OCT-guided PCI in Bifurcation Lesion

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Disclosure Statement of Financial 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.

PCI for bifurcation lesions

- **Bifurcation lesion PCI might be 15-20% of all PCI cases in daily clinical practice, and complex procedure might be required sometimes.**

  Lefe` vre T et al. Catheter Cardiovasc Interv 2000;49:274–283.
  Iakovou I et al. J Am Coll Cardiol 2005;46:1446–1455.

- **Higher risk for complications such as side branch occlusion, stent thrombosis, restenosis, etc. has been reported more frequently in bifurcation lesion PCI.**

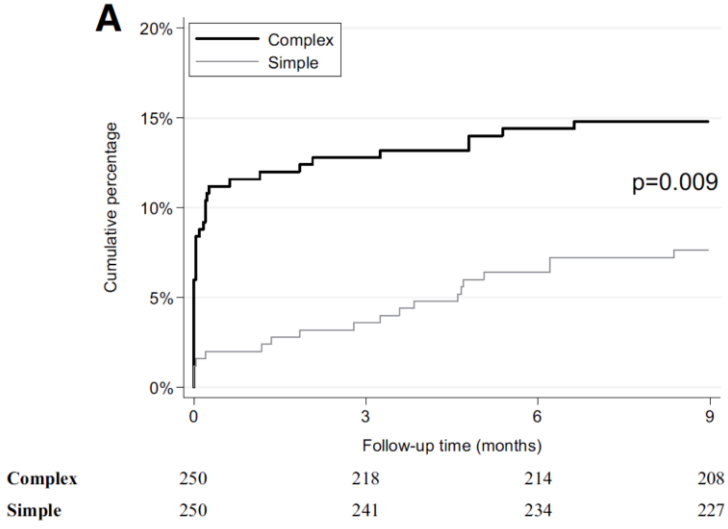
  Iakovou I et al. JAMA 2005; 293 : 2126-2130.
  Colombo A et al. Circulation 2004; 109 : 1244-1249.

Randomized Trial of Simple Versus Complex Drug-Eluting Stenting for Bifurcation Lesions

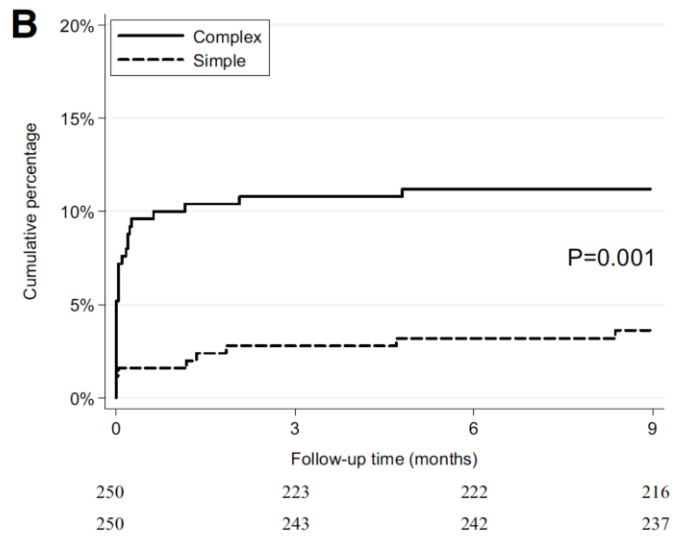
The British Bifurcation Coronary Study: Old, New, and Evolving Strategies

David Hildick-Smith, MD, FRCP; Adam J. de Belder, MD, FRCP; Nina Cooter, MSc; Nicholas P. Curzen, PhD, FRCP; Tim C. Clayton, MSc; Keith G. Oldroyd, MD, FRCP; Lorraine Bennett, MSc; Steve Holmberg, MD, FRCP; James M. Cotton, MD, FRCP; Peter E. Glennon, PhD, FRCP; Martyn R. Thomas, MD, FRCP; Philip A. MacCarthy, PhD, FRCP; Andreas Baumbach, MD, FRCP; Niall T. Mulvihill, MD; Robert A. Henderson, DM, FRCP; Simon R. Redwood, MD; Ian R. Starkey, BSc, FRCP; Rodney H. Stables, DM, FRCP

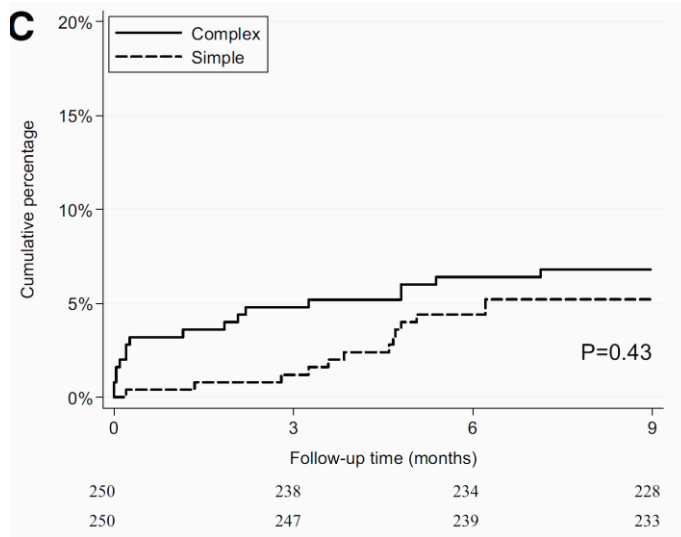
Cumulative risk of primary endpoint



Cumulative risk of MI



Cumulative risk of TV failure



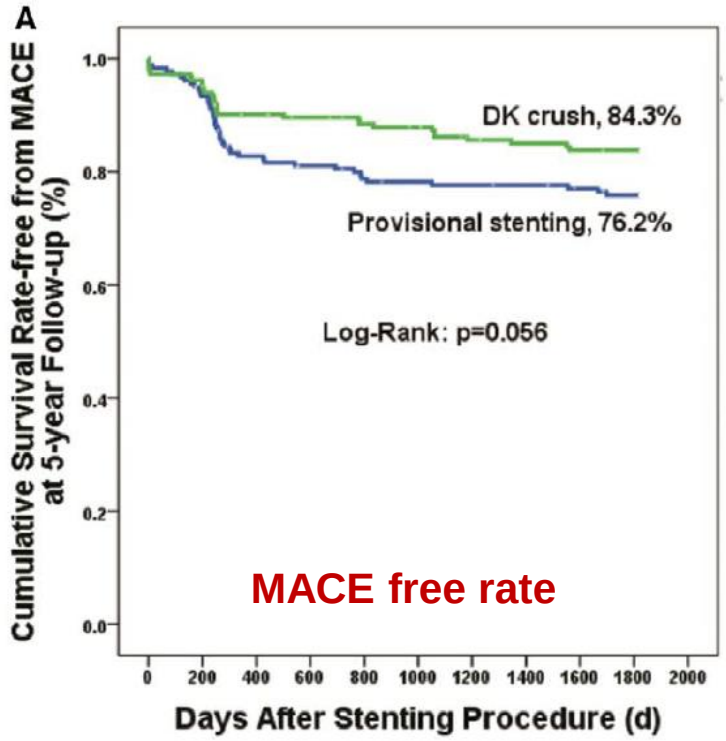
Circulation 2010:121(10):1235-1243

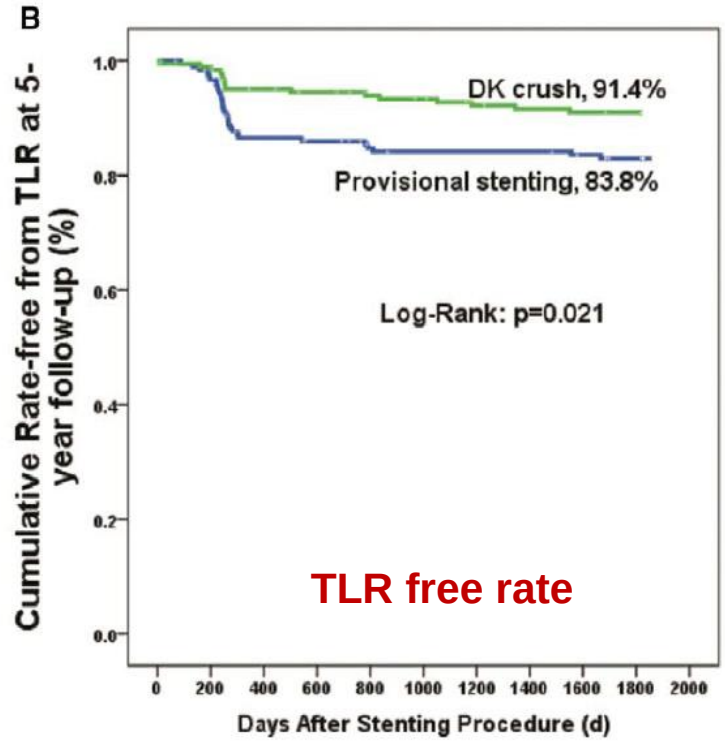
Clinical Outcome of Double Kissing Crush Versus Provisional Stenting of Coronary Artery Bifurcation Lesions

The 5-Year Follow-Up Results From a Randomized and Multicenter DKCRUSH-II Study (Randomized Study on Double Kissing Crush Technique Versus Provisional Stenting Technique for Coronary Artery Bifurcation Lesions)

Circ Cardiovasc Interv. 2017;10:e004497. DOI: 10.1161/CIRCINTERVENTIONS.116.004497.

Shao-Liang Chen, MD; Teguh Santoso, MD; Jun-Jie Zhang, PhD; Fei Ye, MD; Ya-Wei Xu, MD; Qiang Fu, MD; Jing Kan, MBBS; Feng-Fu Zhang, MD; Yong Zhou, MD; Du-Jiang Xie, MD; Tak W. Kwan, MD





Clinical Outcome of Double Kissing Crush Versus Provisional Stenting of Coronary Artery Bifurcation Lesions

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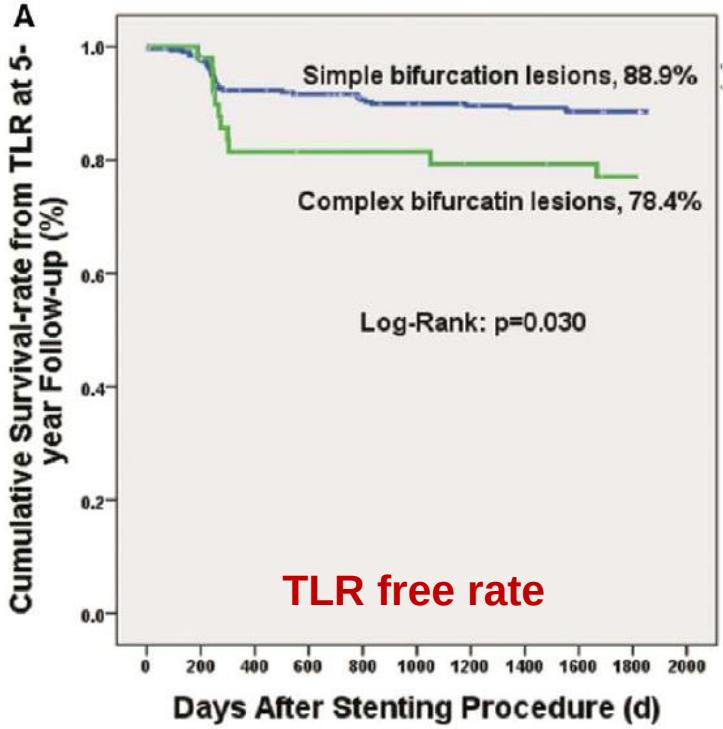
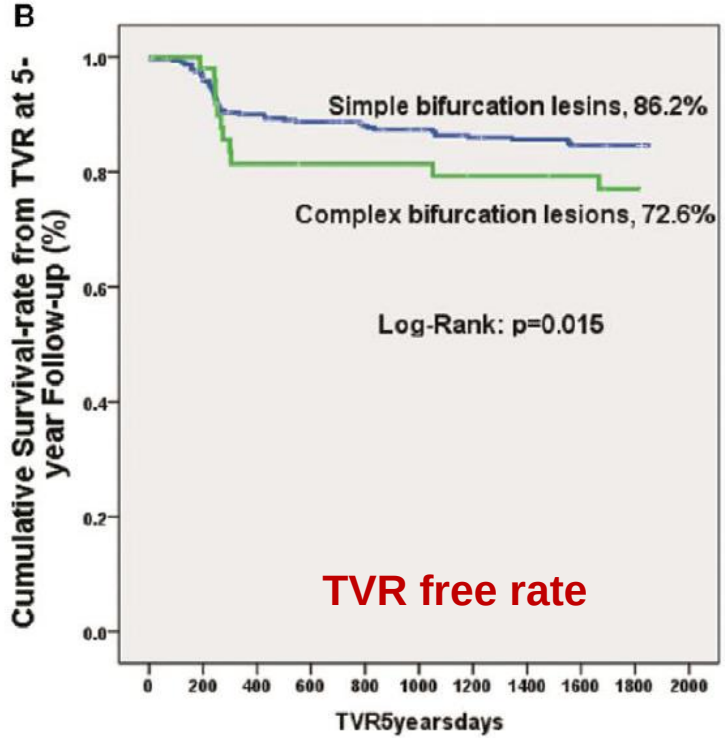
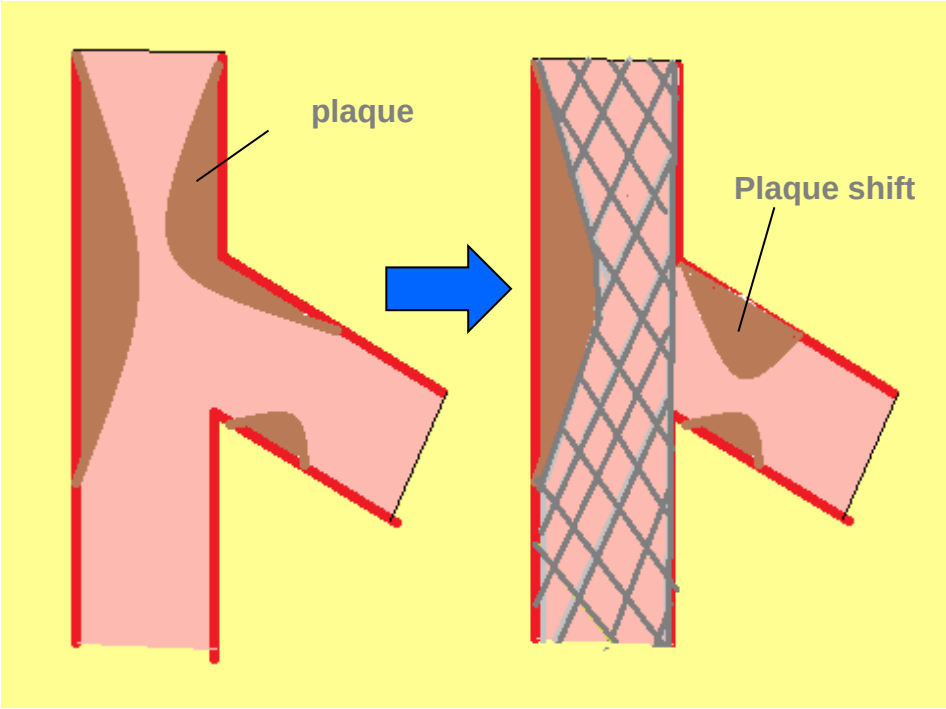


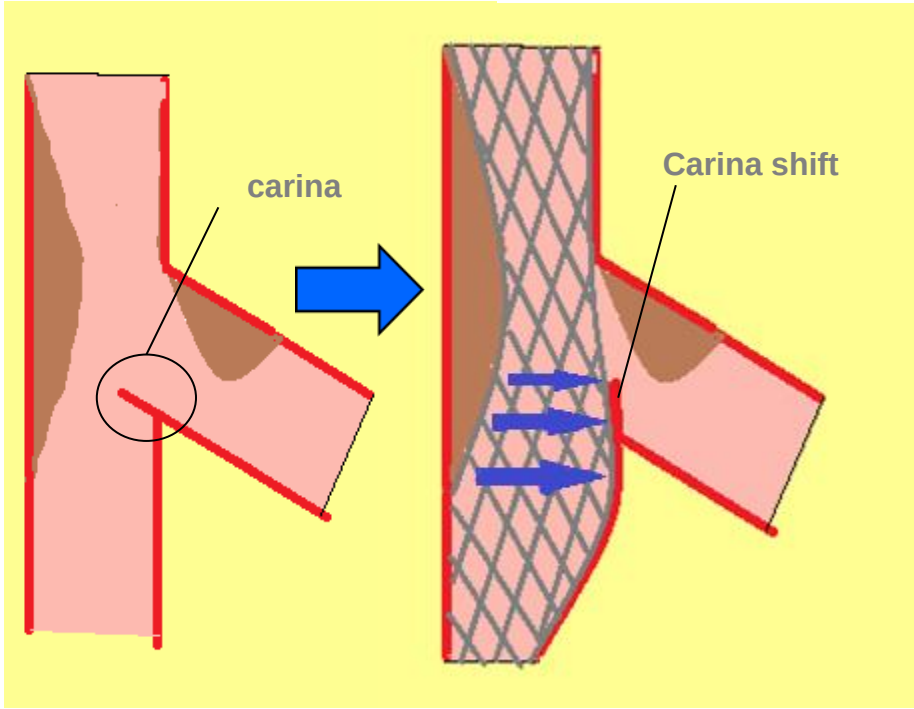


Mechanism of side branch occlusion after stenting

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

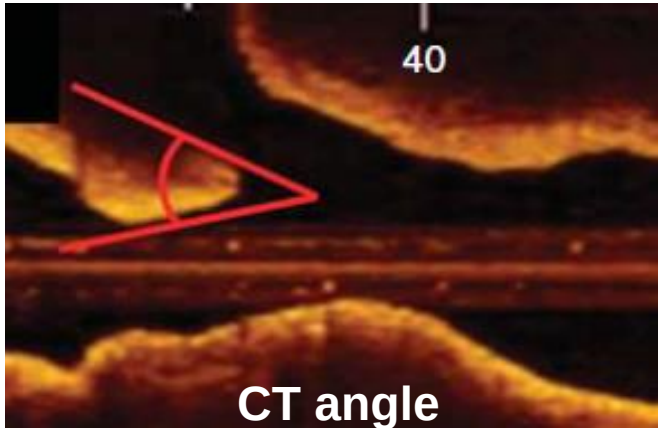


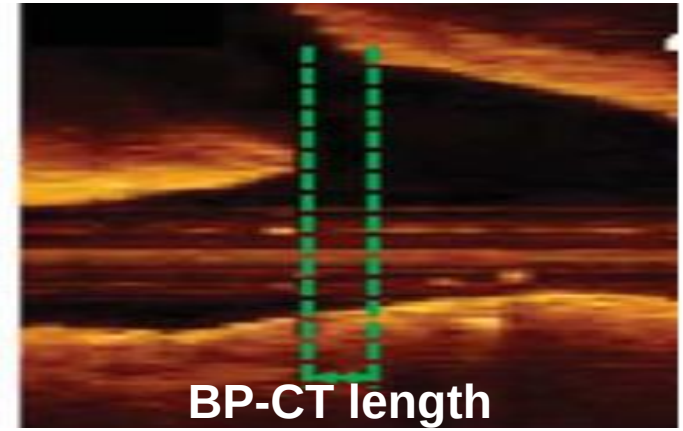
Carina shift

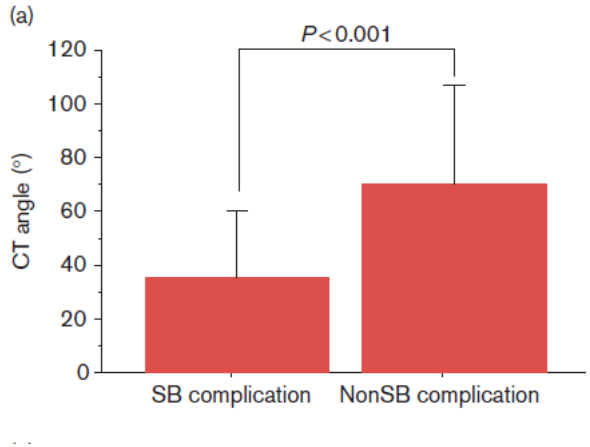
Prediction of side branch occlusion by OCT

