OCT-guided PCI Step-by-Step: Basic, Artifacts & Pitfalls

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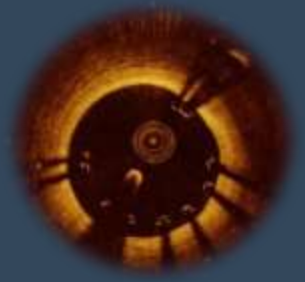
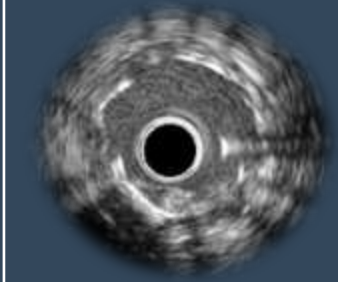
OCT vs. IVUS

	C7-XR	IVUS
		
Axial Resolution	15 – 20 µm	100 – 200 µm
Beam Width	20 – 40 mm	200 – 300 mm
Frame Rate	100 frames/s	30 frames/s
Pullback Speed	20 mm/s	mm/s
Max. Scan Dia.		m
Tissue P		m
Li		256
Lateral Sa	19 µm	225 µm
Blood Clearing	Required	Not Required

Higher resolution is almost 10 times more
Imaging core size is a half of that in IVUS

Modern OCT Guided PCI Workflow | MLD MAX

- Each OCT run serves a separate purpose. The pre-PCI run helps determine the PCI strategy, and the post-PCI run allows for optimization of the stent as needed.

Pre-PCI OCT | Strategize

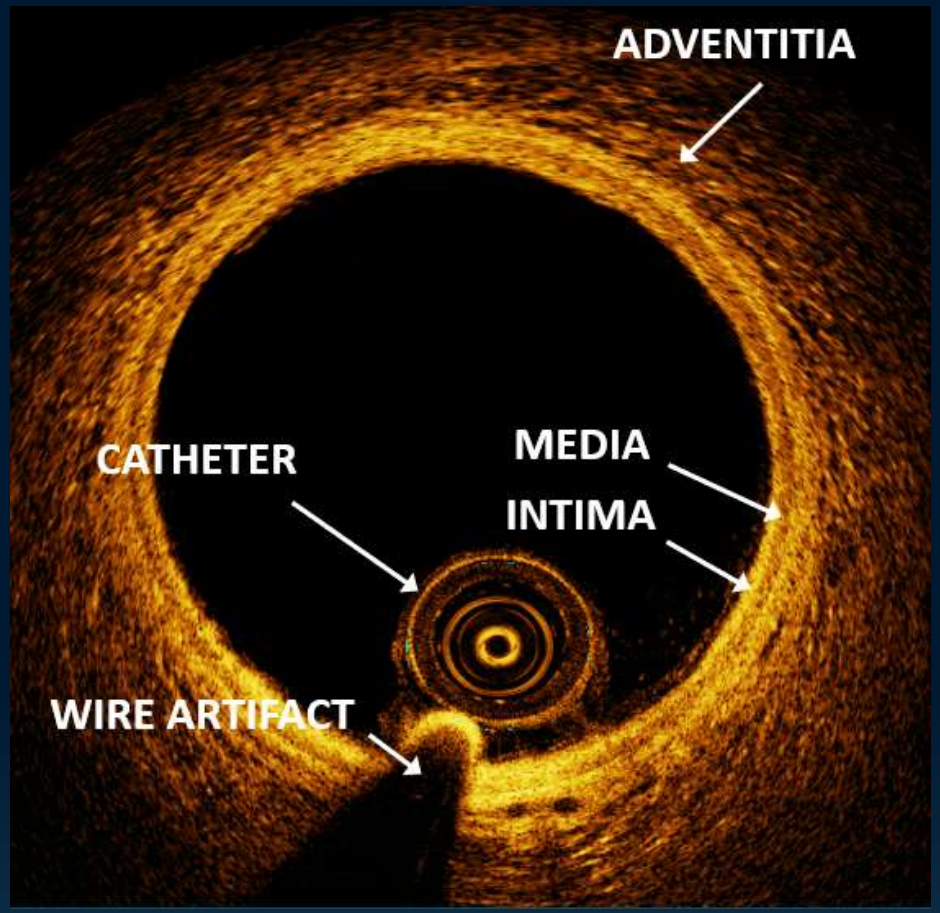
- **M**ORPHOLOGY
- **L**ENGTH
- **D**IAMETER

