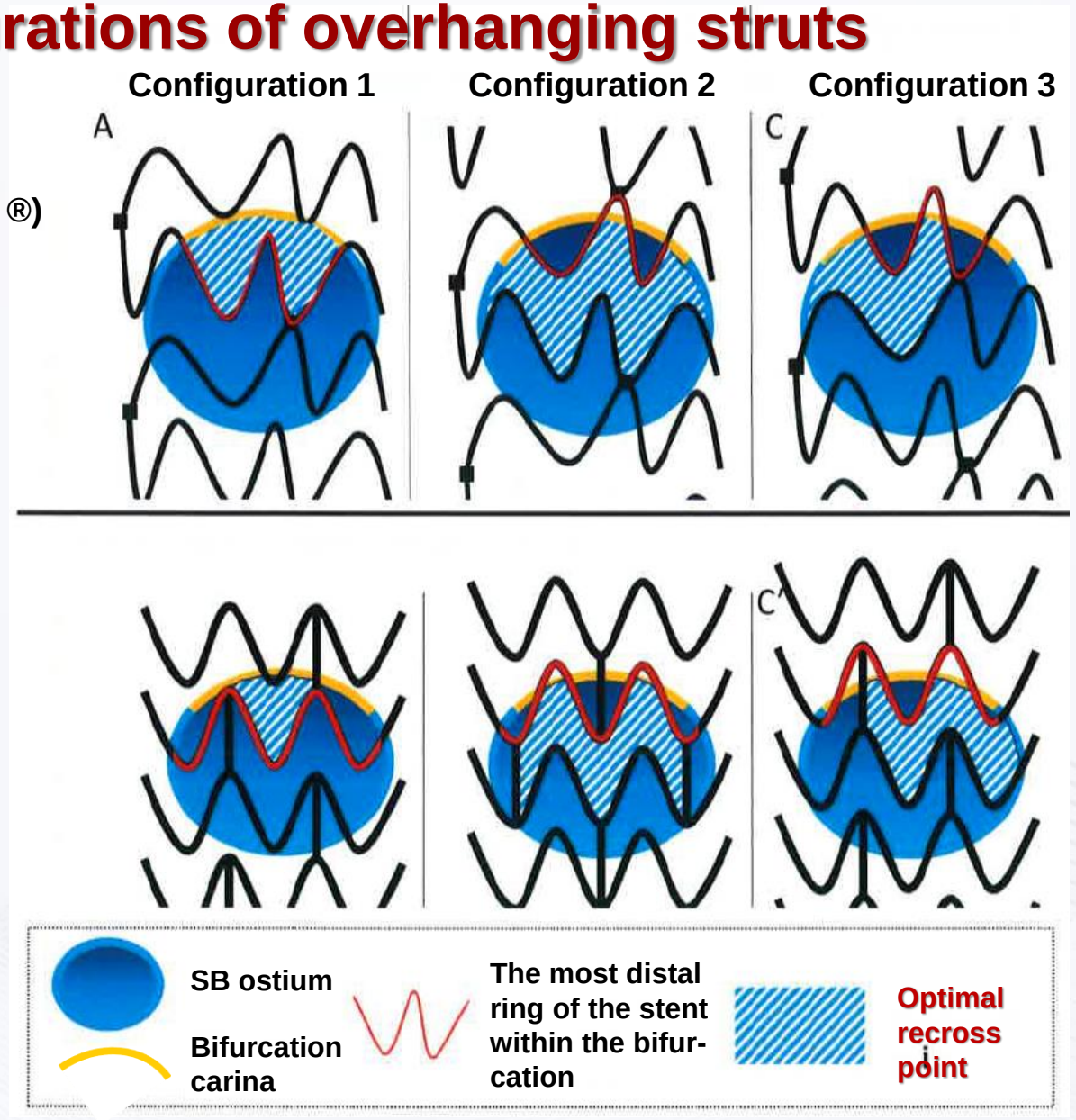




Optimal rewiring point at the side branch ostium according to different configurations of overhanging struts

Out-of-phase,
Peak to peak design
(Ultimaster ® , Resolute ®)