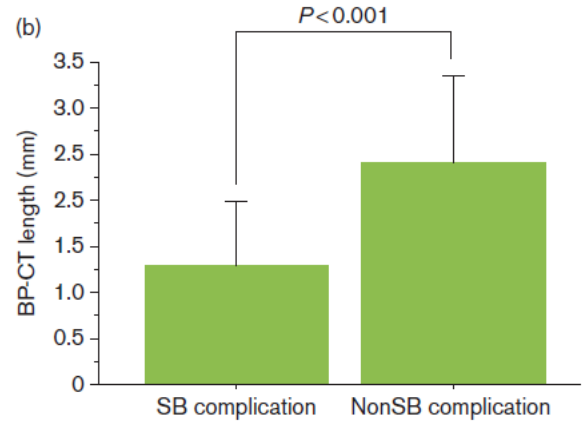
Watanabe M et al. Coron Artery Dis 2014; 25: 321-329

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







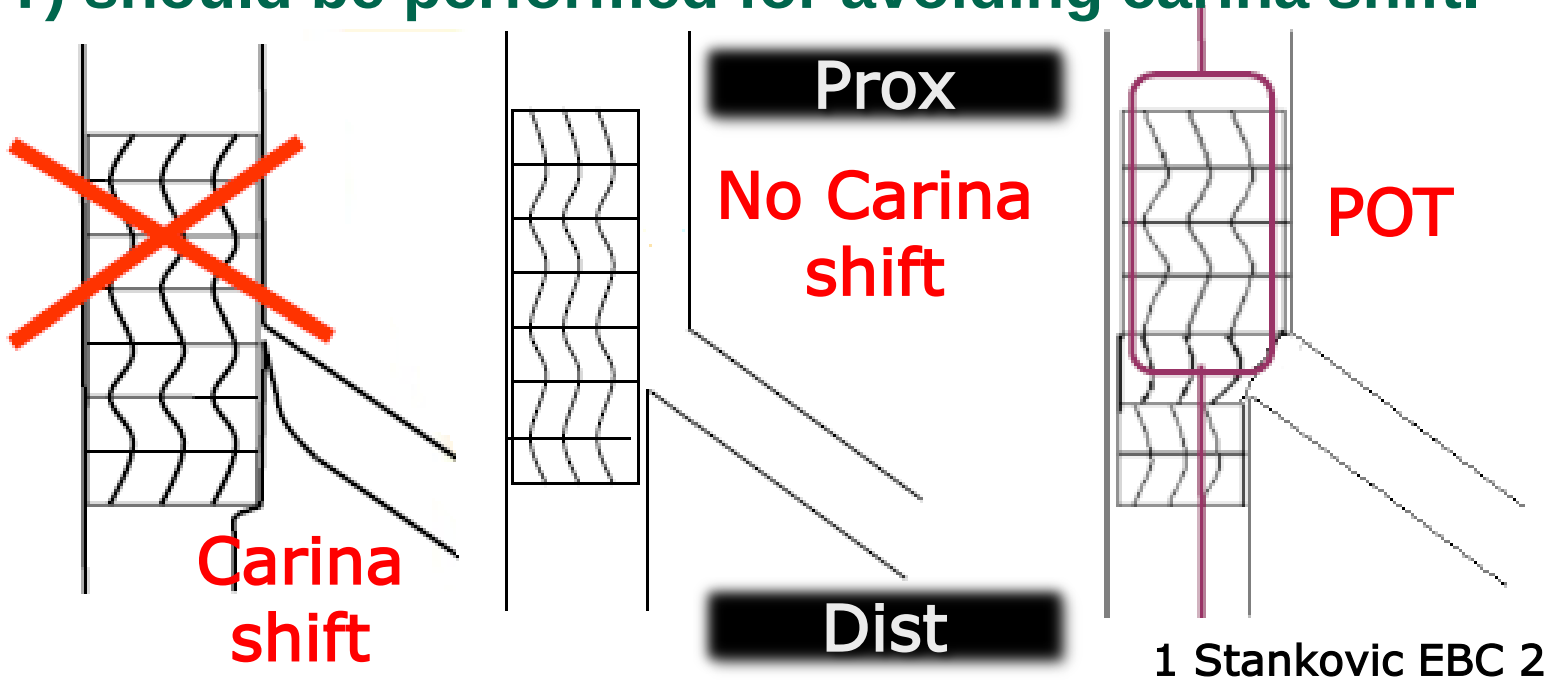


Importance of proximal optimization technique (POT)

In bifurcation, there is a vessel size change in main vessel at proximal and distal of side branch.

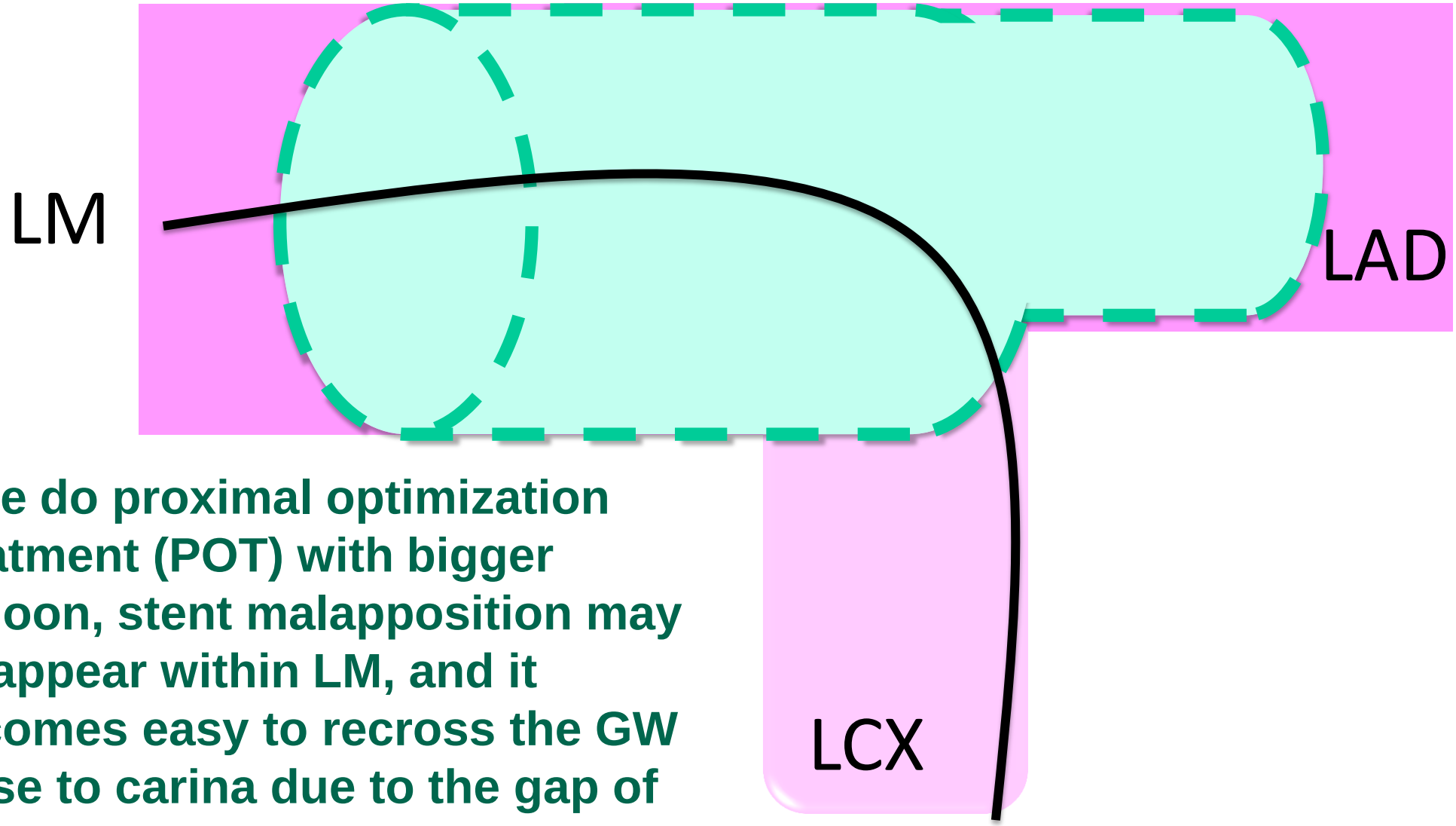
If the stent size selected to adjust proximal reference, stent distal edge dissection and carina shift may happen.

If the stent selected to adjust distal reference, no edge dissection and no carina sift may happen, however, stent malapposition may occur. Proximal optimization technique (POT) should be performed for avoiding carina shift.



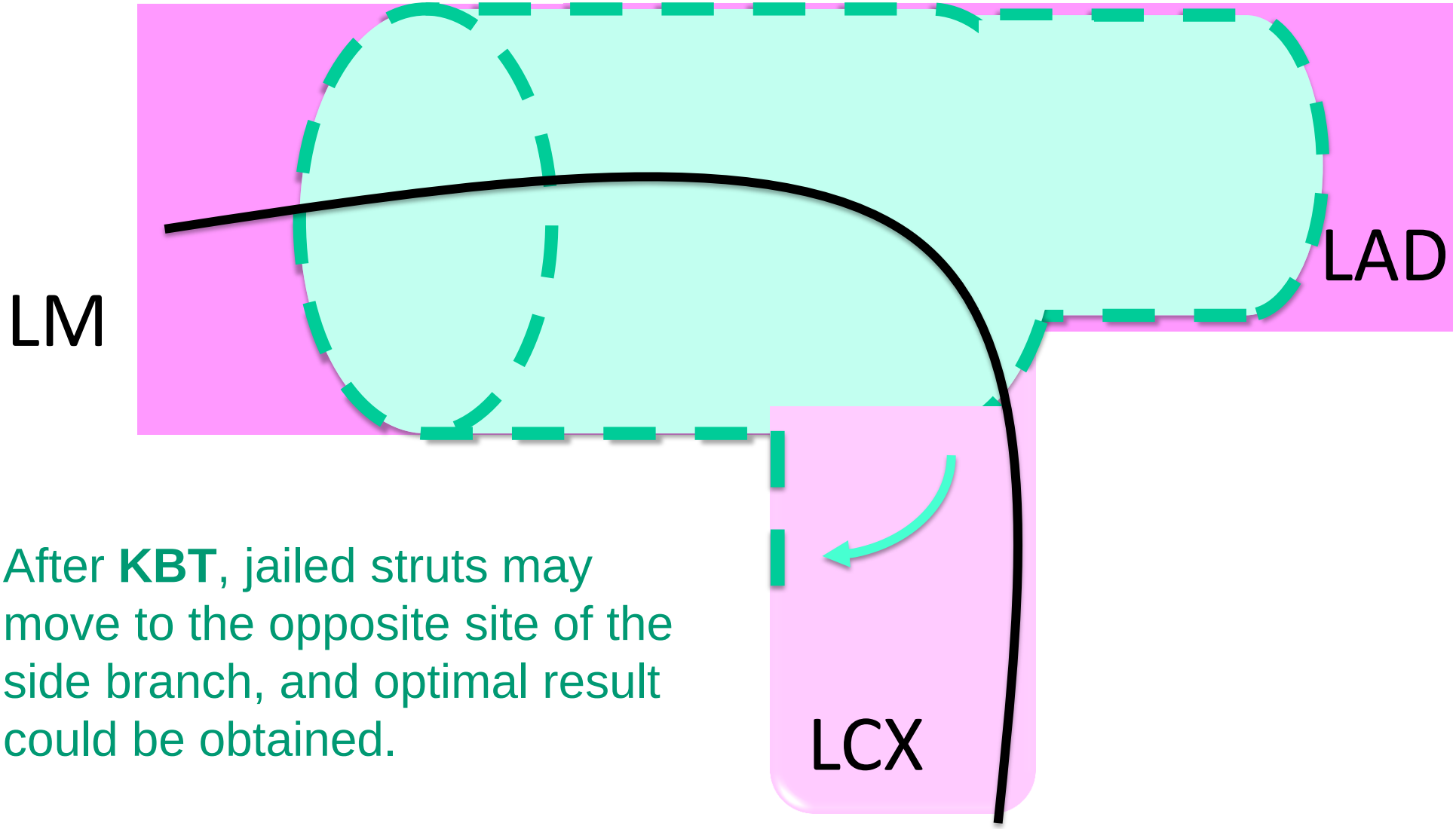
1 Stankovic EBC 2012

Importance of proximal optimization technique (POT)



If we do proximal optimization treatment (POT) with bigger balloon, stent malapposition may disappear within LM, and it becomes easy to recross the GW close to carina due to the gap of the strut becomes much greater.

Importance of proximal optimization technique (POT)



After **KBT**, jailed struts may move to the opposite site of the side branch, and optimal result could be obtained.

Comparative Analysis of Sequential Proximal Optimizing Technique Versus Kissing Balloon Inflation Technique in Provisional Bifurcation Stenting

Fractal Coronary Bifurcation Bench Test

Gérard Finet, MD, PhD,* François Derimay, MD, MSc,* Pascal Motreff, MD, PhD,† Patrice Gueri
Paul Pilet, B Eng,‡ Jacques Ohayon, PhD,§ Olivier Darremont, MD,‖ Gilles Rioufol, MD, PhD*

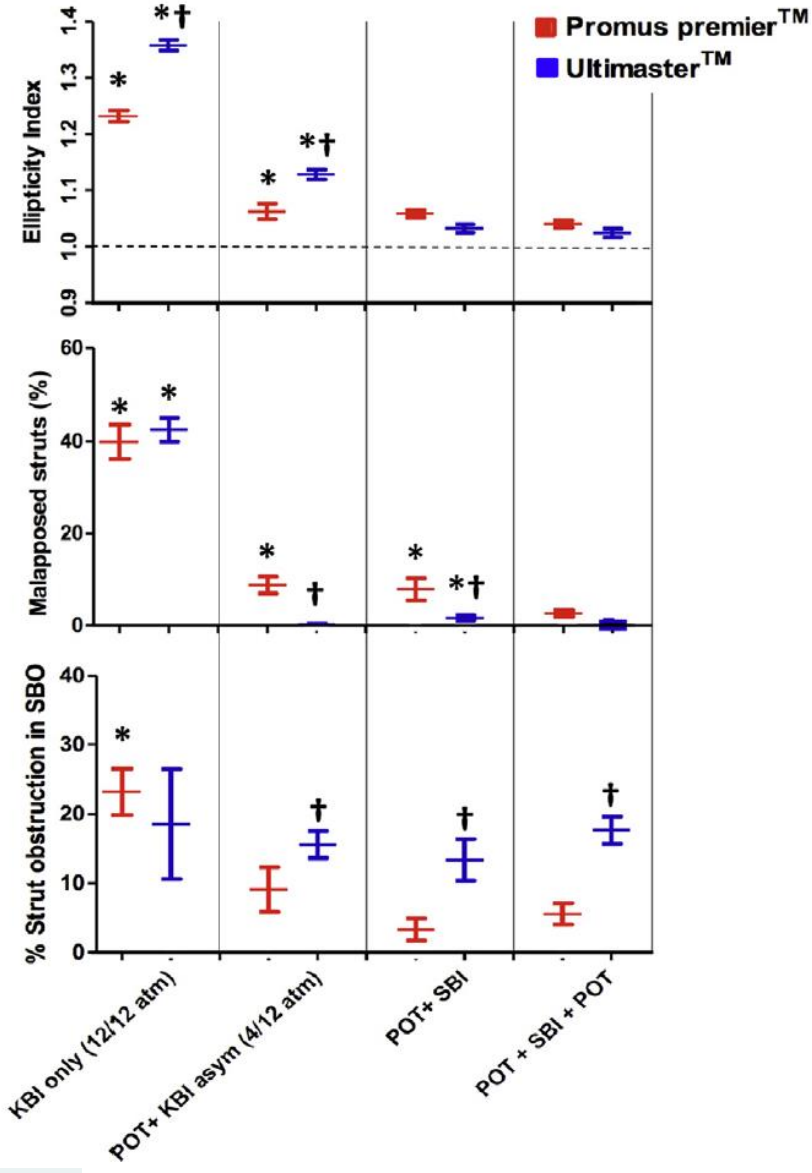
OBJECTIVES This study used a fractal bifurcation bench model to compare 6 optimization sequences for co bifurcation provisional stenting, including 1 novel sequence without kissing balloon inflation (KBI), comprising proximal optimizing technique (POT) + side-branch inflation (SBI) + final POT, called "re-POT."

BACKGROUND In provisional bifurcation stenting, KBI fails to improve the rate of major adverse cardiac eve Proximal geometric deformation increases the rate of in-stent restenosis and target lesion revascularization.

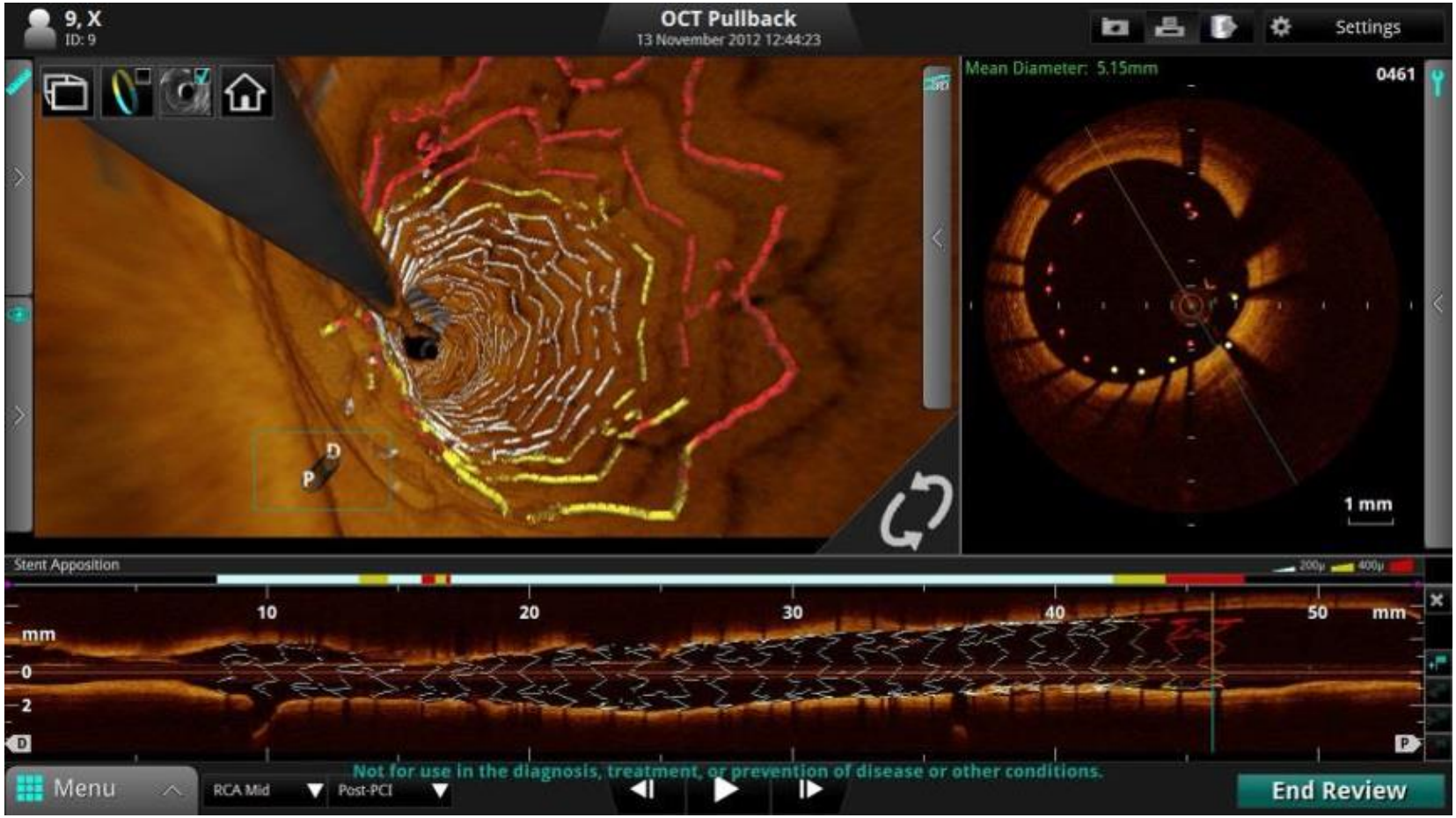
METHODS A bifurcation bench model was used to compare KBI alone, KBI after POT, KBI with asymmetric in pressure after POT, and 2 sequences without KBI: initial POT plus SBI, and initial POT plus SBI with final POT ("re-POT"). For each protocol, 5 stents were tested using 2 different drug-eluting stent designs: that is, a total of

RESULTS Compared with the classic KBI-only sequence and those associating POT with modified KBI, the re- sequence gave significantly ($p < 0.05$) better geometric results: it reduced SB ostium stent-strut obstruction fro 6.0% to 5.6 ± 8.3%, provided perfect proximal stent apposition with almost perfect circularity (ellipticity index from 1.23 ± 0.02 to 1.04 ± 0.01), reduced proximal area overstretch from 24.2 ± 7.6% to 8.0 ± 0.4%, and global strut malapposition from 40 ± 6.2% to 2.6 ± 1.4%.