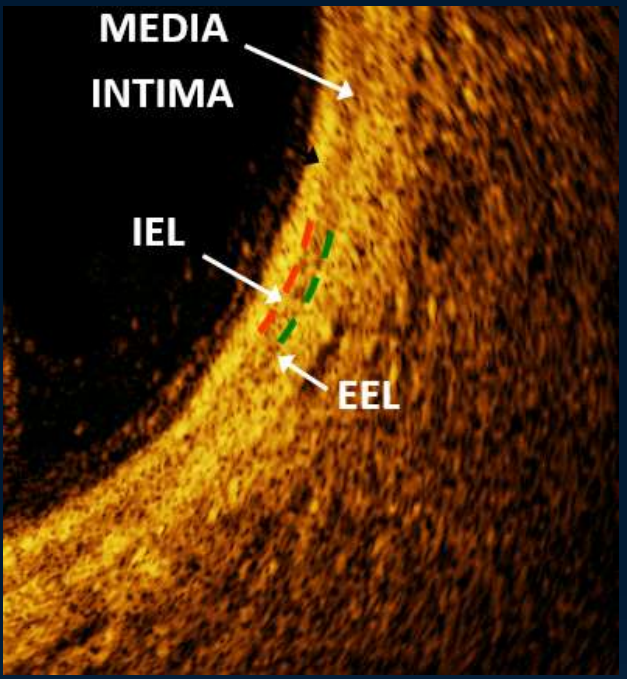
Post-PCI OCT | Optimize

- **M**EDIAL DISSECTION
- **A**PPOSITION
- E**X**PANSION

Normal Artery Morphology on OCT

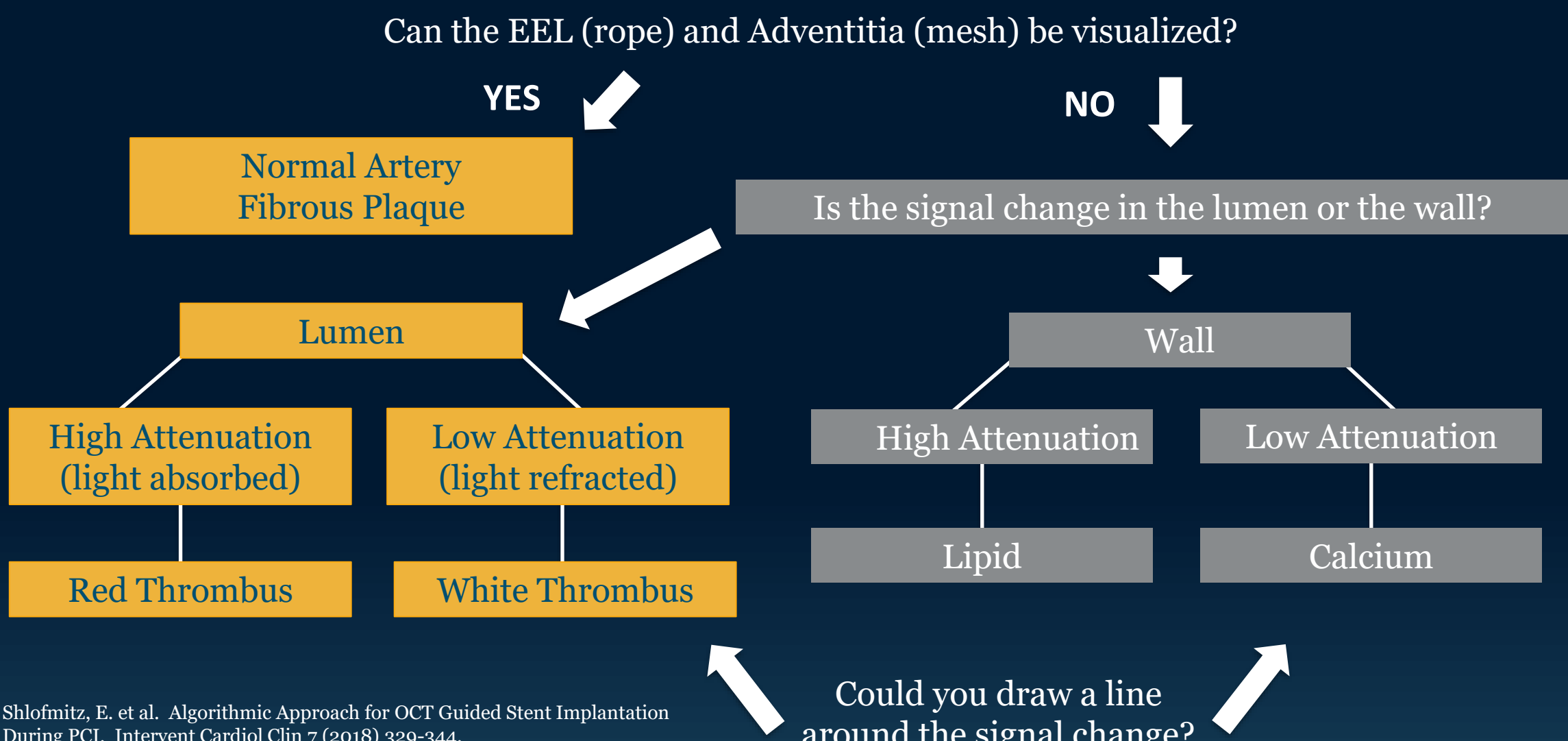
- **Intima** = hard sponge
- **IEL** = rubber band
- **Media** = soft rope
- **EEL** = rubber band
- **Adventitia** = mesh