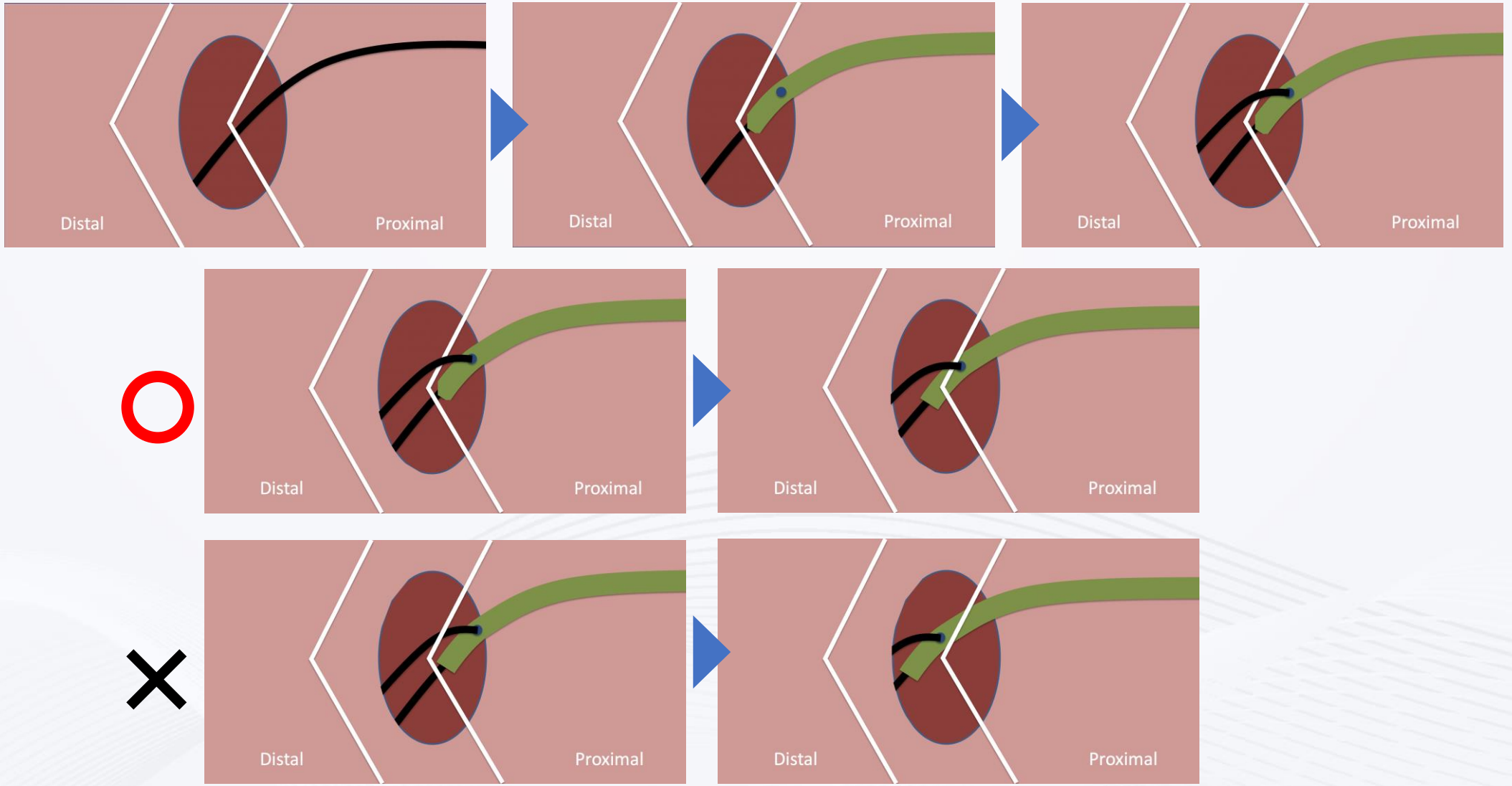
In-phase,
Peak to valley design
(Xience ®)