CONCLUSIONS In comparison with 5 other techniques, the re-POT sequence significantly optimized the fina of provisional coronary bifurcation stenting, maintaining circular geometry while significantly reducing SB osti obstruction and global strut malapposition. These experimental findings confirm that provisional stenting may be optimized more effectively without KBI using re-POT. (J Am Coll Cardiol Intv 2015;8:1308–17)



New Development in OCT



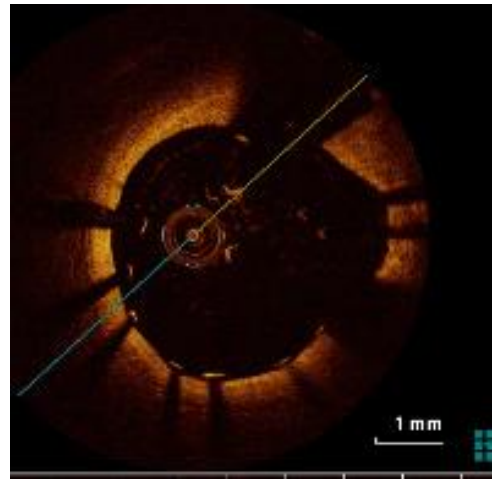
3-D reconstruction and auto-detection of incomplete apposition of stent can be demonstrated as fly through image in addition to cross sectional and longitudinal images by newly developed OCT.

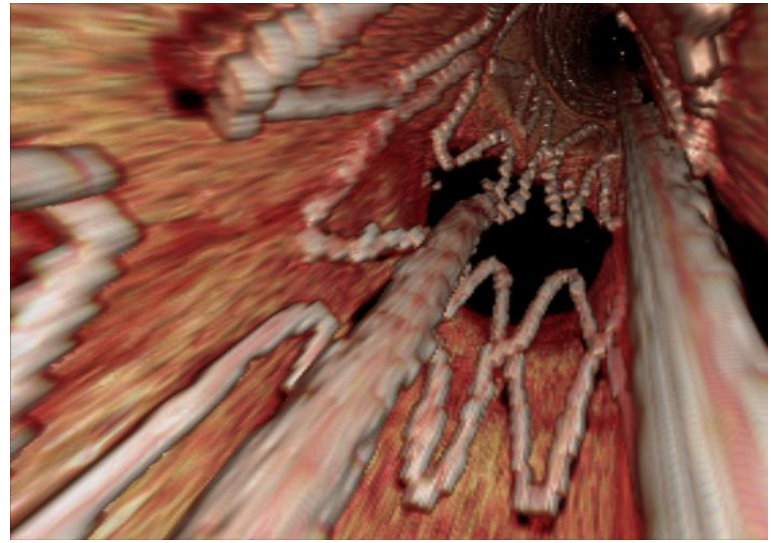
New Development in OCT

Re-crossing wire position in the jailed side branch can be easily identified by newly developed OCT software and improvement of side branch KBT procedure could be expected by the guidance of new OCT.

3D-OCT image information

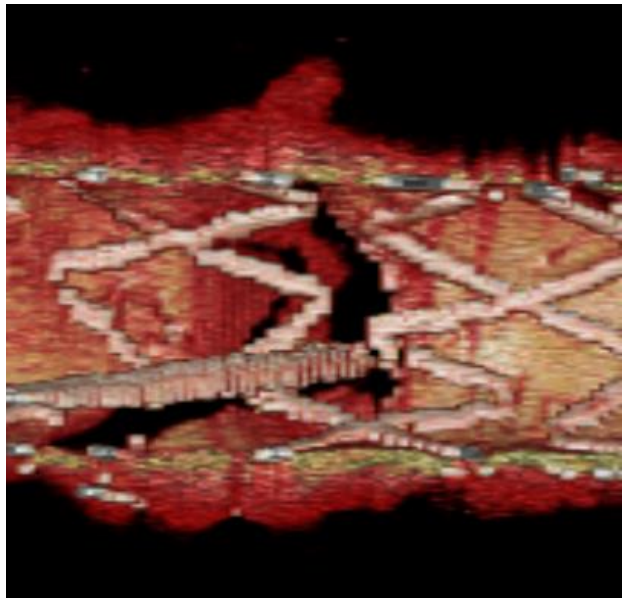
- Stent apposition
- Stent cell figure
- Location of stent link in relation to side branch orifice
- GW recrossing position

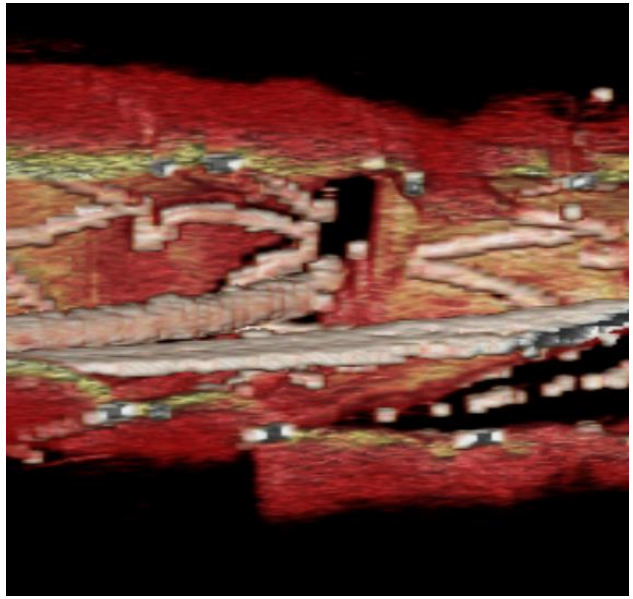




Using specific off-line
3D-software provided by Dr. Okamura

Relation between stent link & side branch orifice





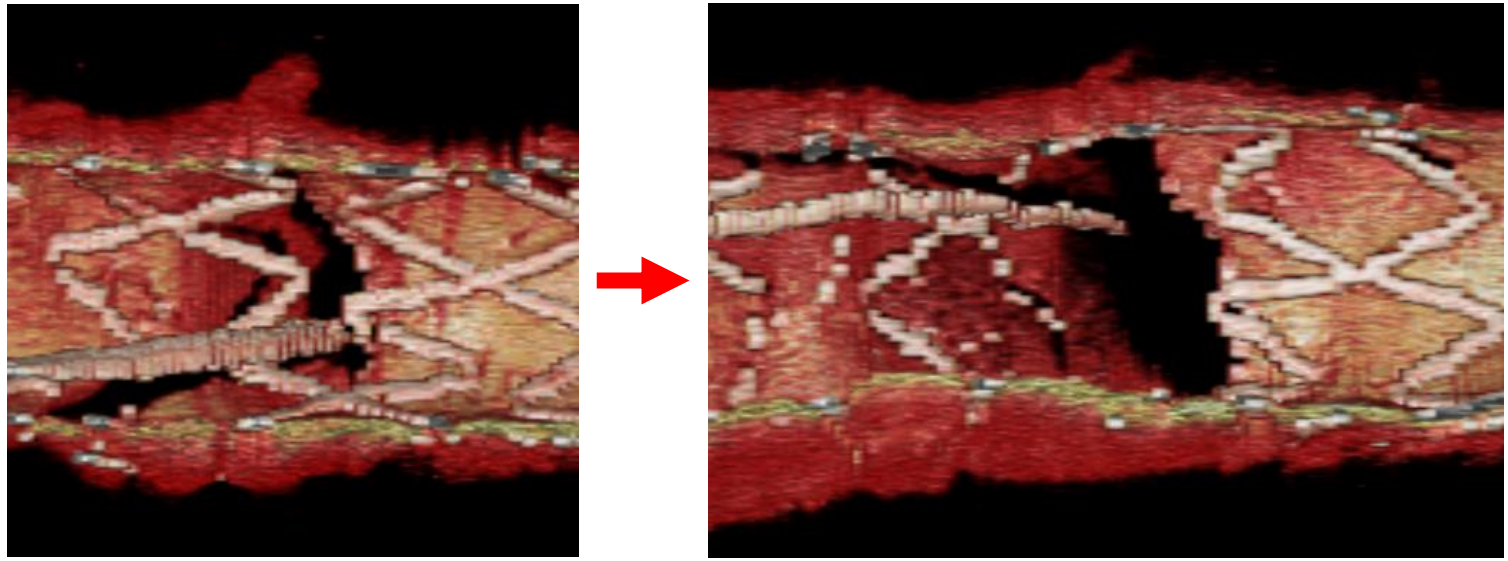
Stent link did not locate at side branch orifice:

Link Free type

Optimal GW re-cross point:

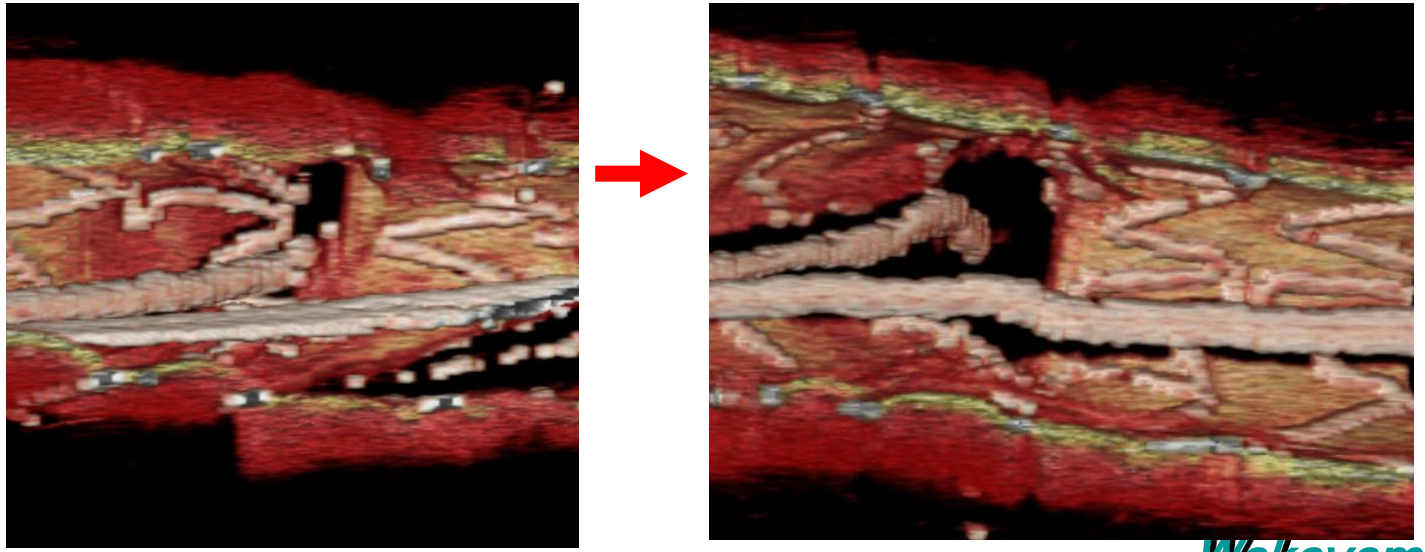
Distal cell close to carina

Link Free type



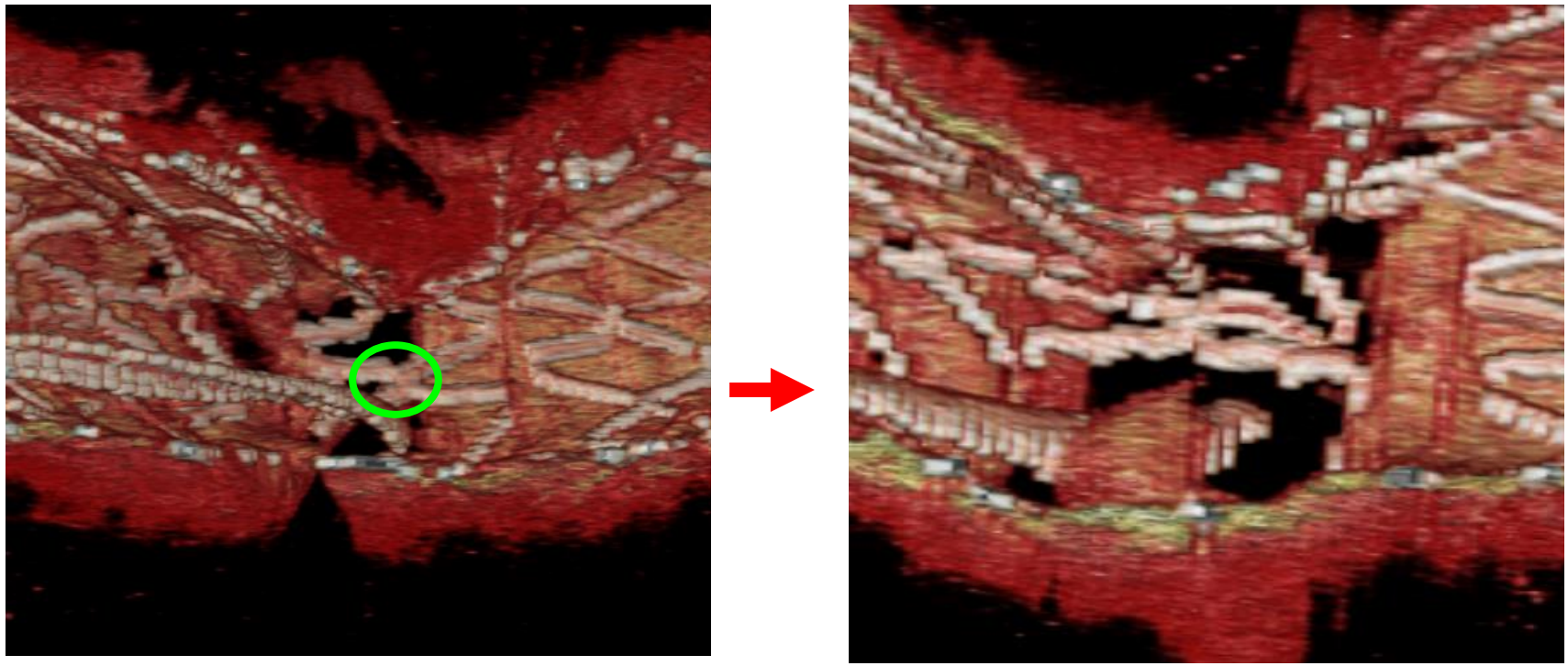
GW distal cell re-cross and KBT

Optimal



Relation between stent link & side branch orifice

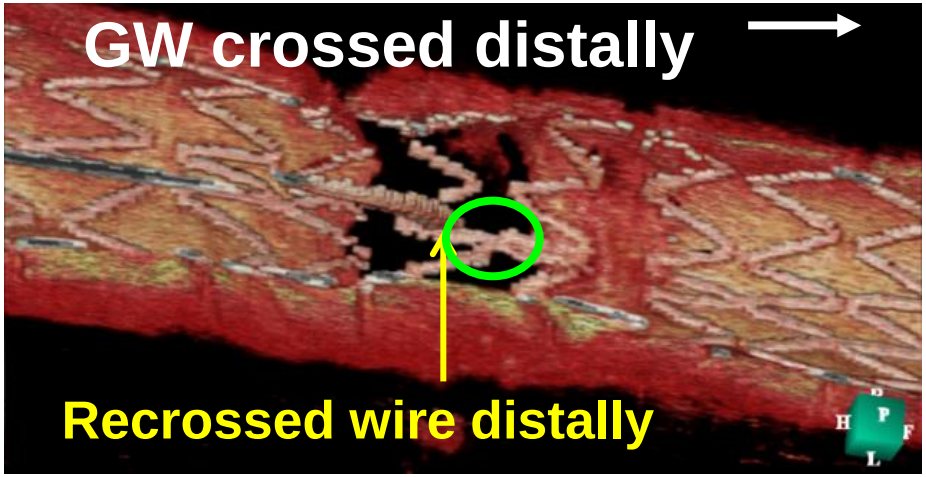
If the stent link locates closed to carina, it would be difficult to remove the jailed struts by KBT: Link connecting to carina type