Shlofmitz, E. et al. Algorithmic Approach for OCT Guided Stent Implantation During PCI. Intervent Cardiol Clin 7 (2018) 329-344.

OCT Image Interpretation

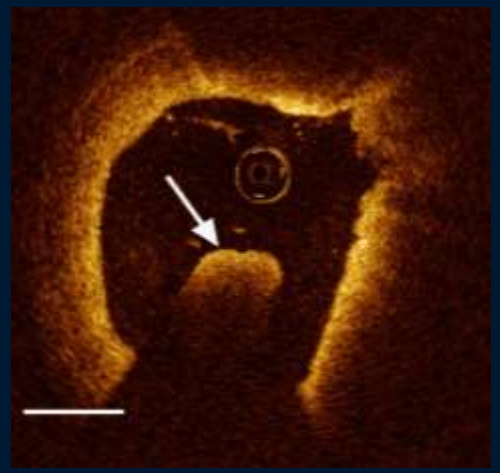


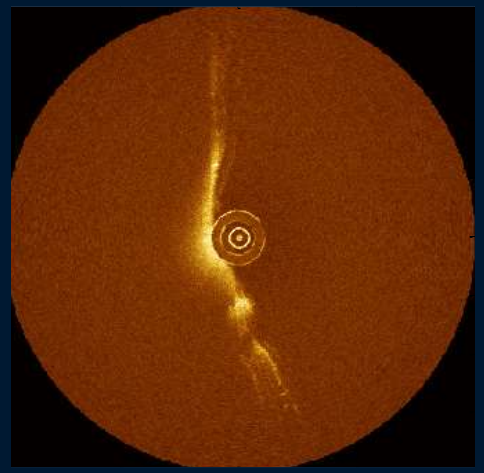
Shlofmitz, E. et al. Algorithmic Approach for OCT Guided Stent Implantation During PCI. Intervent Cardiol Clin 7 (2018) 329-344.

Thrombus: Red vs. White

Red Thrombus
(RBC and fibrin rich)

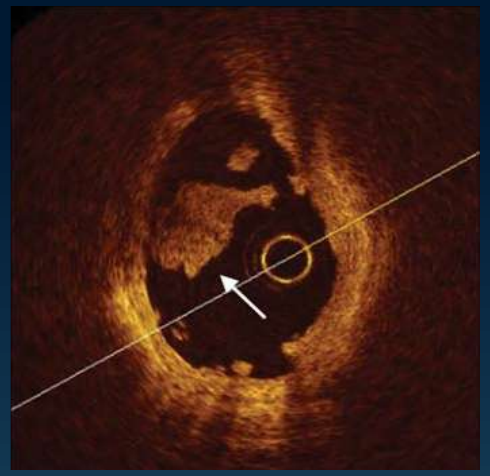
- High backscatter on surface
- High attenuation RBC shadow; cannot see beyond