Onuma Y, et al. EuroInterv 2019;14:e1568-e1577

3D-OCT guided ideal cell selection for bifurcation PCI

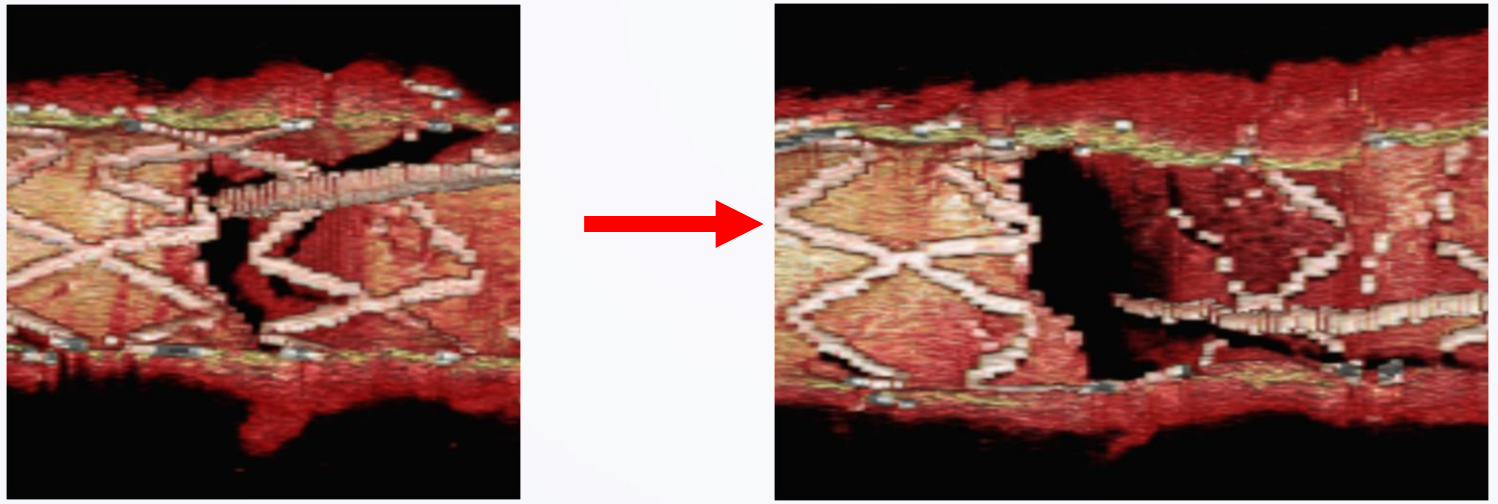
DLC (dual lumen catheter) occlusion technique



Courtesy by Dr. T. Sugaya (Hanaoka Seishu Memorial Hosp.)