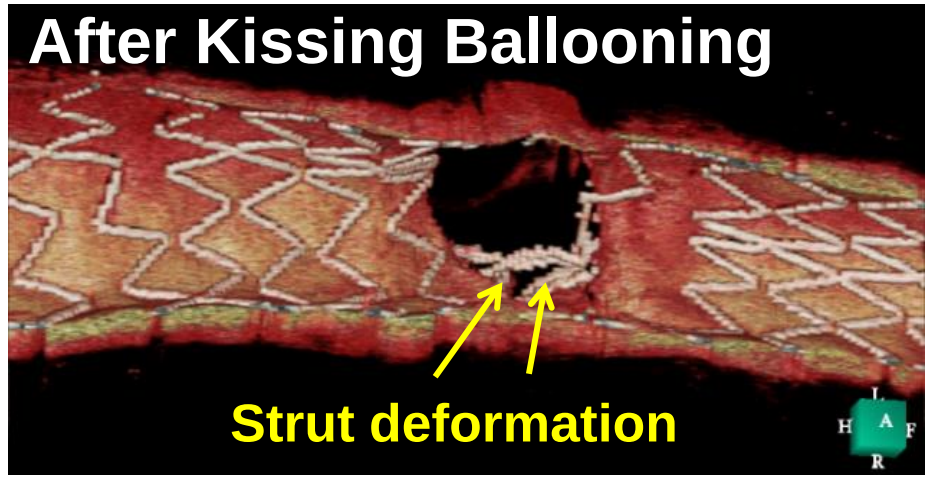


Suboptimal

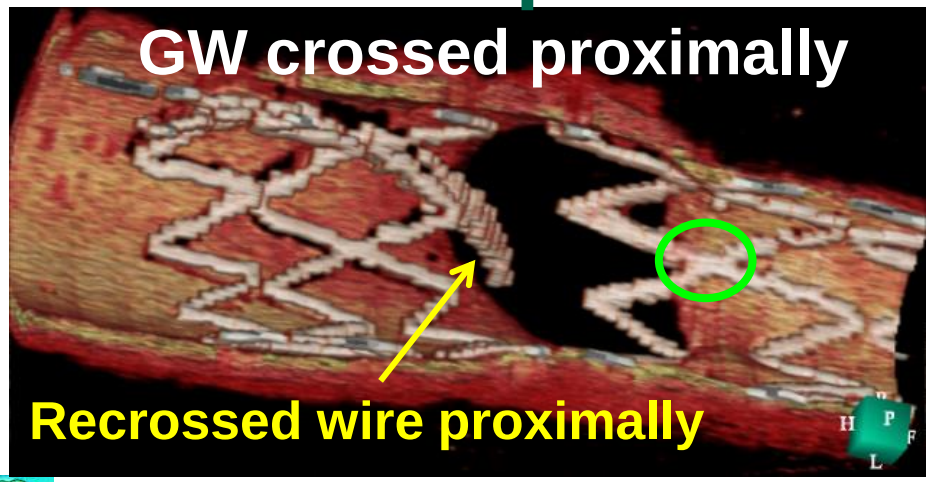
Link connecting to carina type

GW recross distal cell





GW recross proximal cell



suboptimal

Case 85y.o., Male

Clinical Diagnosis

Effort AP

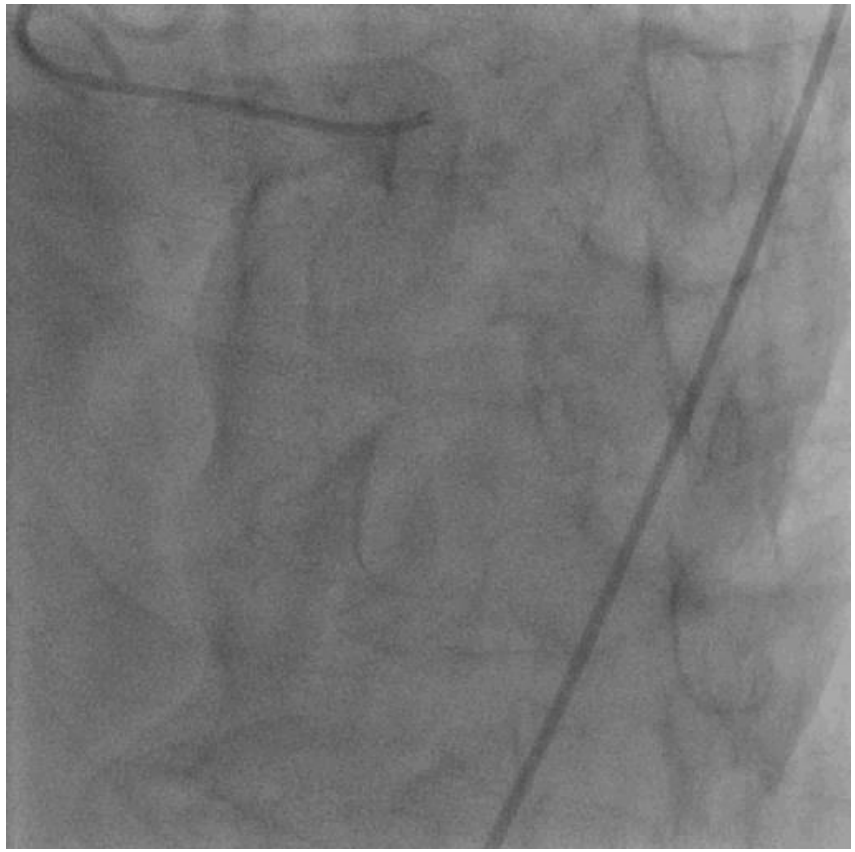
History

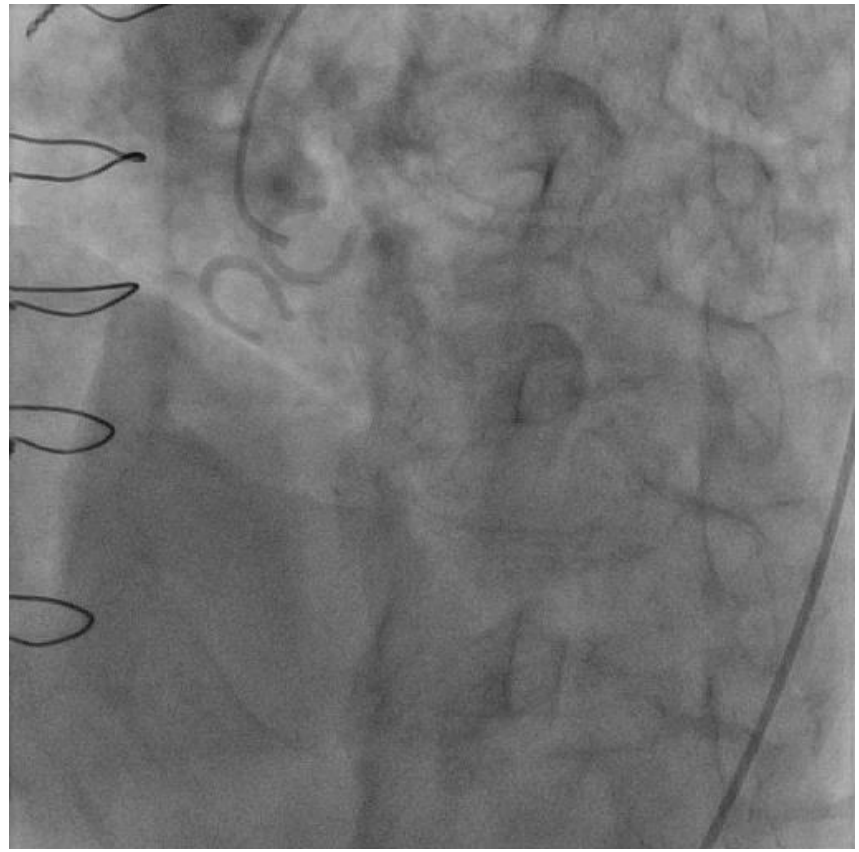
2012: CABG（SVG-LAD, SVG-DG）for unstable AP

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

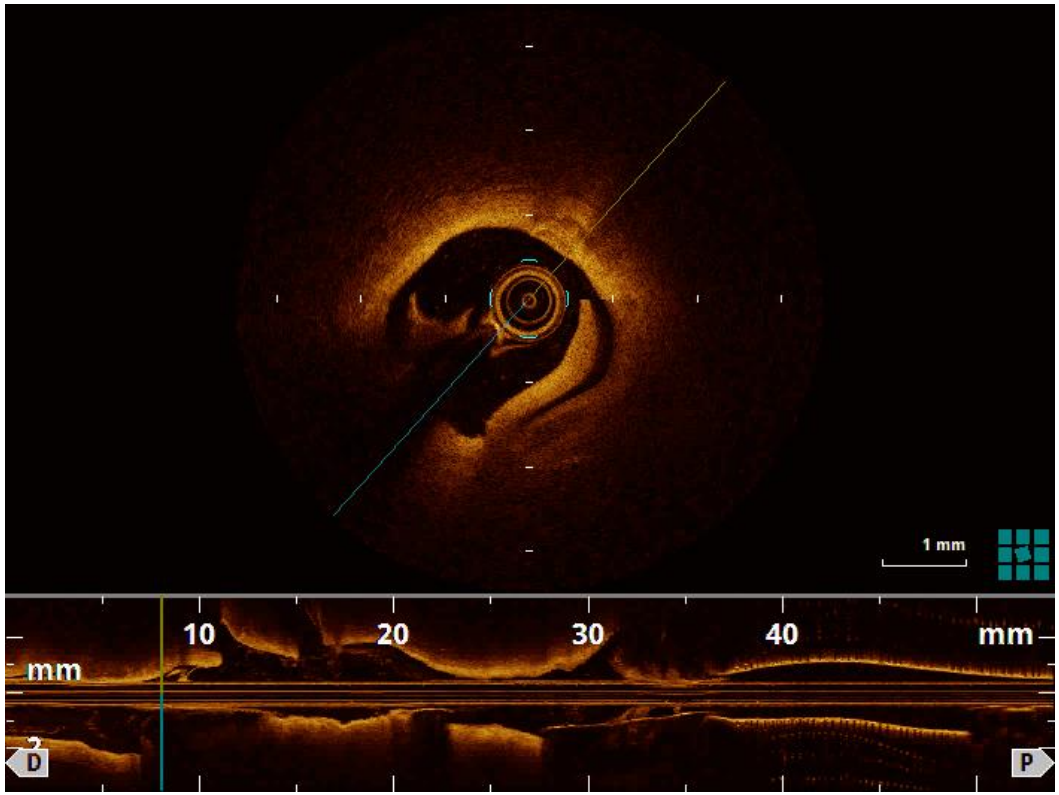
2016: Effort AP for 2-5 min during exercise

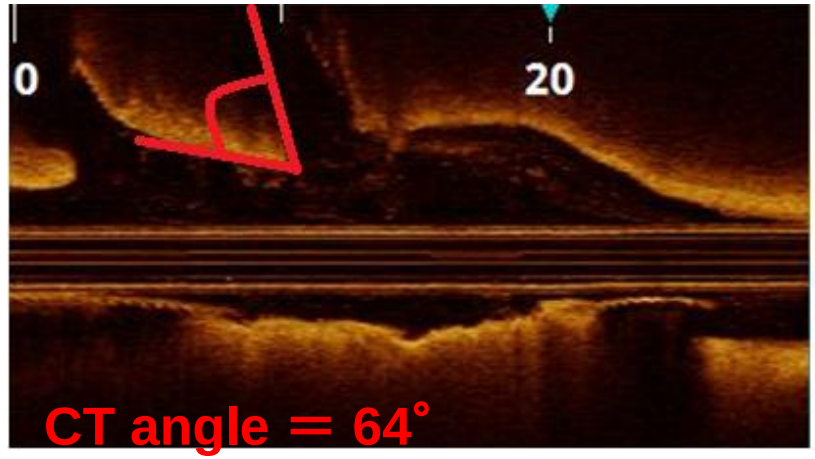
Coronary Angiography

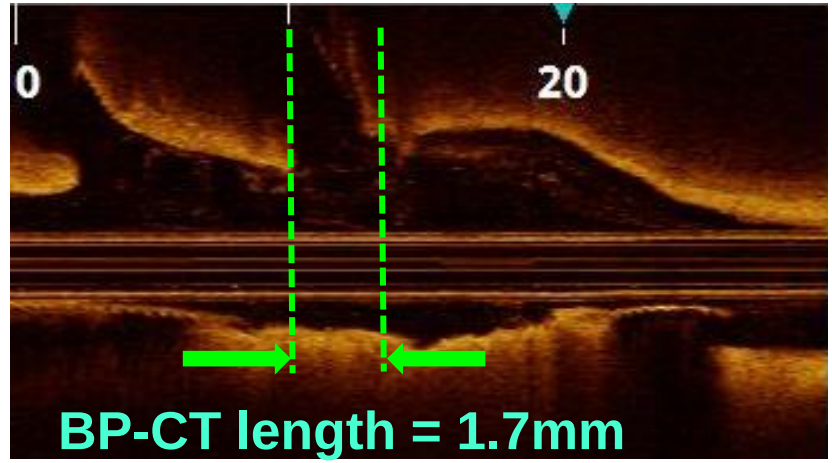




OCT before bifurcation stenting

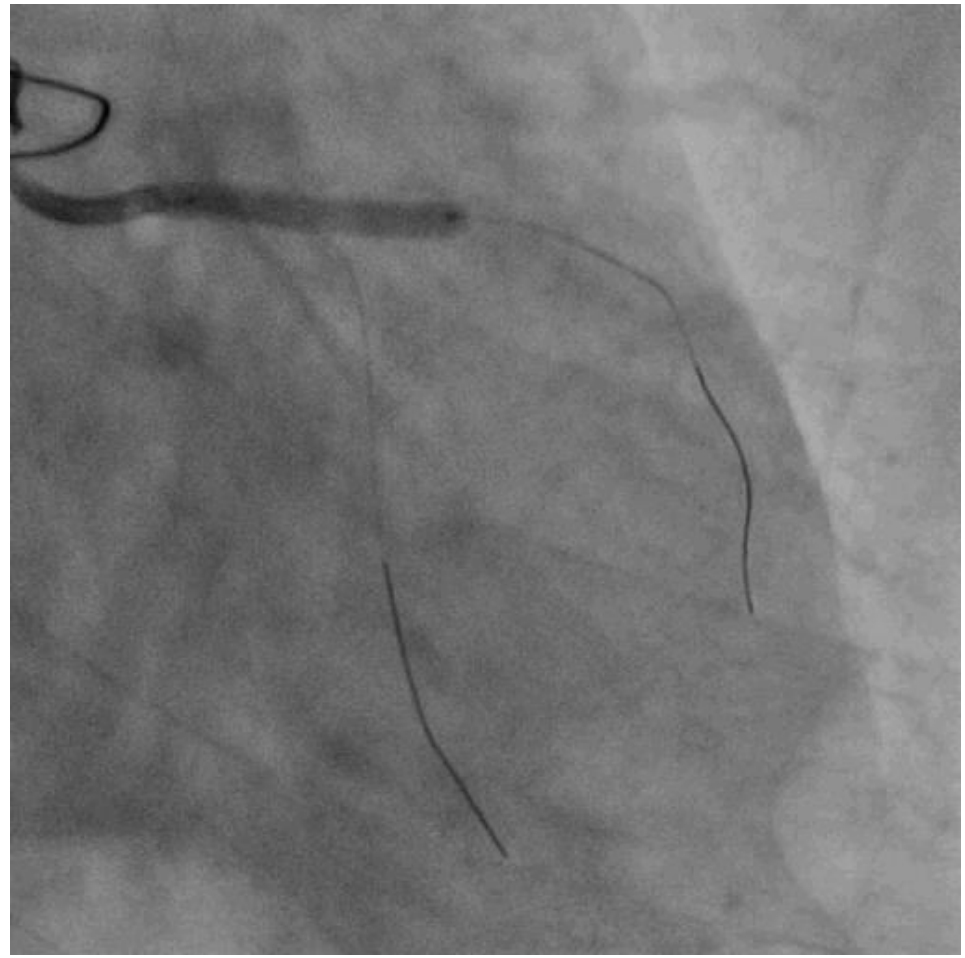




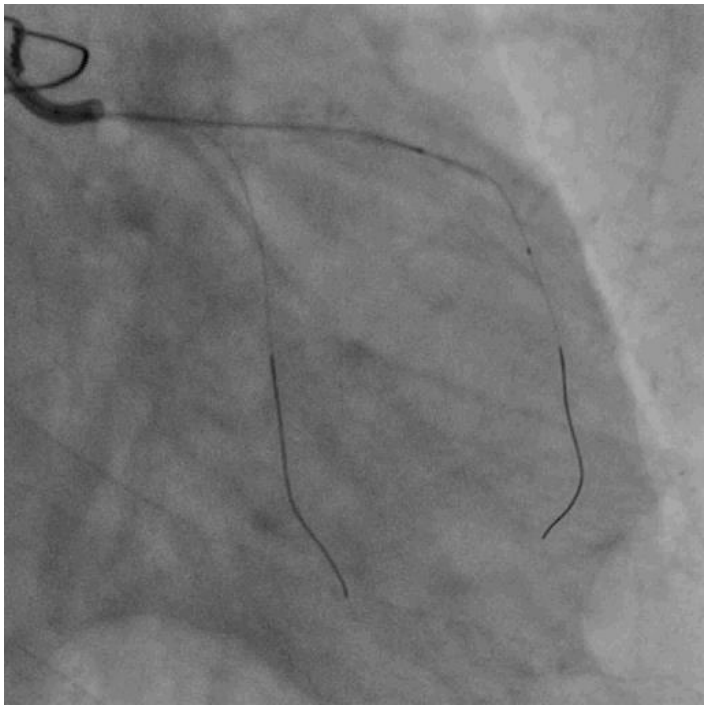


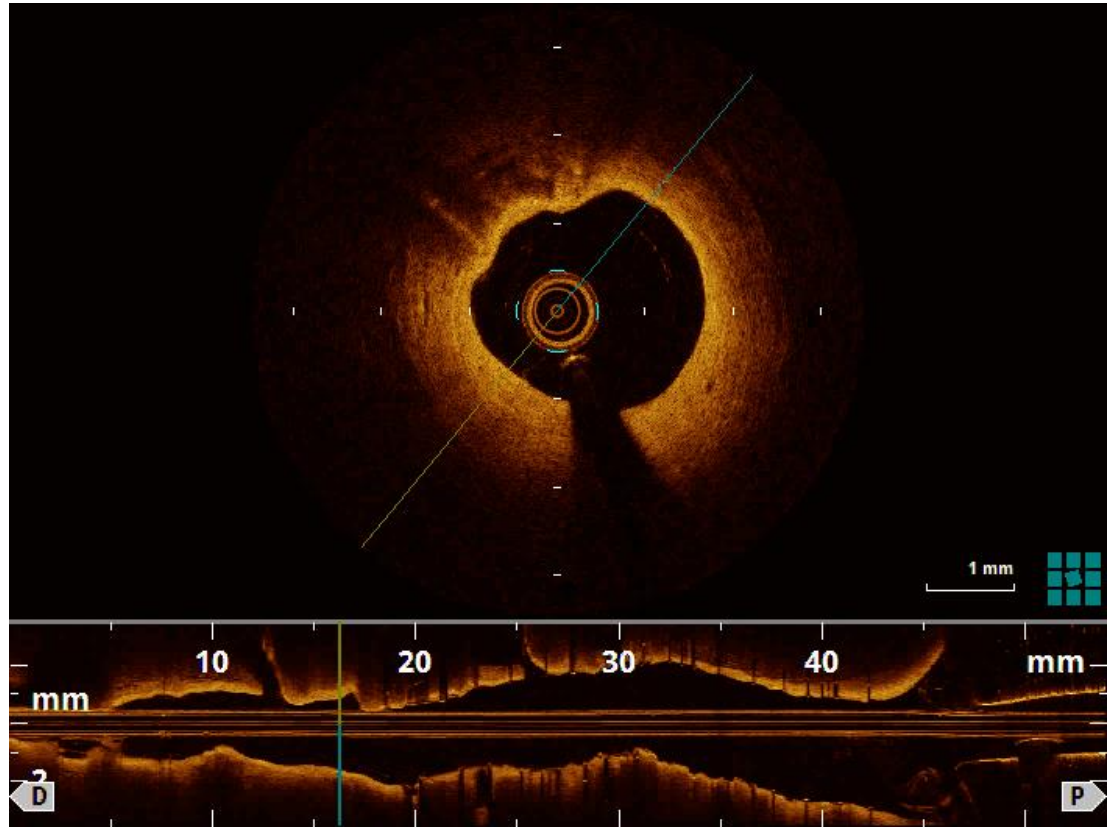
Bifurcation stenting

Xience Alpine 3.5×23mm



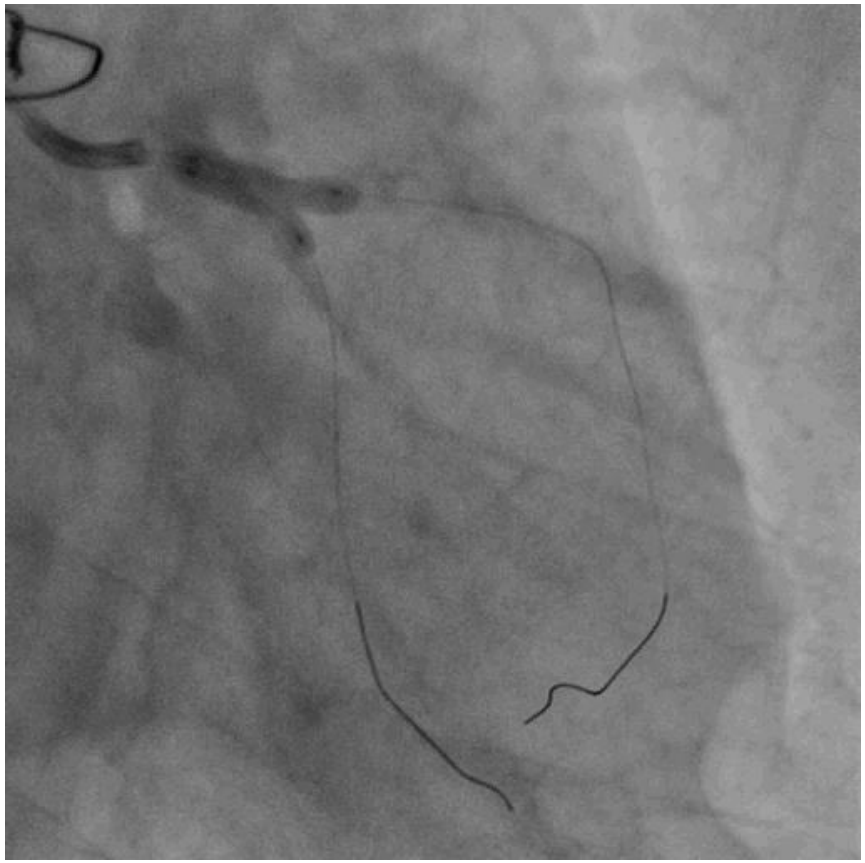
OCT after bifurcation stenting

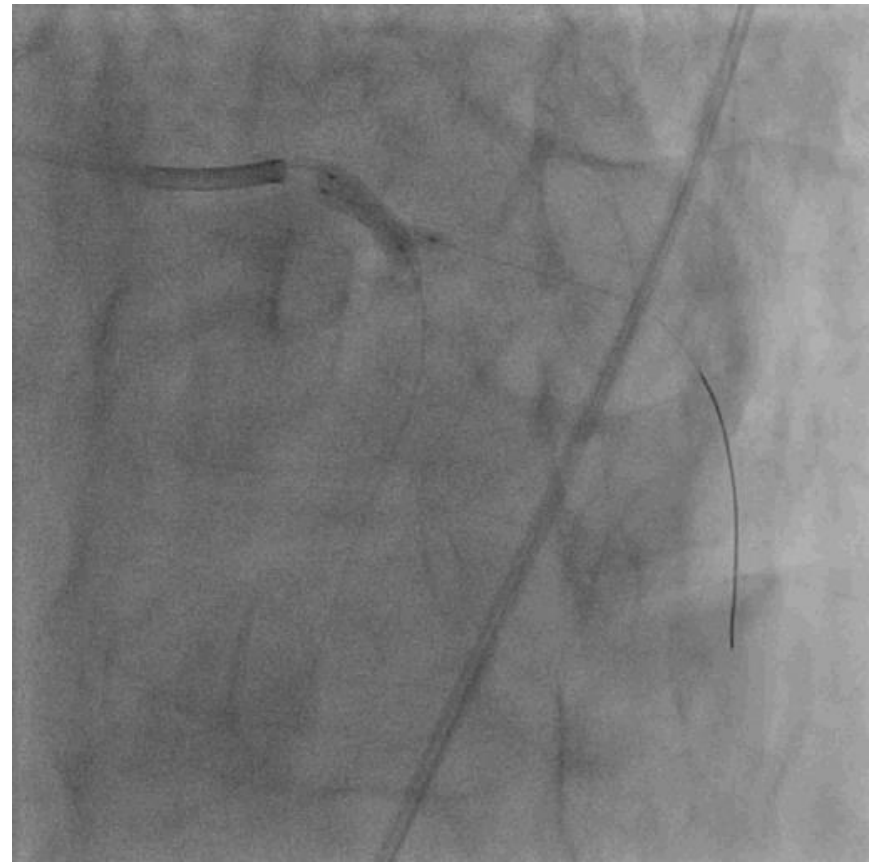




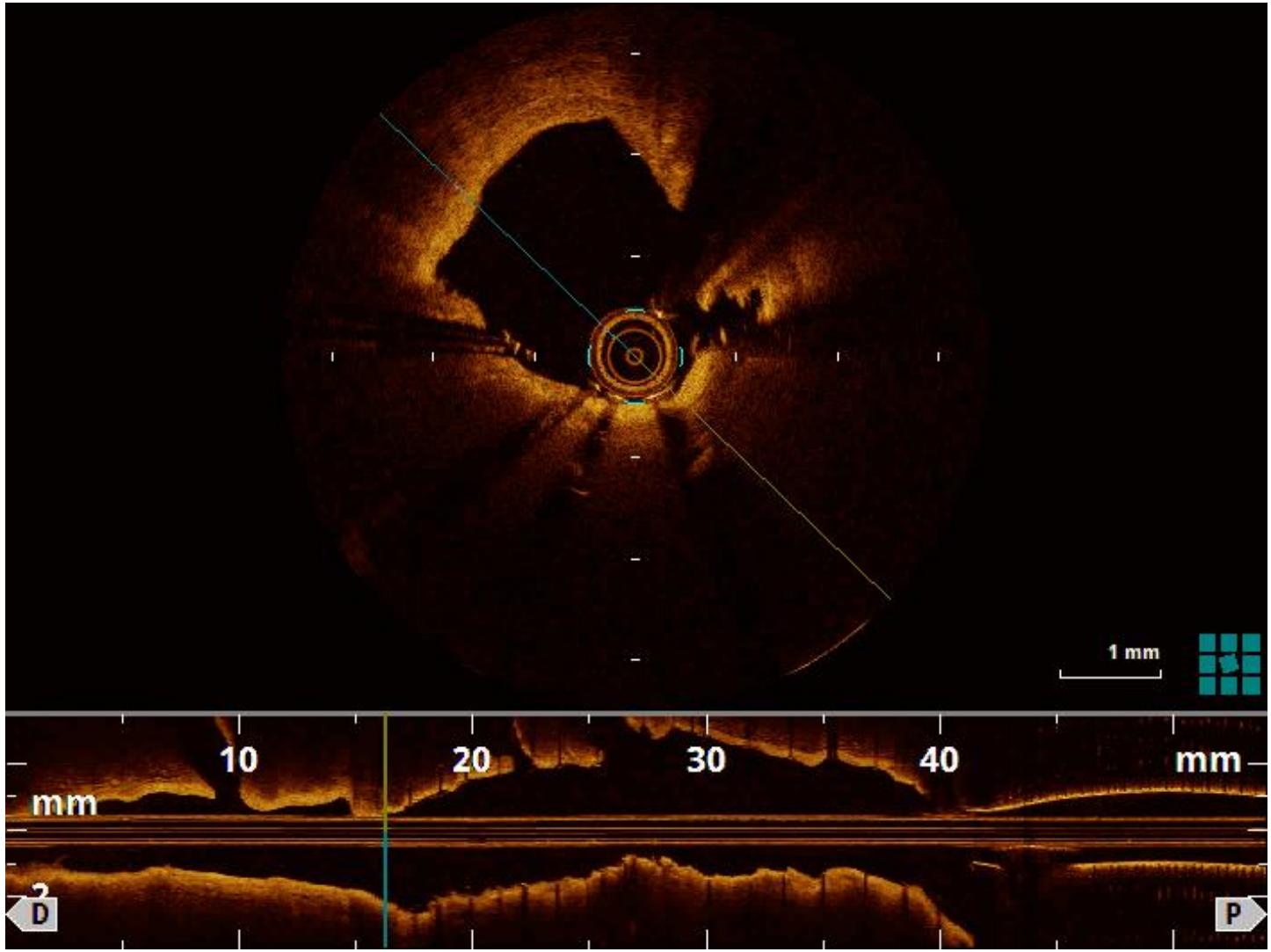
3D- OCT after bifurcation stenting
Link free type

KBT

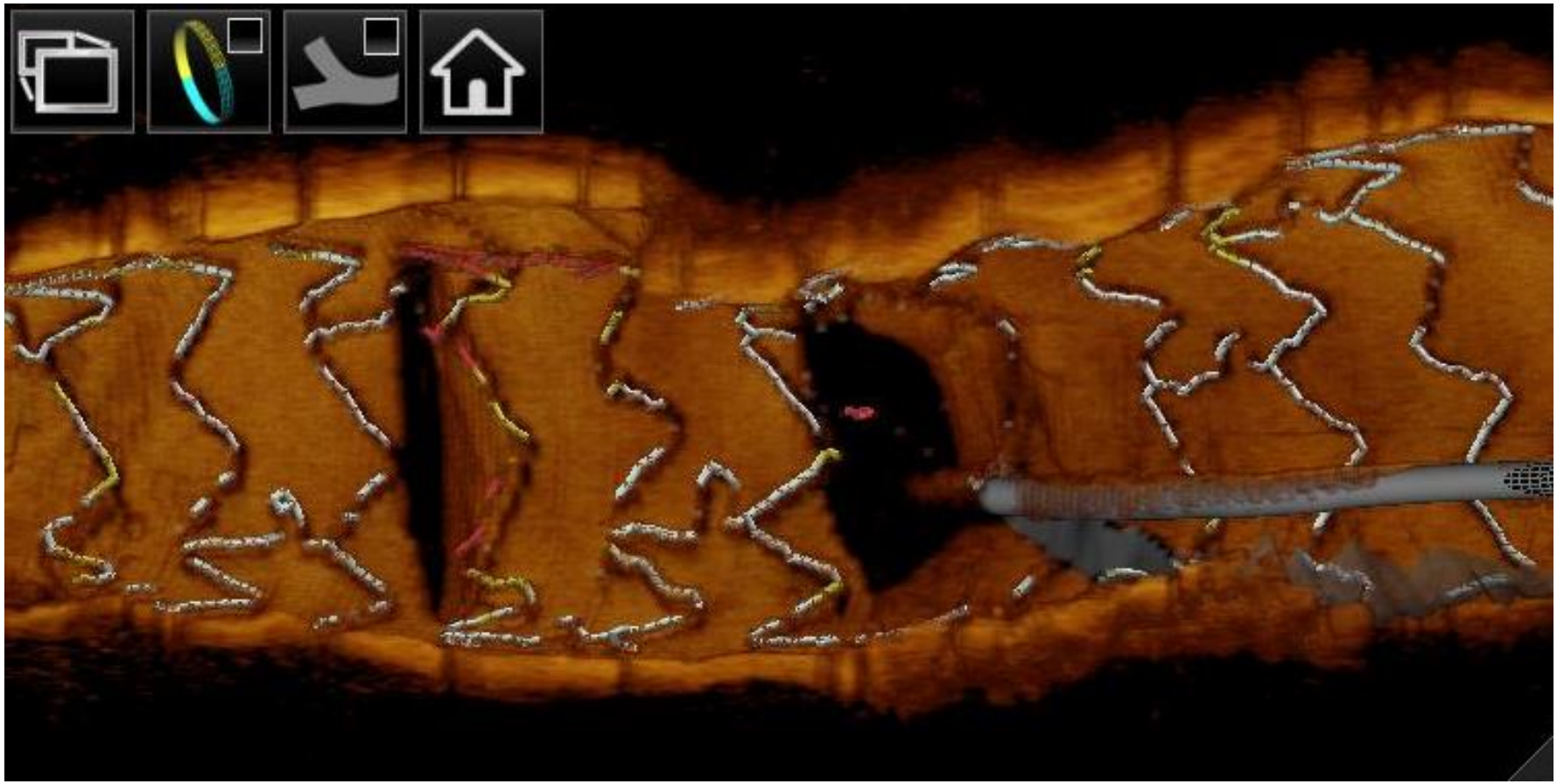




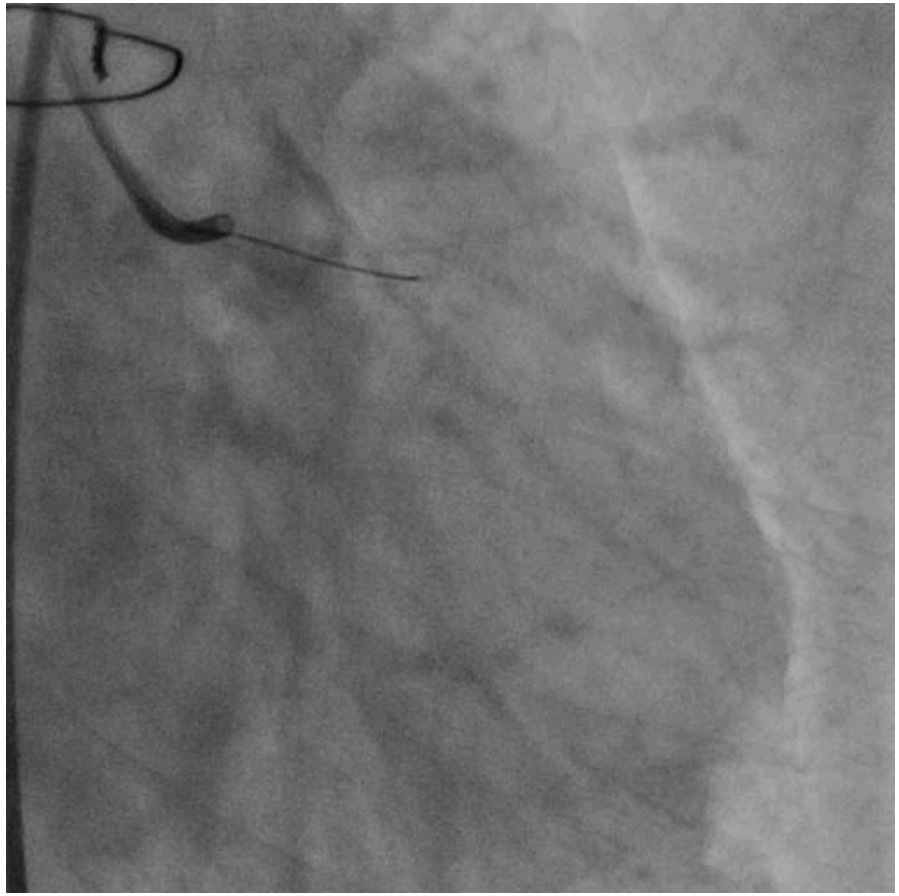
OCT after KBT

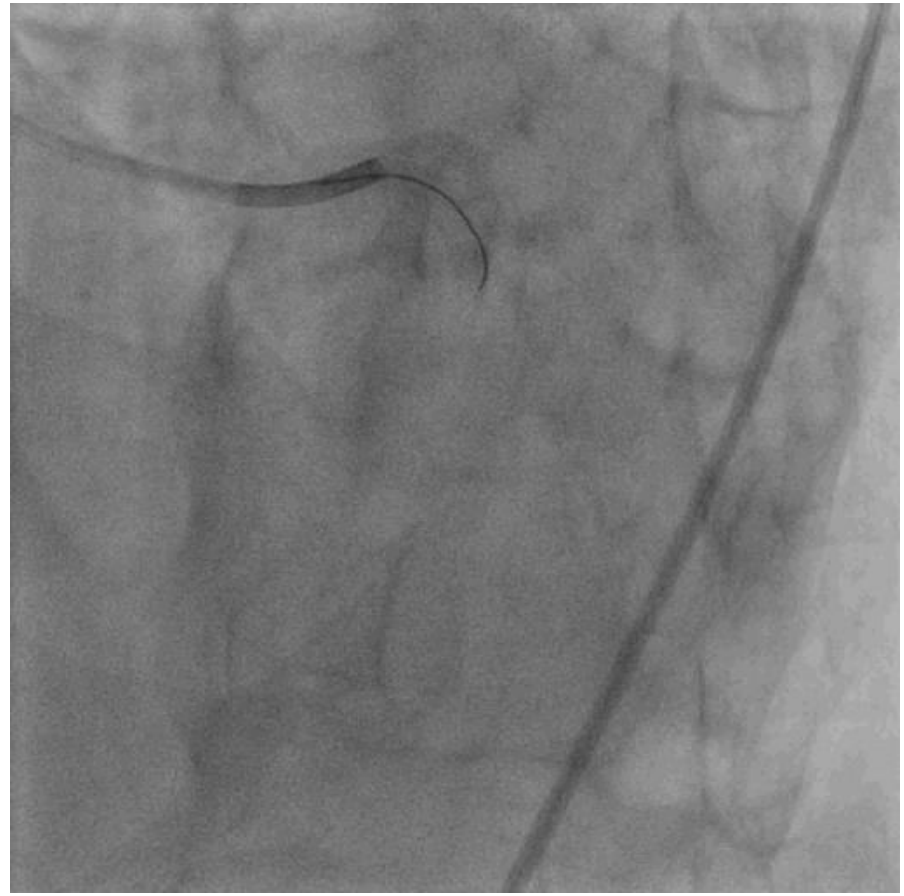


3D-OCT after KBT



Final Angio





Case: 73yo, Male

Clinical diagnosis

unstable AP

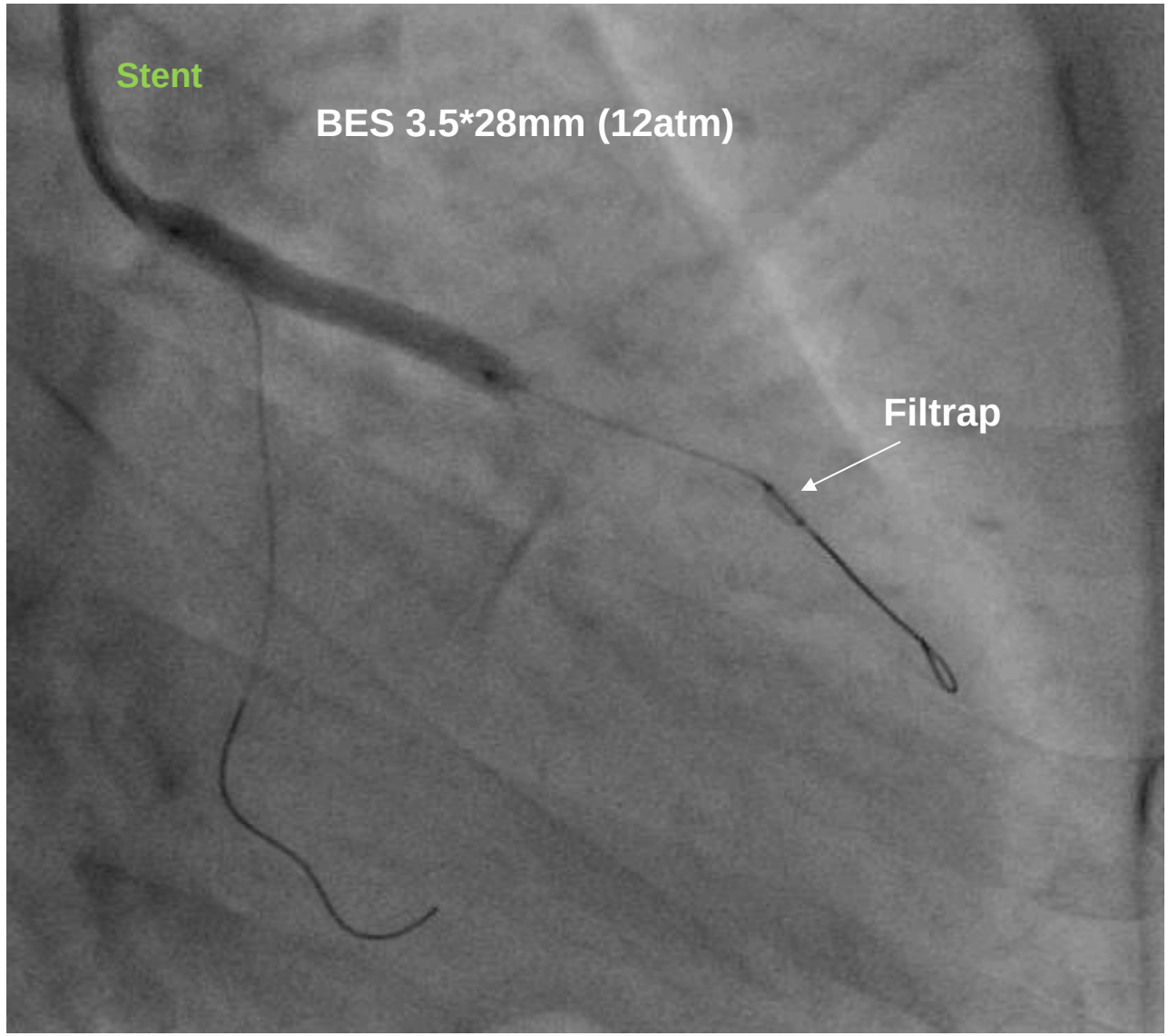
Clinical history

201X. 7~	**Chest pain on effort**
201X. 10	**Chest pain at rest**
	Coronary catheterization

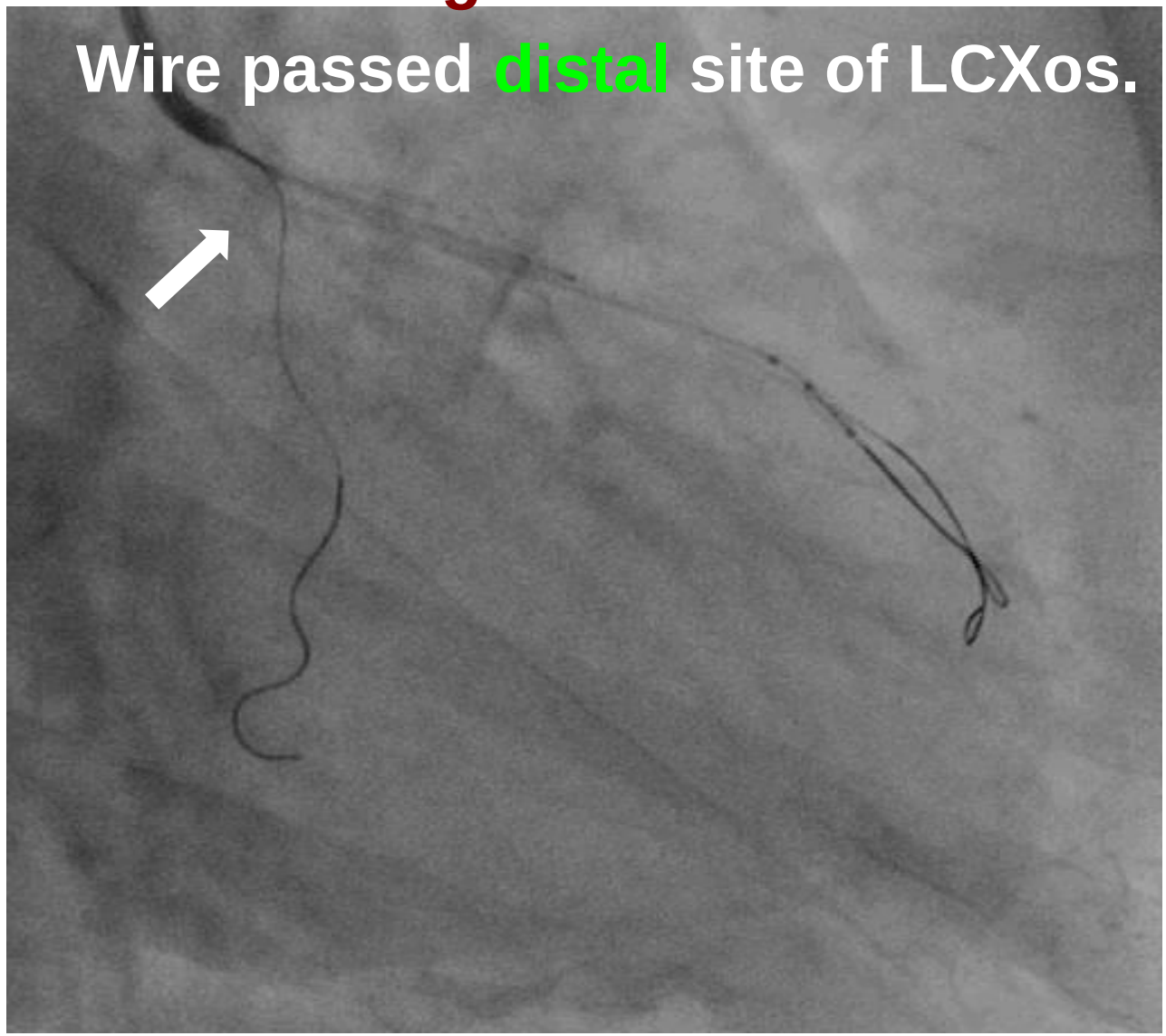
Coronary risk factors

HT (-), DLP (+), DM (-), Obesity (-),
Current smoking (-), Family history (+)