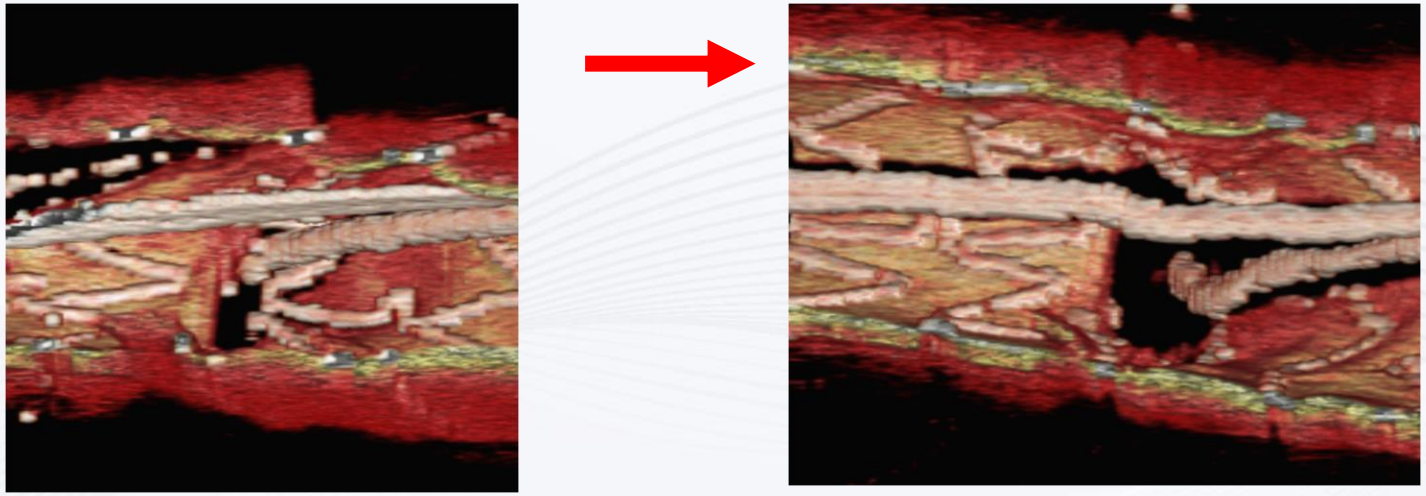
3D OCT images of bifurcation PCI

Link Free type



GW distal cell re-cross and KBT

After kissing ballooning



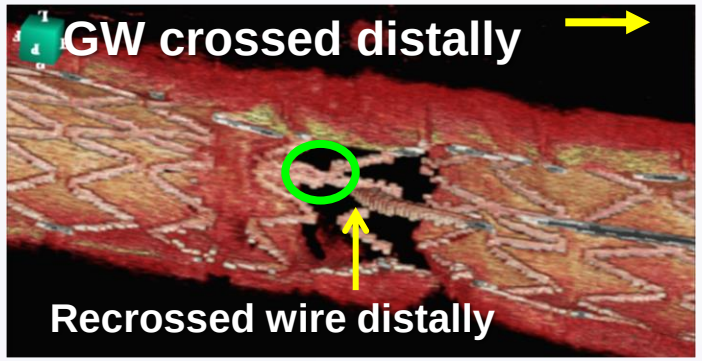
Optimal

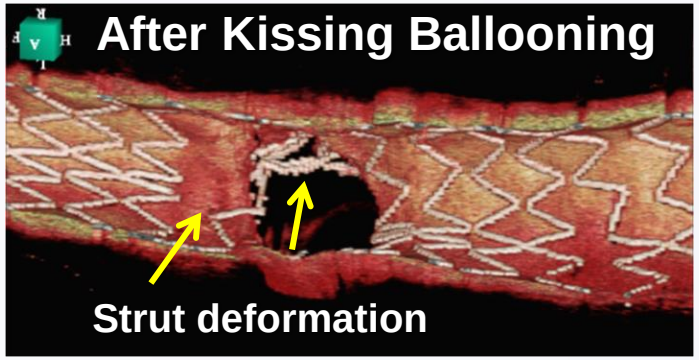
Okamura T, et al. EuroIntervention 2018;13:e1785-e1793