BES from the LM to LAD across the LCx

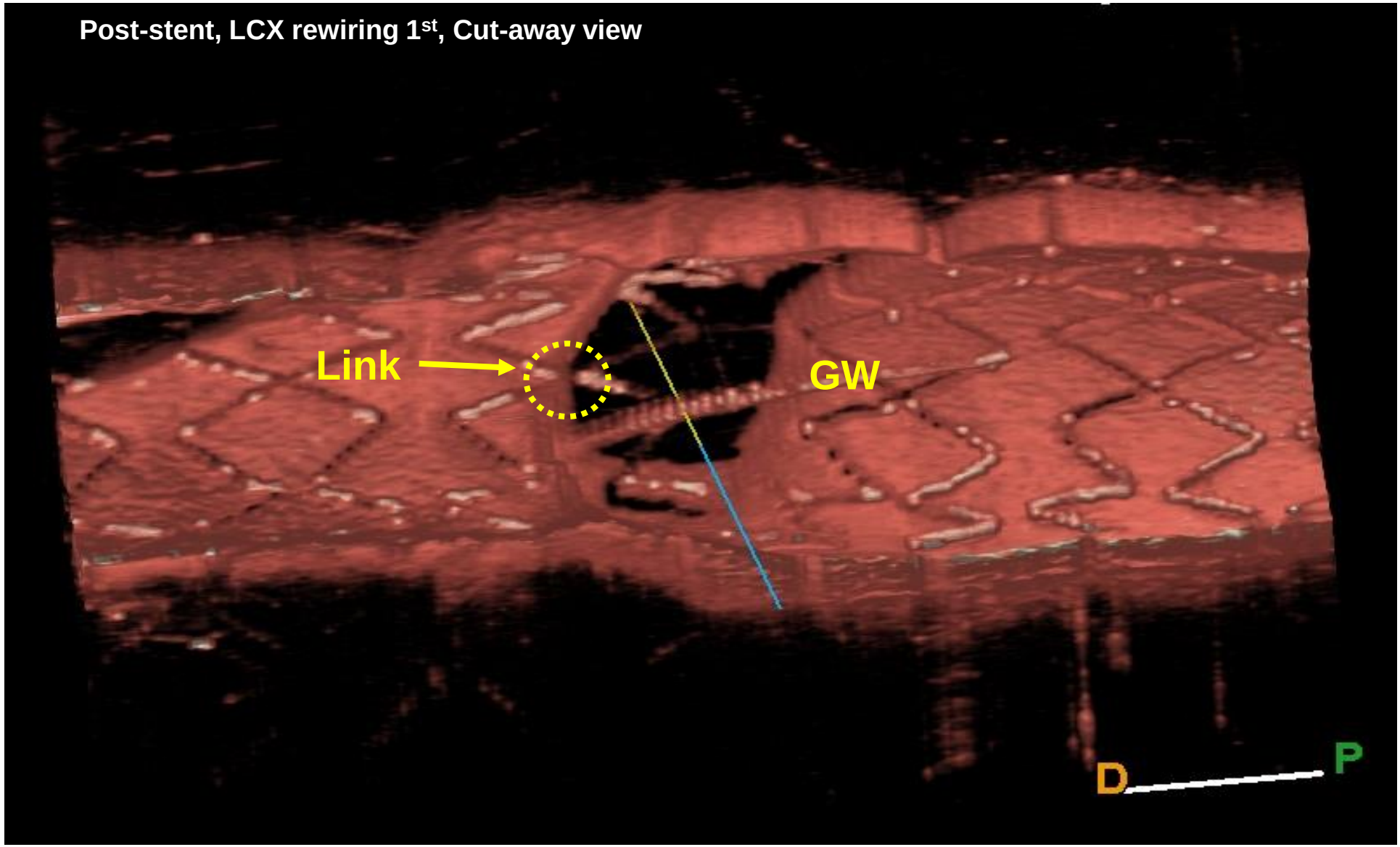


LCX rewiring 1st

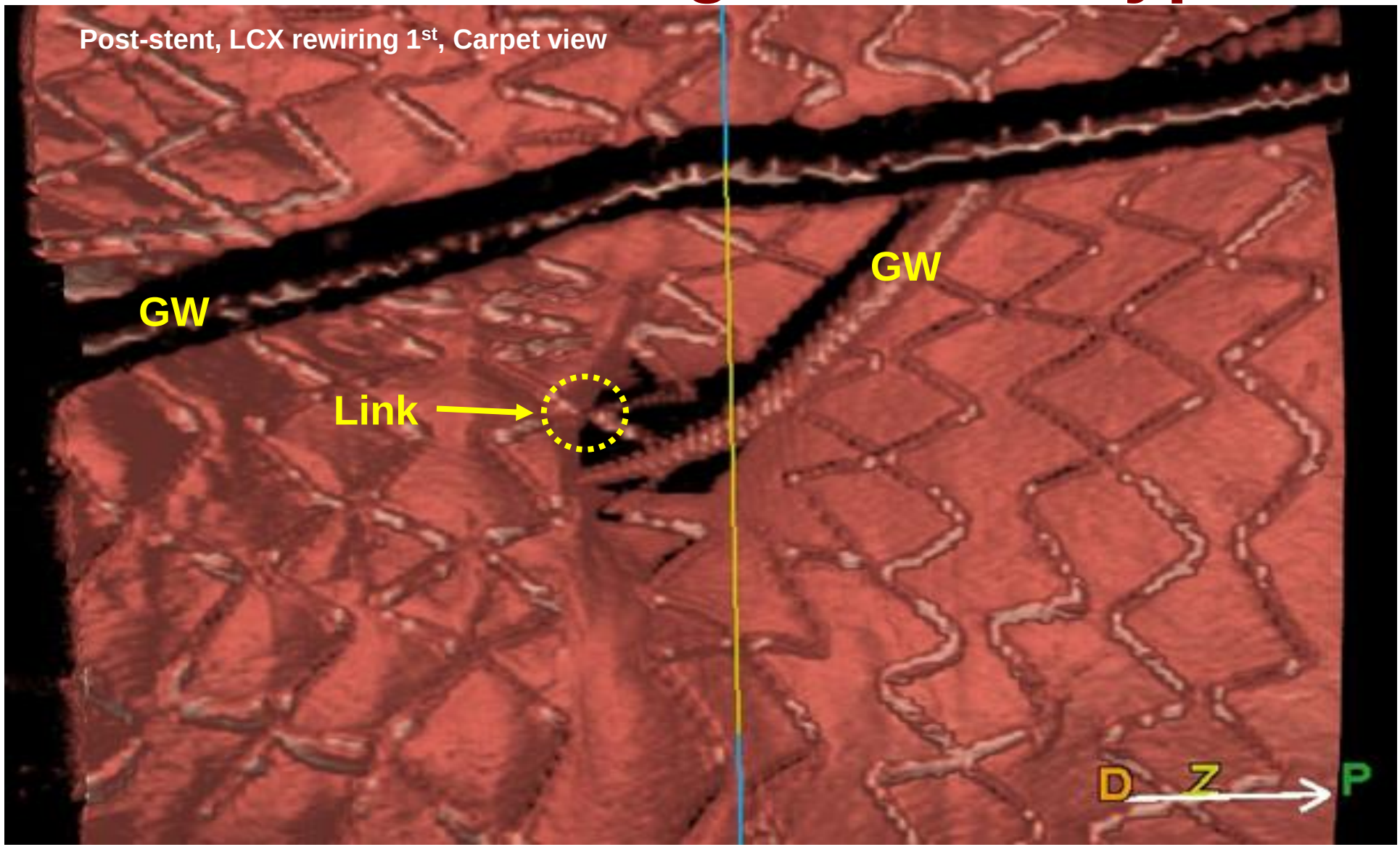


Re-cross the wire through the distal site of the LCx orifice

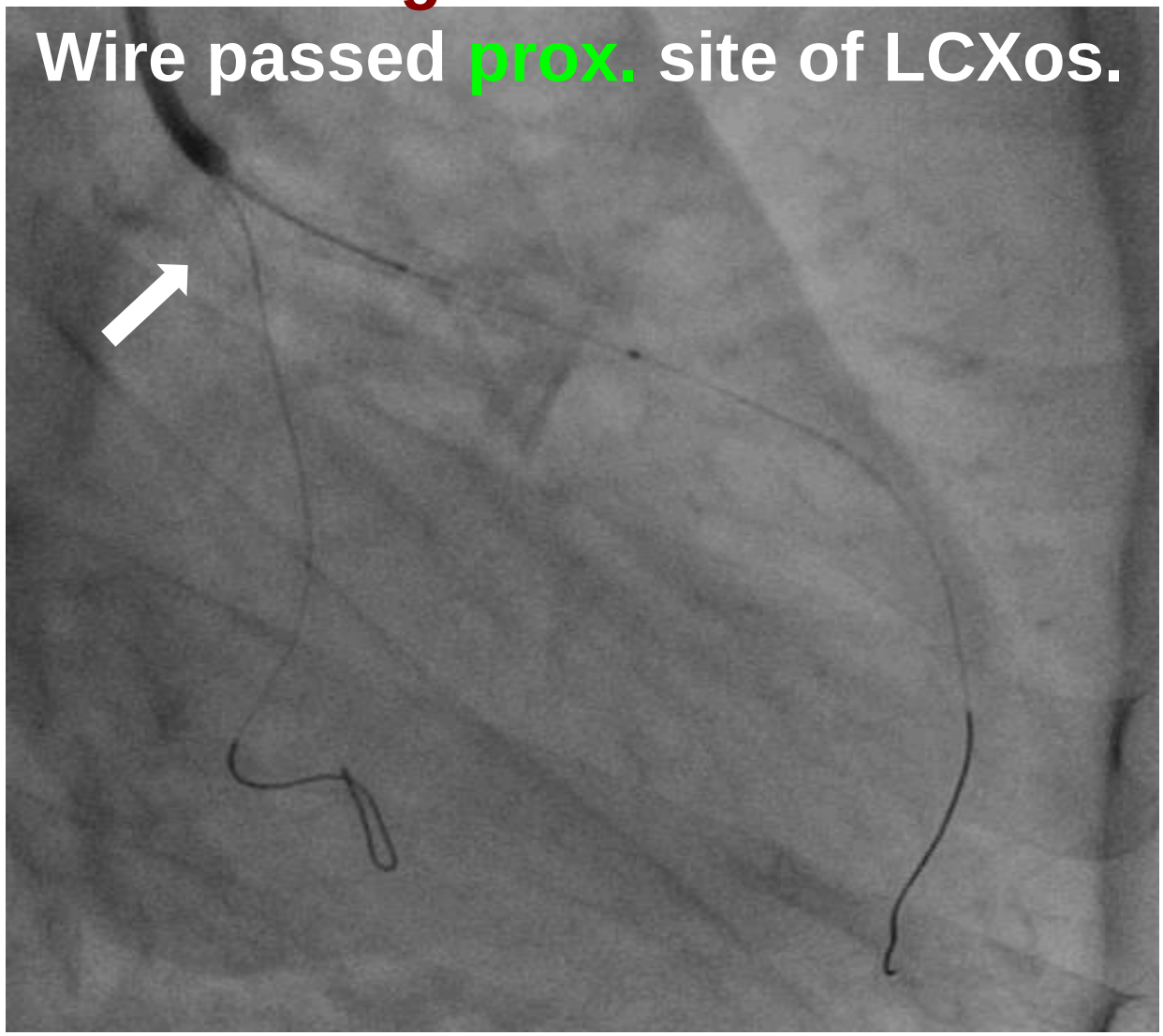
Link connecting to carina type



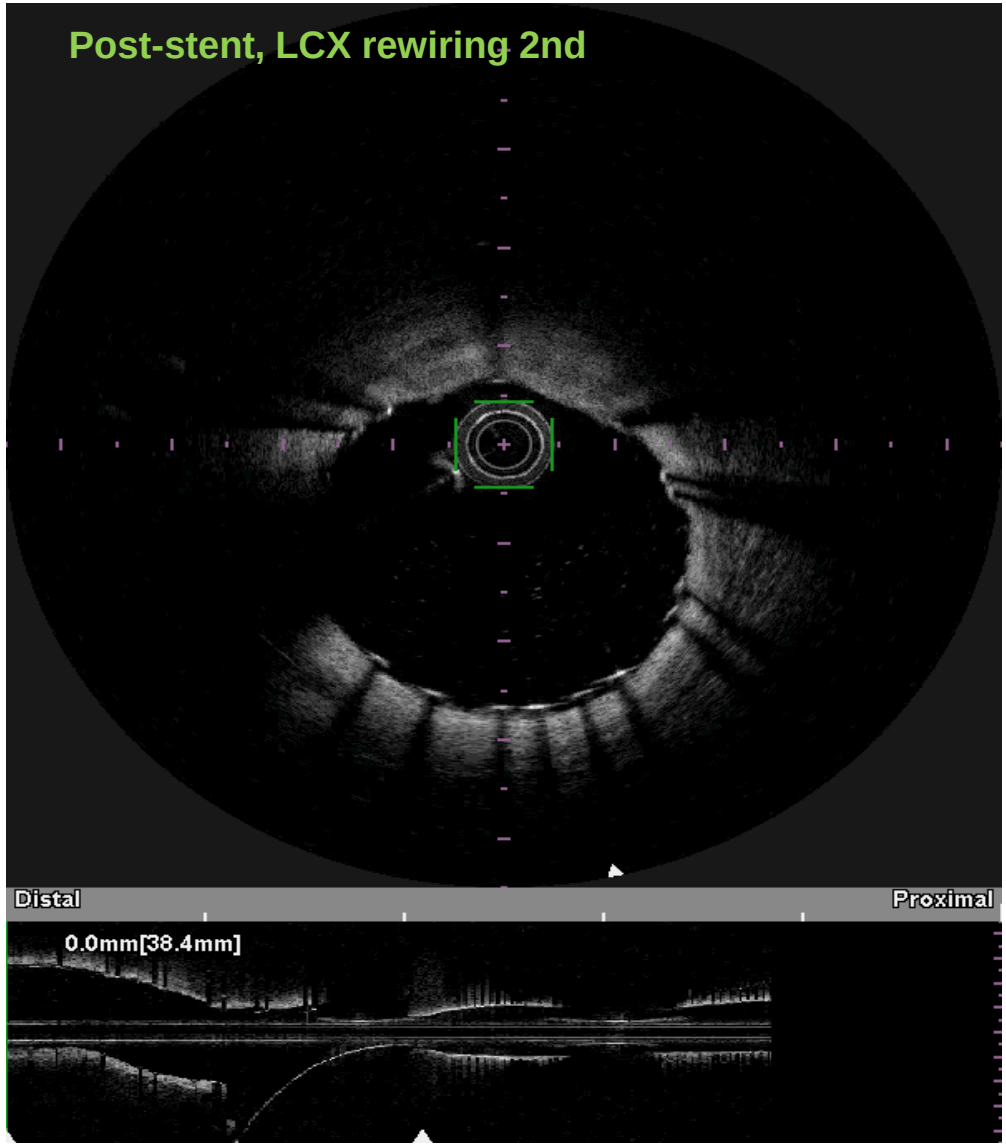
Link connecting to carina type



LCX rewiring 2nd



Recross the wire again from the prox. site of LCx os.

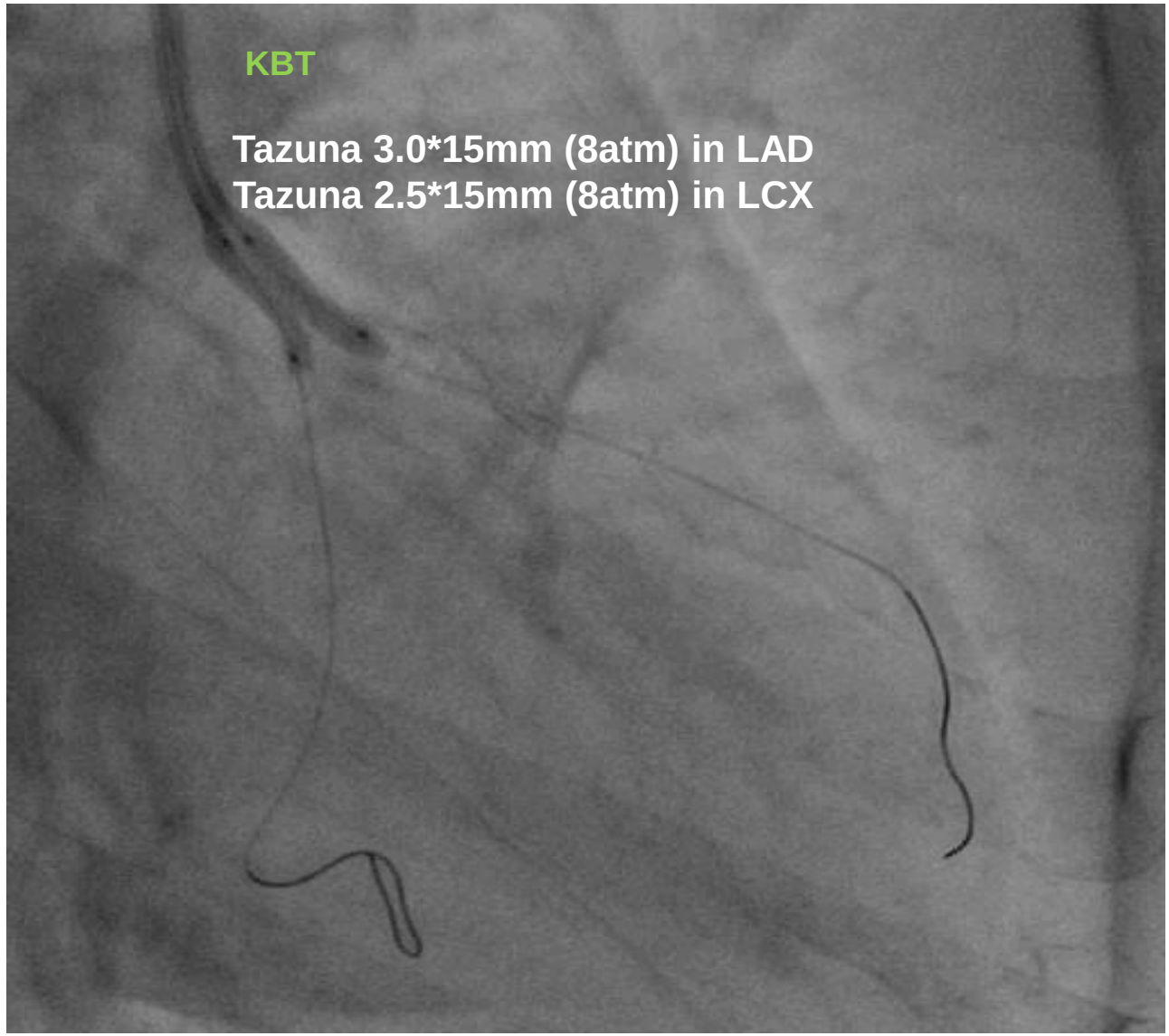


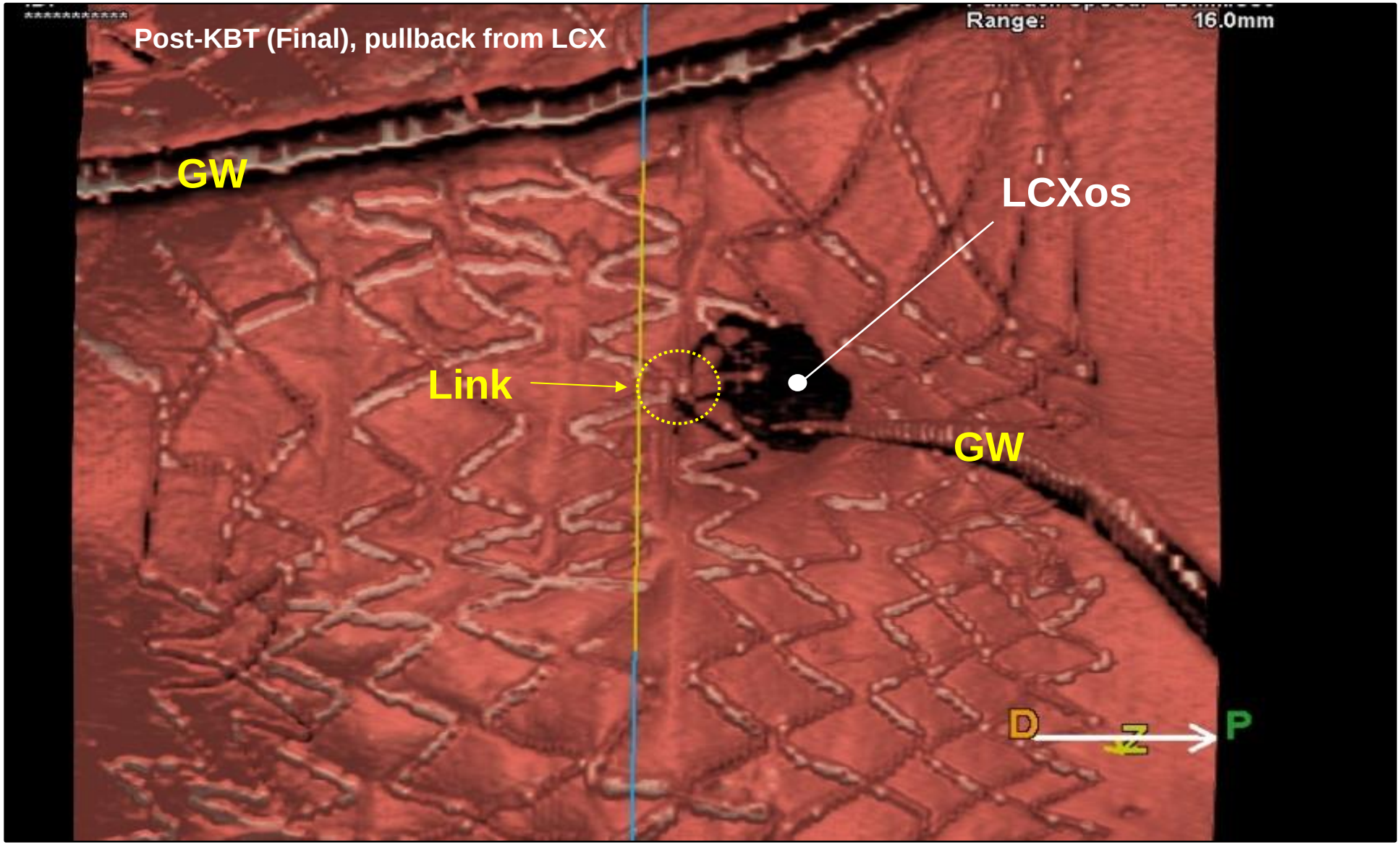
The wire coming from the prox. site of the LCx orifice, although it is difficult to confirm the wire position clearly.