3D OCT images of bifurcation PCI

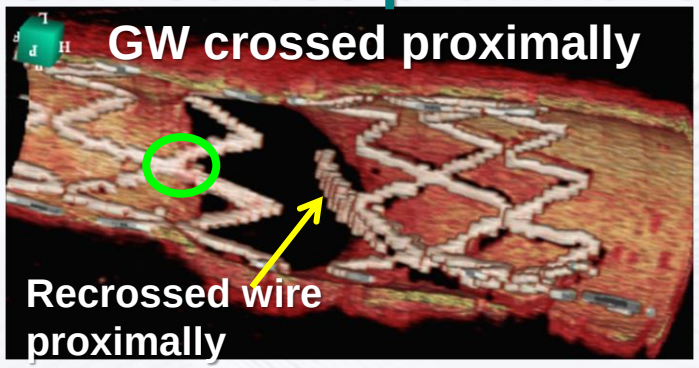
Link connecting to carina type

GW recross distal cell





GW recross proximal cell

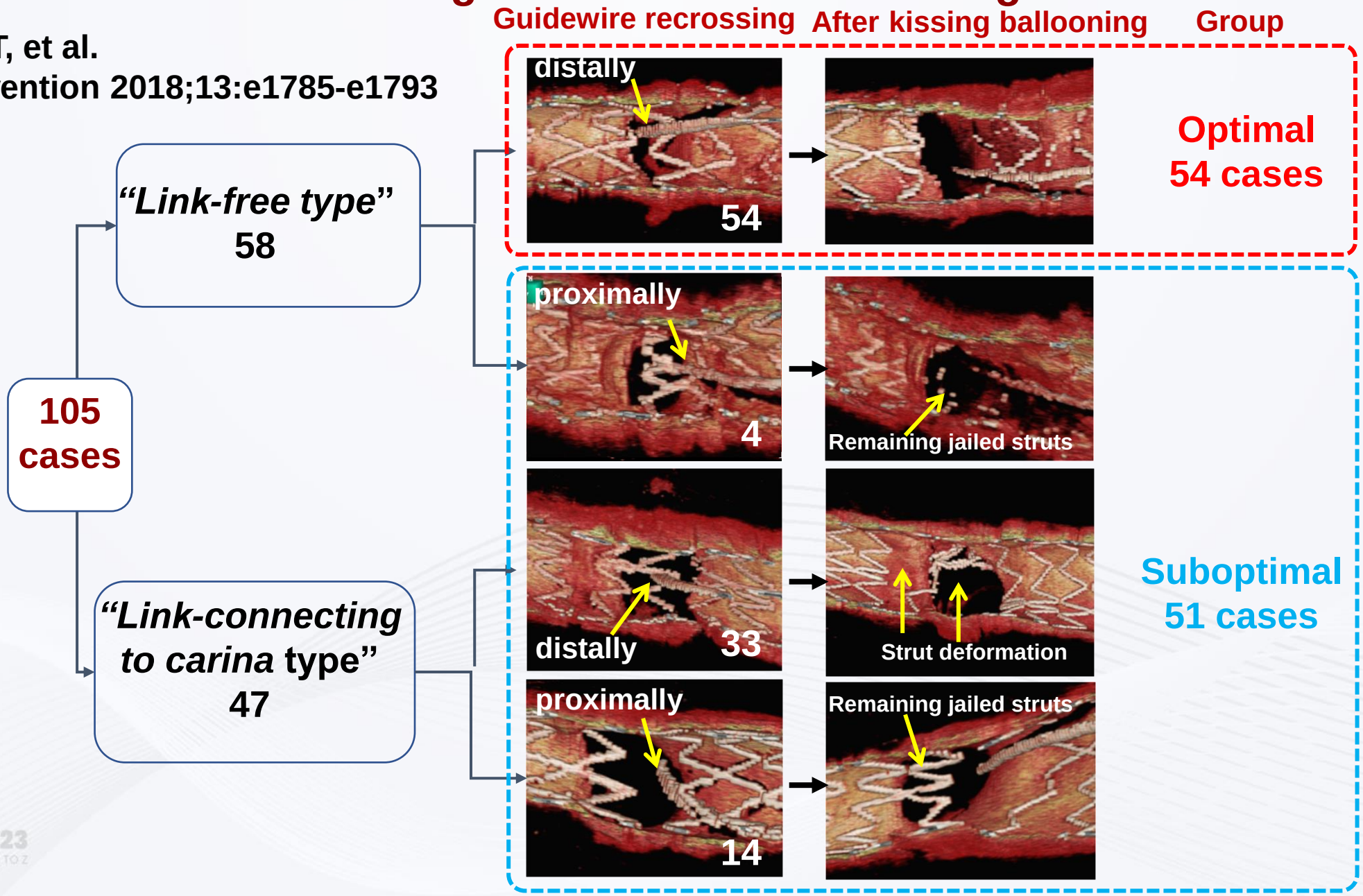


suboptimal

Okamura T, et al. EuroIntervention 2018;13:e1785-e1793

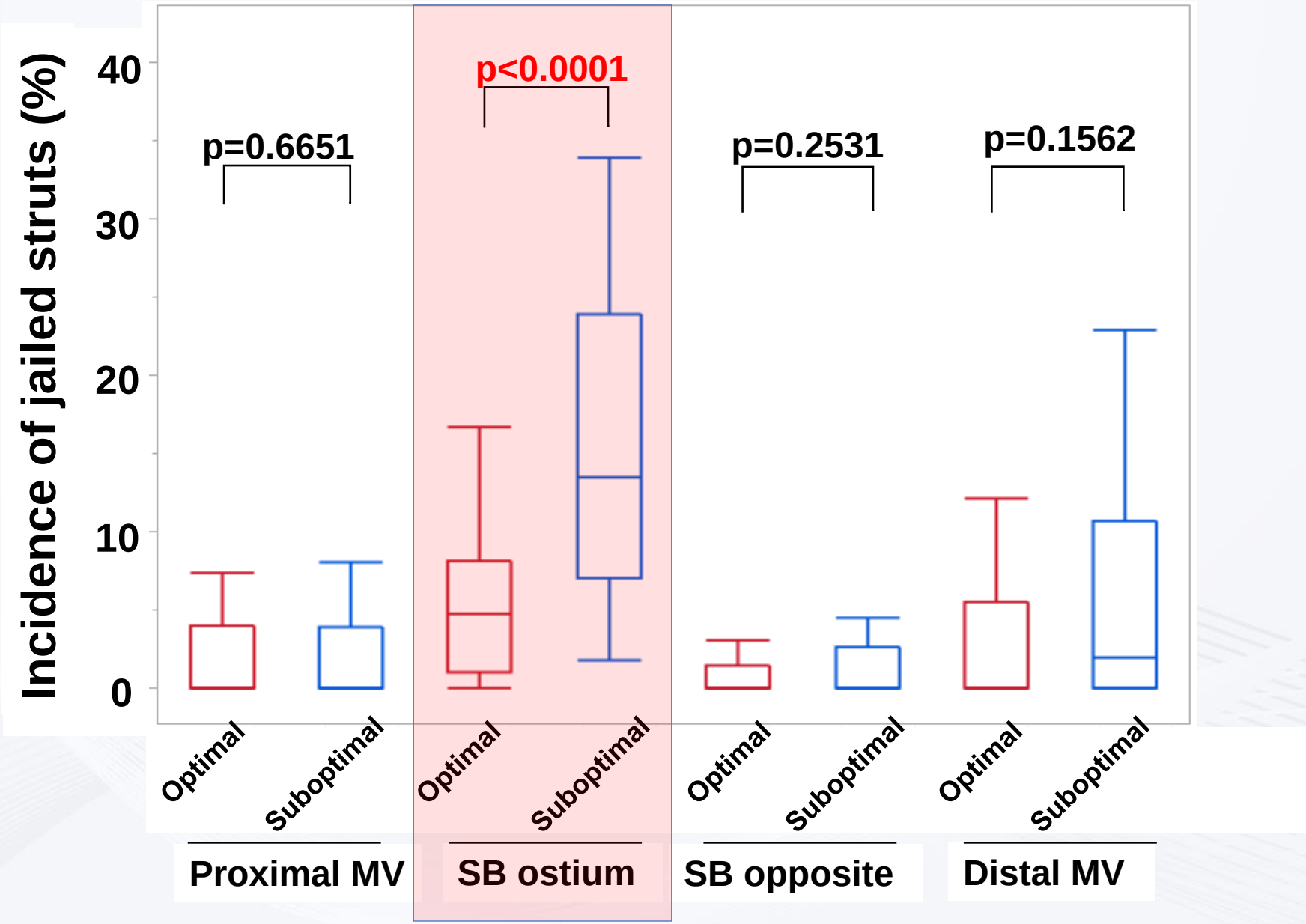
Frequency of jailing configuration & GW rewiring position in 3D-OCT guided bifurcation stenting

Okamura T, et al.
EuroIntervention 2018;13:e1785-e1793



Incidence of ISA at each segment

Okamura T, et al. EuroIntervention 2018;13:e1785-e1793



Angiographic ISR at 9 month

Okamura T, et al. EuroIntervention 2018;13:e1785-e1793

	All	Optimal	Suboptimal	P value
n	87	48	39	
ISR	12(13.8%)	4(8.3%)	8(20.5%)	0.1254
PMV	0(0%)	0(0%)	0(0%)	-
DMV	1(1.1%)	1(2.1%)	0(0%)	1.0000
Side Br Orifice	12(13.8%)	4(8.3%)	8(20.5%)	0.1254

Japanese registry for 3-D OCT guided bifurcation stenting

Study population

600 bifurcation lesions

Side branch opening guided by 3-D OCT:400

Optimal

Suboptimal

No side branch opening:200

Primary endpoint

Incidence of side branch restenosis at 1 year.

Secondary endpoint

MACE at 3 years

PI

Dr. Junya Shite (Osaka Nakatsu Saiseikai Hospital)

Frequency of jailing configuration and rewiring position

Side branch dilatation; 404
- **KBT:344**
- **Sequential Balloon inflation:18**
- **Non KBT: 42**

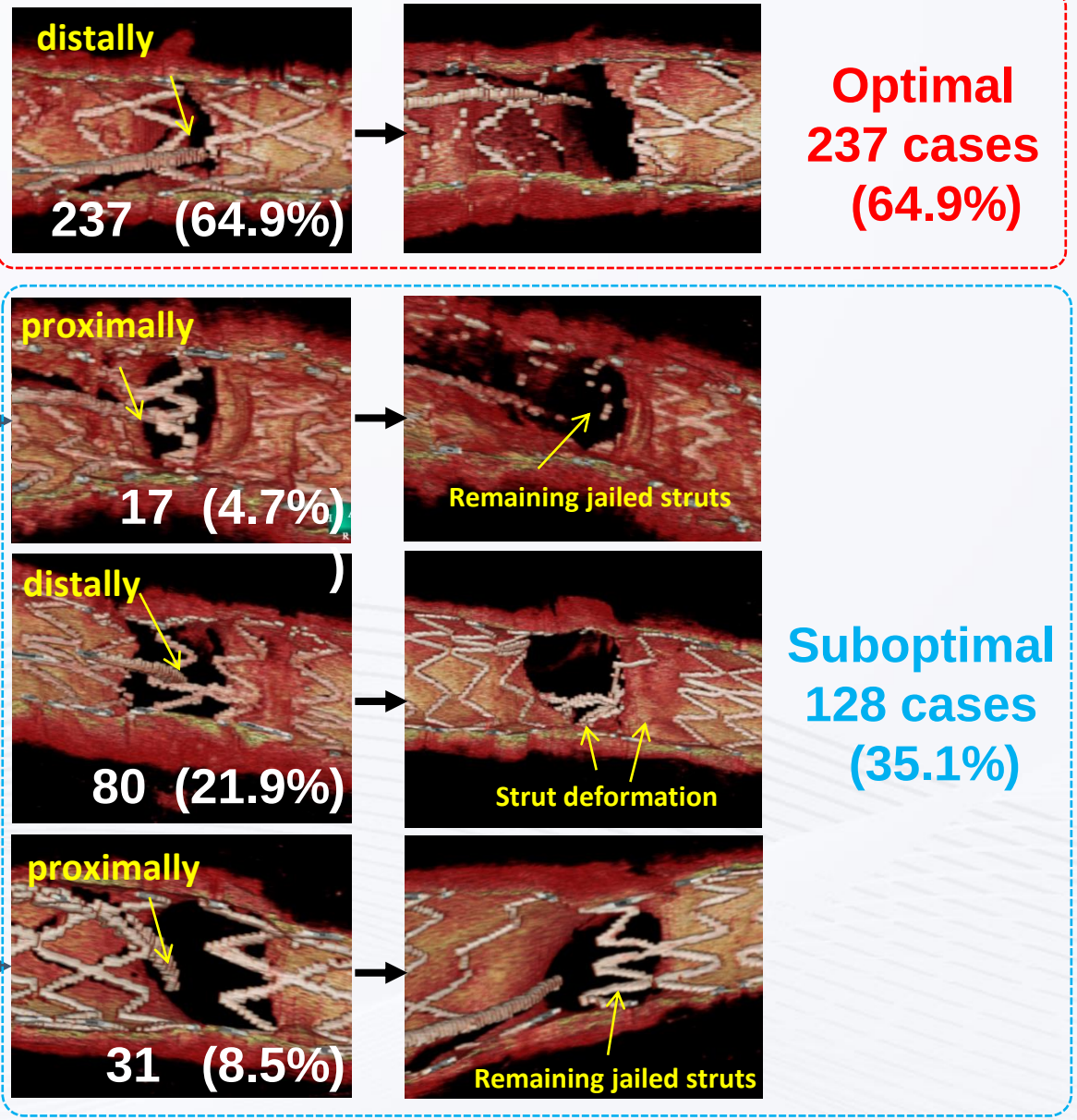
365 cases
# of cases wire cross position confirmed

LF type
254 (69.6%)