Link connecting to carina type

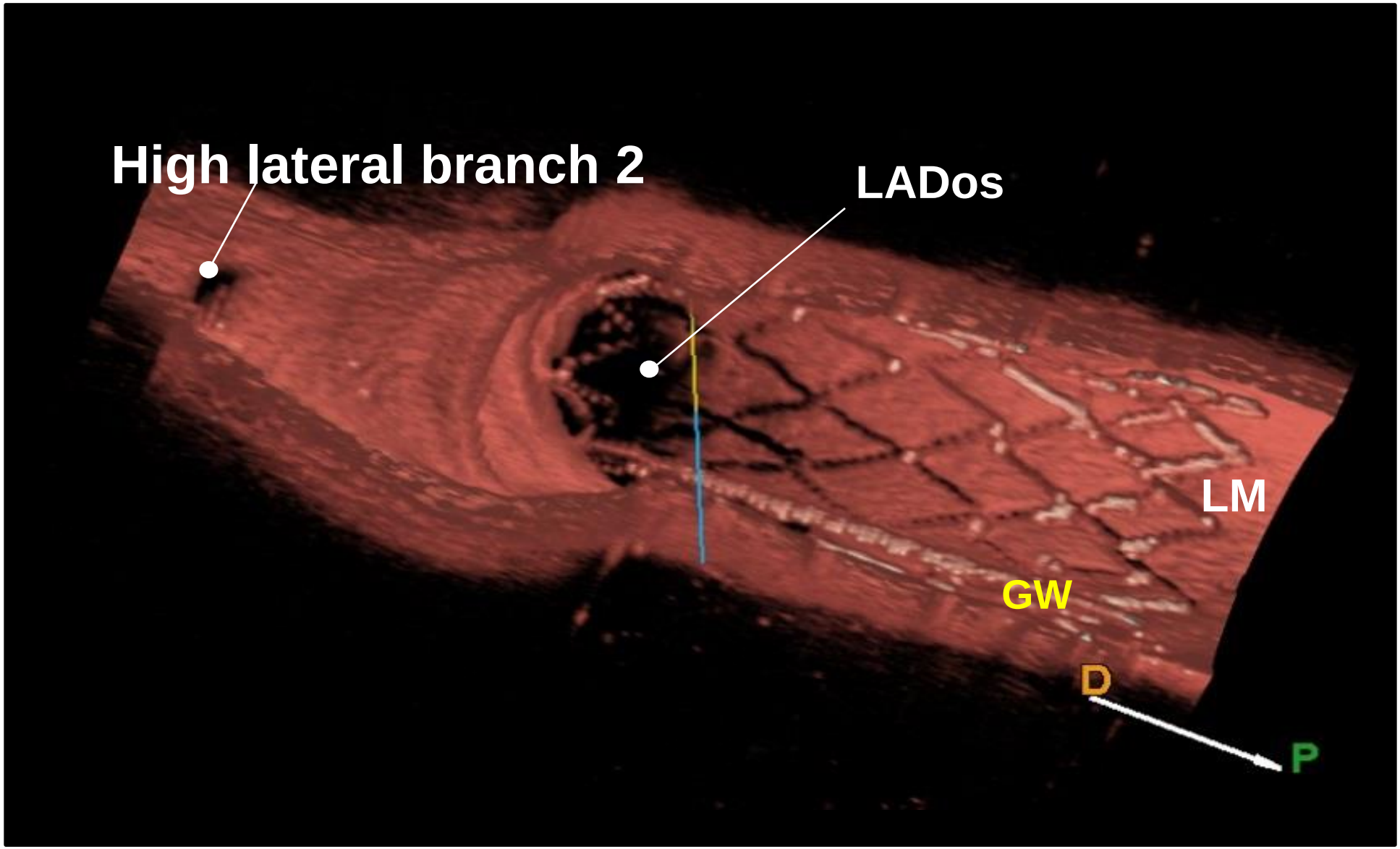
KBT

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



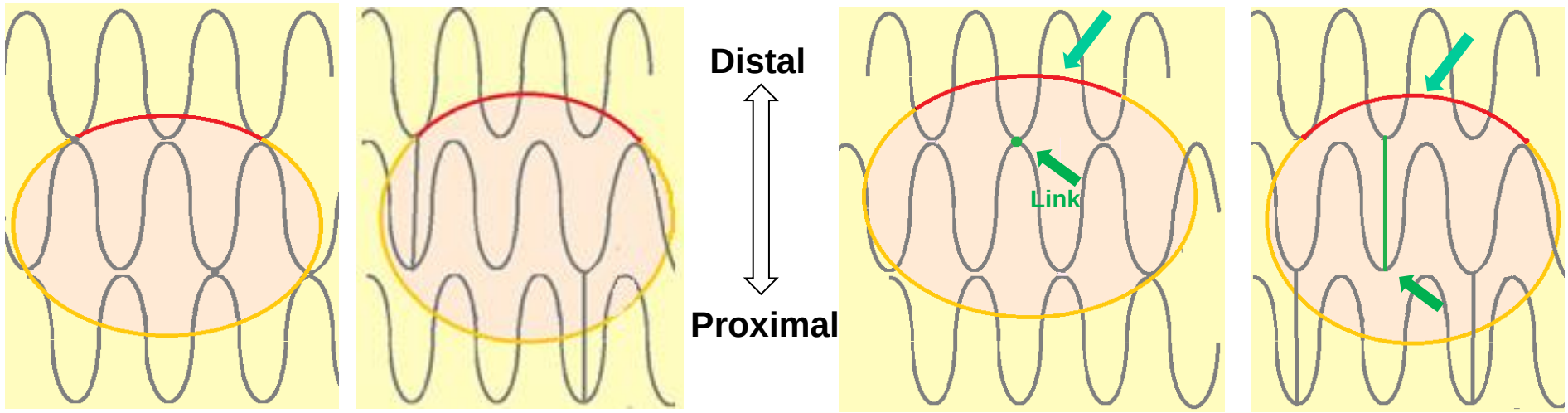

Post-KBT (Final), pullback from LCX
Range:
16.0mm
GW
LCXos
Link
GW
D
P

Post-KBT (Final), pullback from LCX



Incidence of ISA after side branch opening

Okamura T et al. EuroIntervention 2014; 10: 907-915



Free carina type

Connecting to carina type

		Configuration of overhanging struts			
		All (n = 13)	Free carina type (n =7)	Connecting to carina type (n = 6)	P value
The most distal cell	All (n = 13)	—	0.7 ± 0.9 %	12.2 ± 6.5 %	0.0074
	Yes (n =10)	3.7 ± 5.6 %	0.7 ± 0.9 % (n = 7)	10.6 ± 6.2 % (n = 3)	0.1068
	No (n = 3)	13.7 ± 7.8 %	—	13.7 ± 7.8 % (n = 3)	—
P value		0.1422	—	0.6198	—

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, I
Takao Maeda[1], MD; Ta
Patrick W. Serruys[2], M

1. Division of Cardiology, Ube, Japan; 2. Thoraxcen

T. Okamura and Y. Onuma

GUEST EDITOR: Carlo
Brompton Hospital, Londo

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.

Japanese registry for 3-D OCT guided LM bifurcation stenting

Study population (Final)

More than 300 LM bifurcation lesions

Primary endpoint

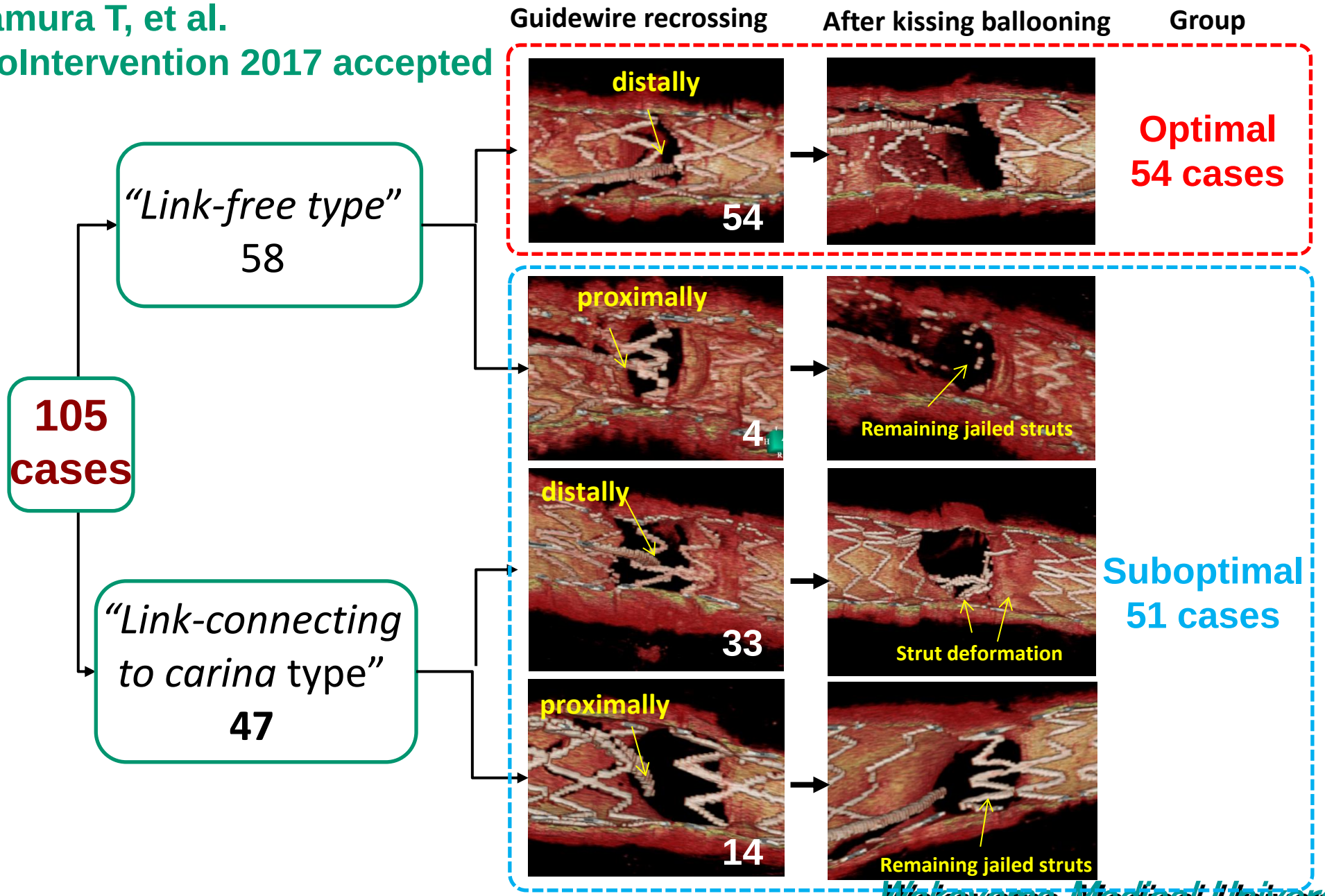
Frequency of re-wiring by 3-D OCT guidance:
re-wiring should be required again more than 30 % cases.

Secondary endpoint

Incidence of ISA:
MACE:

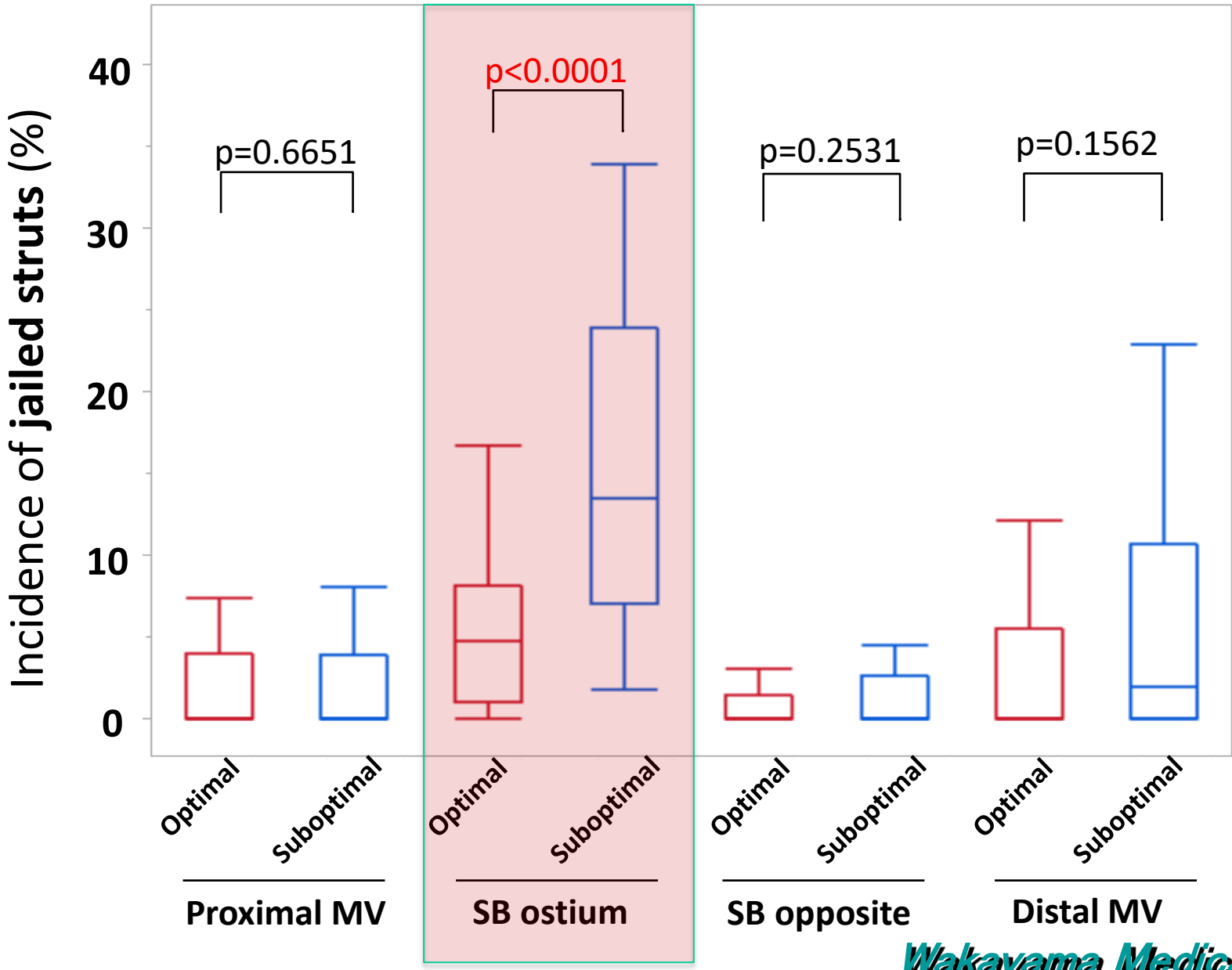
Frequency of jailing configuration & GW rewiring position

Okamura T, et al.
EuroIntervention 2017 accepted



Incidence of ISA at each segment

Okamura T, et al. EuroIntervention 2017 accepted



Factors contributing to incidence of jailed struts at side branch ostium

Parameters	Estimate	Standard Error	t value	p value	Standard Beta
Link-connecting type	0.0289	0.0075	3.82	0.0002	0.3414
GW not distal rewiring	0.0344	0.0098	3.50	0.0007	0.3098
Angle SB-DMV	0.0007	0.0003	2.26	0.0261	0.1985
PMV reference diameter	0.0195	0.0128	1.53	0.1301	0.1572
No smoking	0.0108	0.0079	1.36	0.1757	0.1293
Intercept	0.0722	0.0424	1.70	0.0918	0
Female	-0.010	0.0085	-1.20	0.2324	-0.1123
No hypertension	-0.017	0.0122	-1.39	0.1680	-0.1167
SB balloon size	-0.037	0.0202	-1.87	0.0645	-0.2014

Okamura T, et al. EuroIntervention 2017 accepted

Clinical Outcome at 9 Month

Okamura T, et al. EuroIntervention 2017 accepted

	All	Optimal	Suboptimal	P value
n	100	52	48	
MACE	6(6)	3(5.7)	3(6.3)	1.0000
Death	1(1.0)	0(0)	1(1.0)	0.4800
Non fatal MI	0(0)	0(0)	0(0)	-
Revascularization				
TVR	1(1.0)	1(1.92)	0(0)	1.0000
TLR	4(4.0)	2(3.9)	2(4.2)	1.0000
Stent thrombosis	1(1.0)	0(0)	1(1.0)	0.4800

Angiographic ISR at 9 Month

Okamura T, et al. EuroIntervention 2017 accepted

	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

Take home message

- **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, and 3D reconstruction, etc.**

- **Improvement of clinical outcomes in bifurcation lesion PCI can be expected by the guidance of 3D-OCT, although there are not enough data to support the reduction of the adverse clinical events using OCT guided PCI for bifurcation lesions.**

- **Randomized prospective studies with greater number of study population should be planned to demonstrate the improvement of clinical outcome by 3D-OCT guided PCI for bifurcation lesions in the near future.**