***LC* type**
111 (30.4%)

Non-side branch dilatation; 155

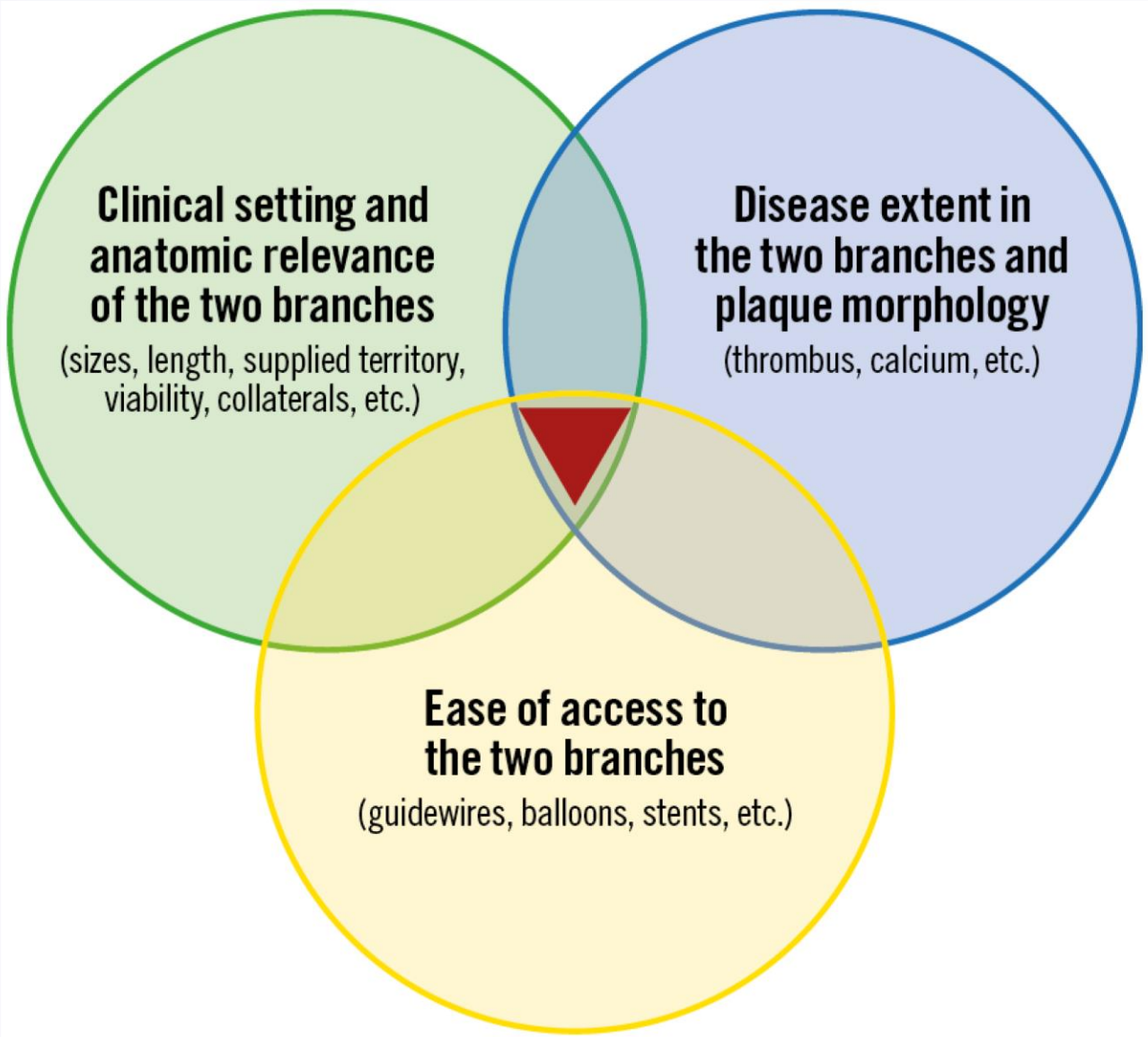
Guidewire recrossing **After KBI**



Optimal
237 cases
(64.9%)

Suboptimal
128 cases
(35.1%)

Main determinants of bifurcation PCI complexity



To assess anatomic relevance of the two branches, and to estimate plaque morphology & disease extent in the two branches should be very important in LM bifurcation PCI. Therefore imaging guidance should be mandatory to obtain better clinical outcome.

Burzotta F, et al. EuroIntv 2021:16:1307-1317

Take home message

OCT Guided precise PCI for LM Bifurcation Stenting

- Pre- & post-PCI lesion morphology with vessel & lumen size, lesion length can be assessed easily & precisely by OCT because of higher resolution with auto-pullback, auto-measurement systems, and/or 3D reconstruction, etc.

- Before PCI, precise lesion assessment focusing on aorto-ostial lesion, bifurcation lesion, just proximal lesion of the LAD and LCx for LM PCI should be performed in addition to the assessment of vessel & lumen size, lesion length, plaque characteristics including the presence and degree of calcium and/or thrombus.

- After PCI, stent expansion, apposition, stent edge dissection, etc., should be confirmed for stent optimization to improve the prognosis of the patients.

- Ideal cell selection by 3D-OCT guidance should be essential to perform optimal stent deployment not only in the main branch but also in the side branch and to obtain enough lumen area at the side branch orifice.

Thank you for your kind attention !!