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

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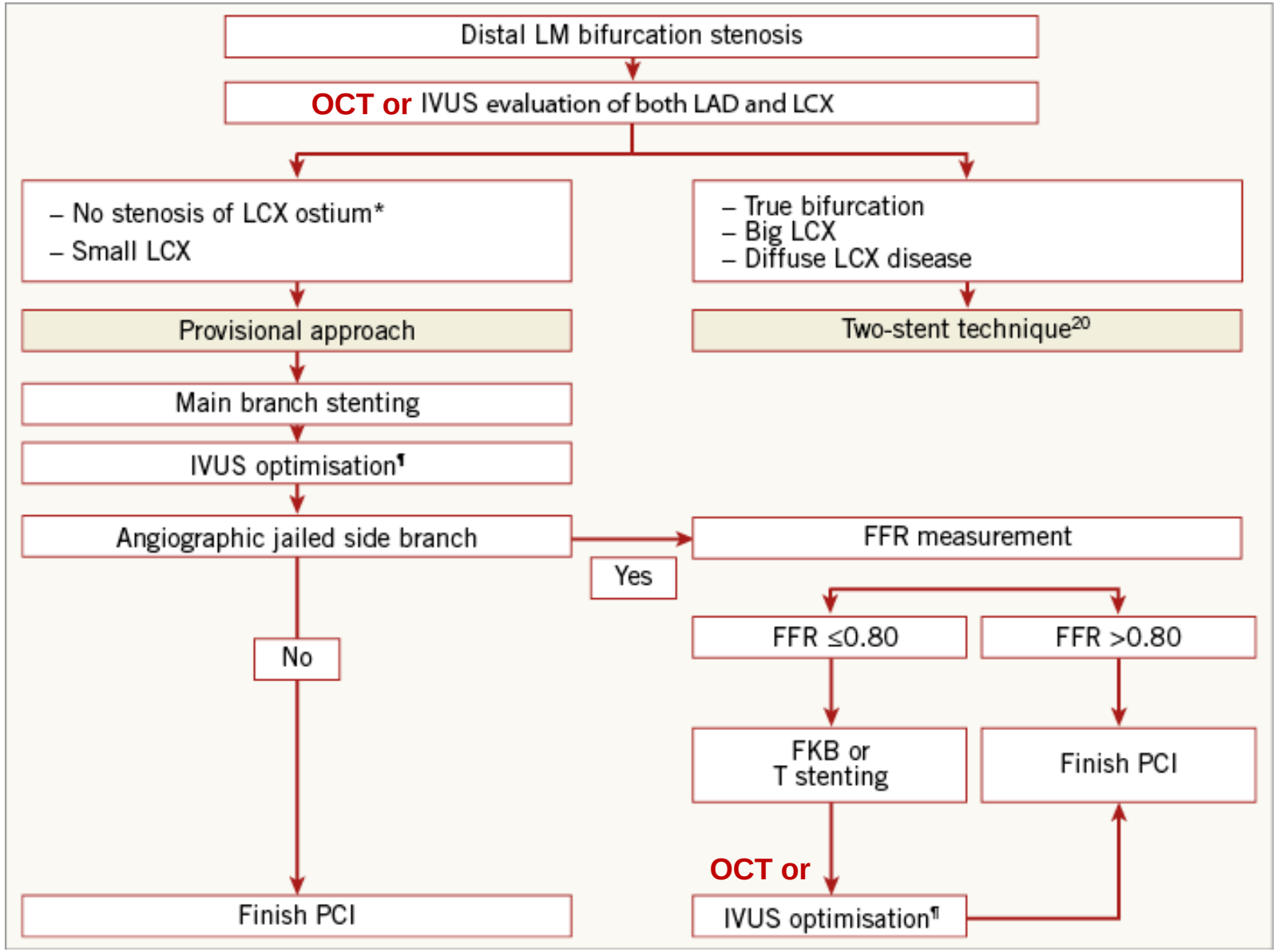
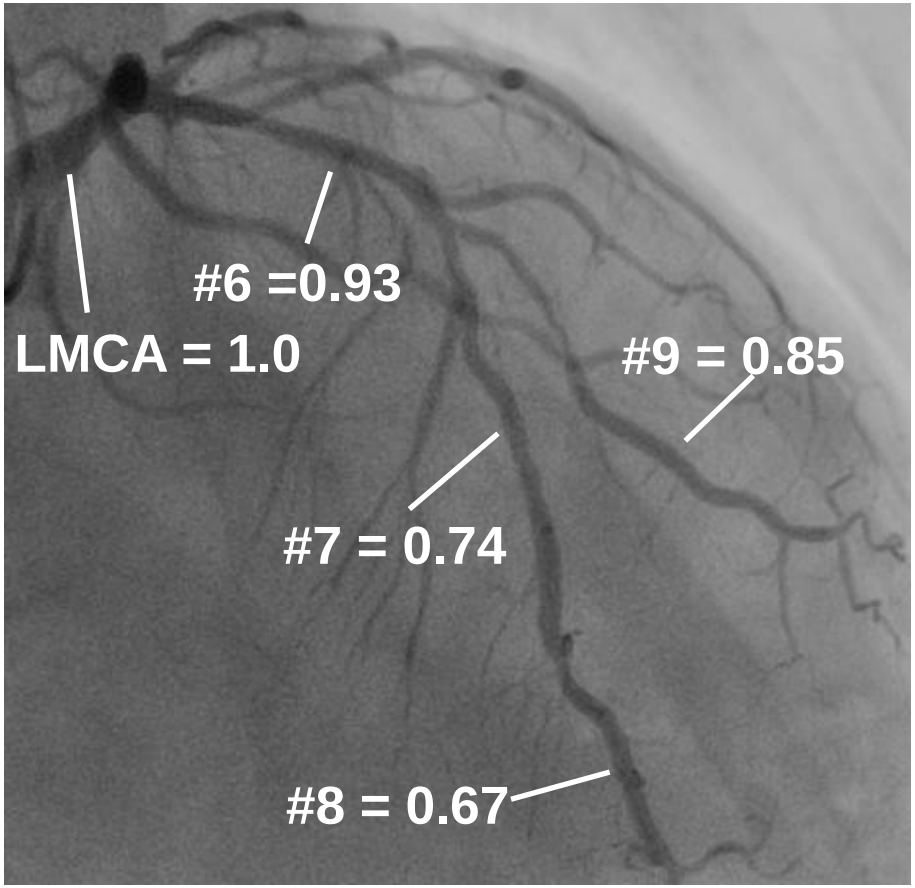
Conclusions: 3D-OCT confirmation of the recrossing into the jailed side branch is feasible during PCI and may help to achieve distal rewiring and favourable stent positioning against the side branch ostium, leading to reduction in ISA and potentially better clinical outcomes.

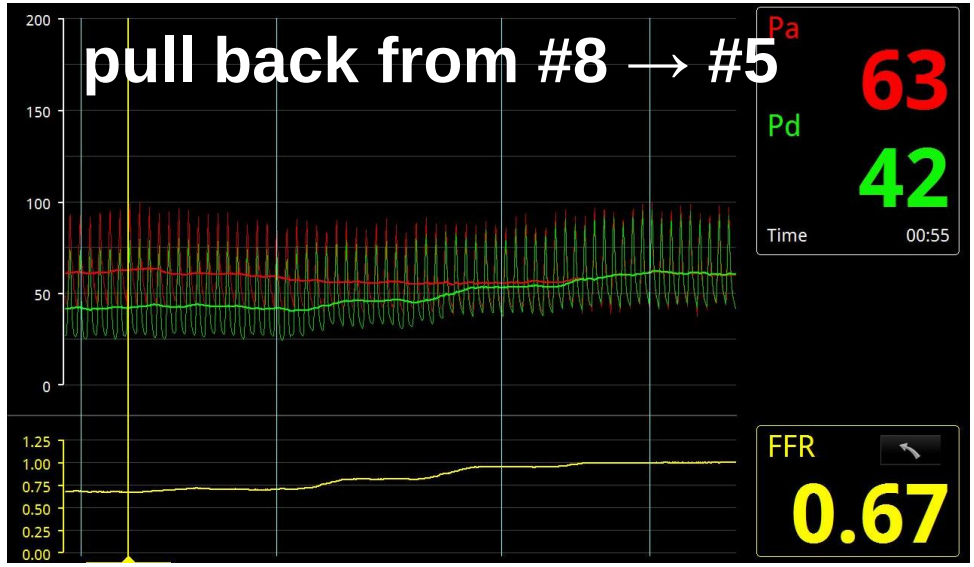
When and how to perform the provisional approach for distal LM stenting

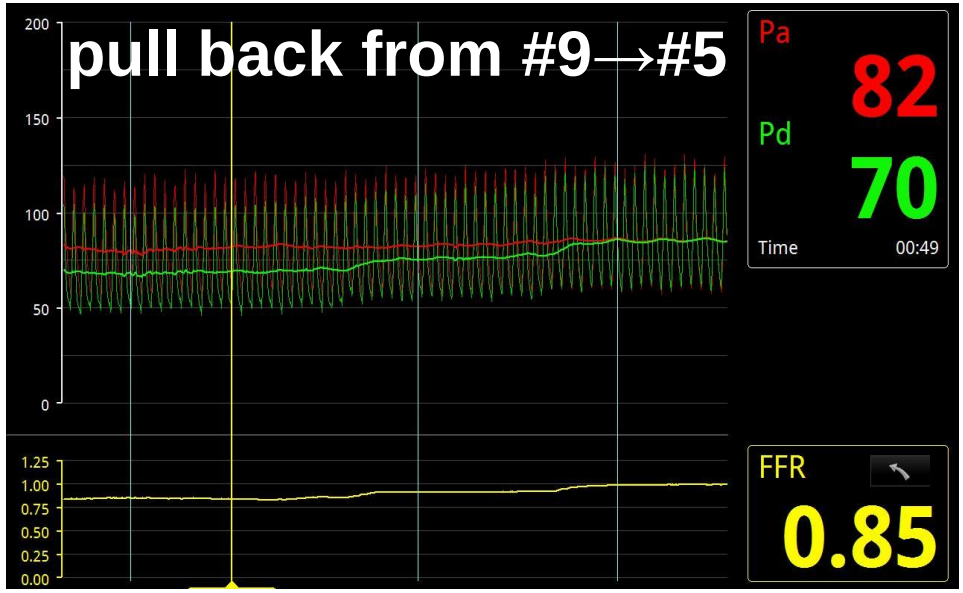
Park SJ, et al. EuroIntervention 2015;11:V120-V124



FFR（Pre PCI）







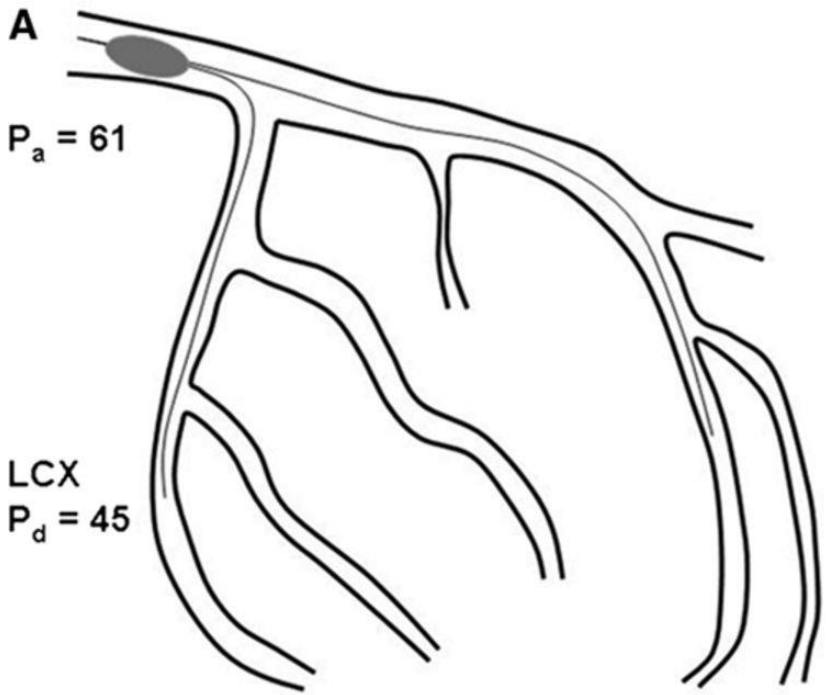
FFR : 0.67 (LAD) / 0.85 (Dx)

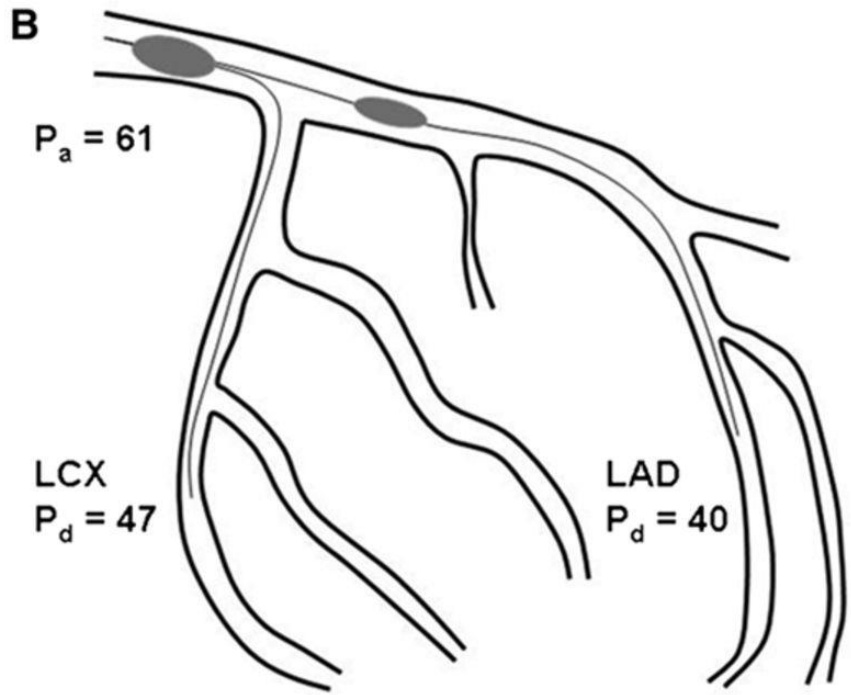
jump up at #6 (0.74⇒0.93)

jump up at #9 (0.85⇒0.93)

Overestimation of side branch stenosis by angiography

Schematic example of physiological measurements of LM stenosis with or without proximal LAD stenosis





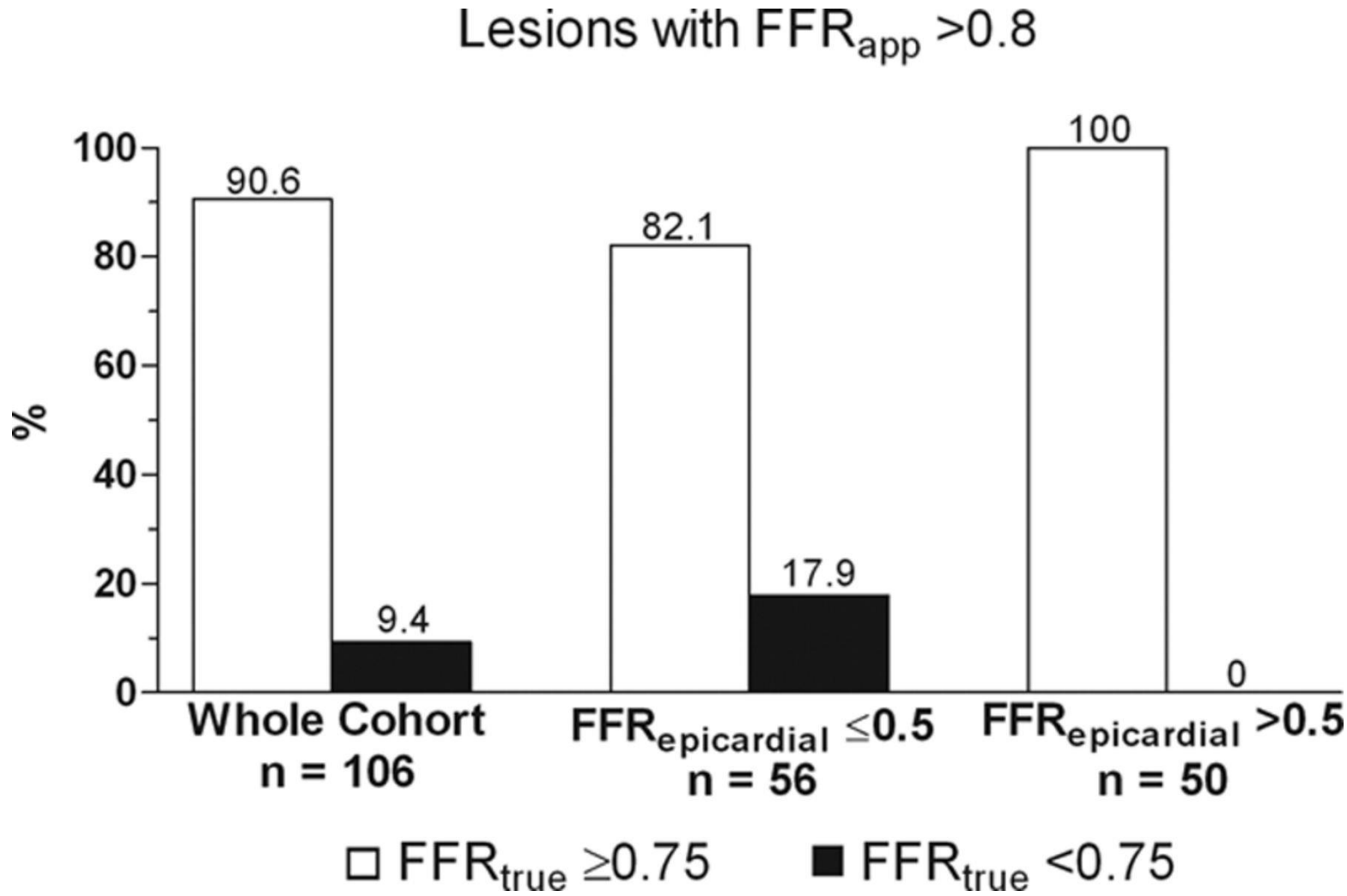
FFR_{true} = 45/61 = 0.74

FFR_{app} = 47/61 = 0.77 $FFR_{epicardial}$ = 40/61 = 0.66

FFR in LCx would be overestimated by the proximal LAD stenosis.

Yong ASC et al. Circ Cardiovasc Interv. 2013;6:161-165

True FFR (FFRtrue) in instances where FFRapp >0.8



In cases with FFR$_{LAD}$ ≦0.5, true FFR$_{LCx}$ would be <0.75 even if apparent FFR$_{LCx}$ is >0.8 .

Yong ASC et al. Circ Cardiovasc Interv. 2013;6:161-165

Take home message

- FFR measurement should be essential for deciding the bifurcation lesion treatment before or after stenting, and the underestimation of the lesion severity should be taken into account in the assessment of side branch stenosis.
- Pre-PCI lesion assessment by imaging may allow us to decide stent size, stent length and landing zone precisely.
- Imaging assessment during PCI should be essential to identify stent under-expansion, incomplete apposition or complications including stent edge dissection, intramural hematoma and so on.
- Confirmation of the final result of PCI by imaging should improve the prognosis of patients by avoiding acute or subacute stent thrombosis, restenosis or MACE.

Take home message

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, and 3D reconstruction, etc.

Improvement of clinical outcomes in bifurcation lesion PCI can be expected by the guidance of 3D-OCT, although there are not enough data to support the reduction of the adverse clinical events using OCT guided PCI for bifurcation lesions.

Randomized prospective studies should be planned to demonstrate the improvement of clinical outcome by 3D-OCT guided PCI for bifurcation lesions in the near future.

Recommendation for the type of revascularization (CABG or PCI) in pts with stable coronary artery disease

with suitable coronary anatomy for both procedures & low surgical mortality

Recommendations according to extent of CAD	CABG		PCI	
	Class[a]	Level[b]	Class[a]	Level[b]
One or two-vessel disease without proximal LAD stenosis.	IIb	C	I	C
One-vessel disease with proximal LAD stenosis.	I	A	I	A
Two-vessel disease with proximal LAD stenosis.	I	B	I	C
Left main disease with a SYNTAX score ≤ 22.	I	B	I	B
Left main disease with a SYNTAX score 23–32.	I	B	IIa	B
Left main disease with a SYNTAX score >32.	I	B	III	B
Three-vessel disease with a SYNTAX score ≤ 22.	I	A	I	B
Three-vessel disease with a SYNTAX score 23–32.	I	A	III	B
Three-vessel disease with a SYNTAX score >32.	I	A	III	B

Windecker S, et al. Eur Heart J 2014;35:2541-2619

NEXT: Procedural Characteristics

	Biolimus-eluting stent	Everolimus-eluting stent	P
No. of lesions treated per patient	1.27 ± 0.56	1.24 ± 0.51	0.1
No. of stents			
Per patient	1.59 ± 0.84	1.6 ± 0.83	0.74
Per lesion	1.29 ± 0.56	1.32 ± 0.6	0.13
Total stent length (mm)			
Per patient	33.0± 20.3	32.9 ± 20.7	0.87
Per lesion	26.9 ± 15.1	27.2 ± 16.5	0.52
Stent diameter (mm)	2.88 ± 0.67	2.87 ± 0.64	0.7
Direct stenting	23 %	23 %	0.93
Maximum inflation pressure (atm)	17.2 ± 4.5	16.9 ± 4.4	0.03
Bifurcation 2-stent	1.2 %	1.0 %	0.41
IVUS use	**88%**	**87%**	**0.21**
Multivessel treatment	13%	11%	0.21
Staged procedures	27%	27%	0.77

Natsuaki M, et al. J Am Coll Cardiol 2013;62:181-190