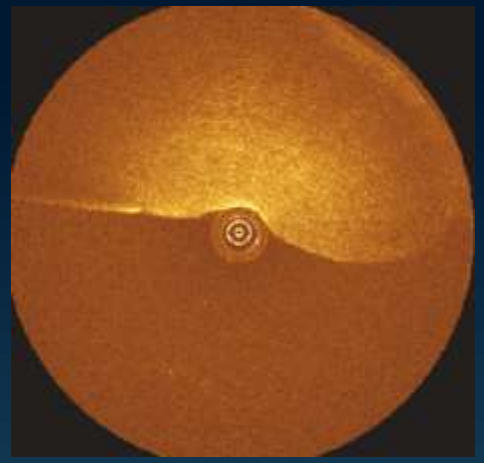




White Thrombus
(platelet rich)

- High backscatter
- Low attenuation
- Can see beyond



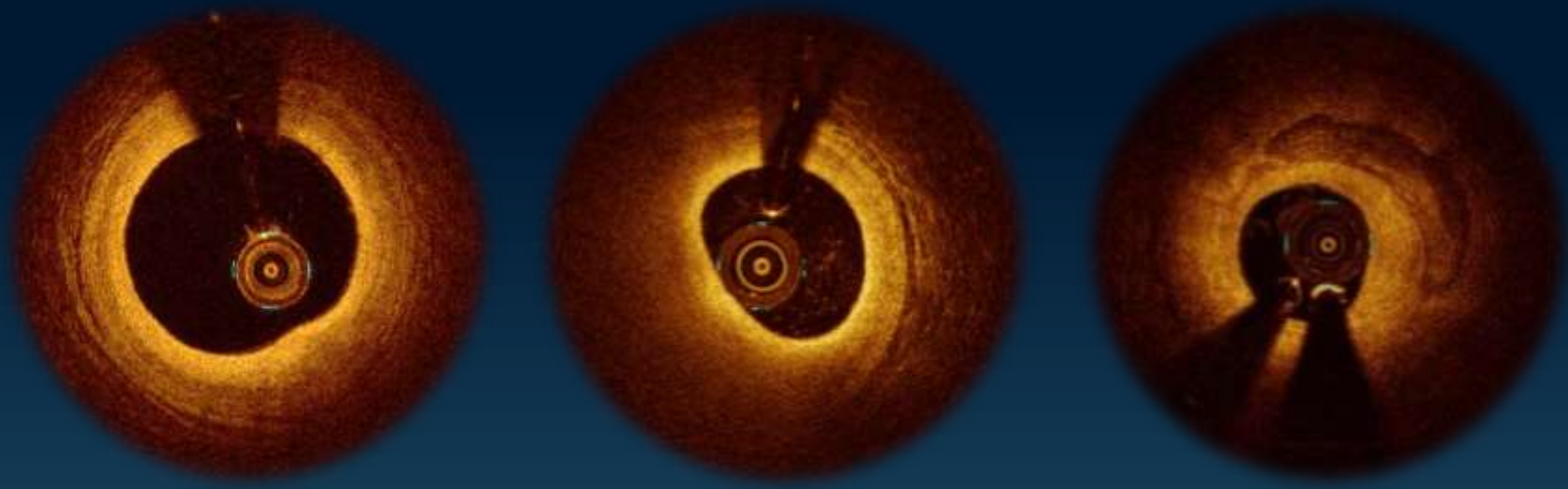


Plaque Characterization by OCT

Fibrous	Bright pixels	Finely textured	Deep penetration	Homogeneous
Lipid	Dark pixels	Diffuse edge	Low penetration	Homogeneous
Calcium	Dark pixels	Sharp edge	Deep penetration	Heterogeneous

Gonzalo N. 2010 "Optical Coherence Tomographty for the Assessment of Coronary Atherosclerosis and Vessel Response after Stent implantation". (Thesis)

Fibrous ***Lipid-rich*** ***Calcified***



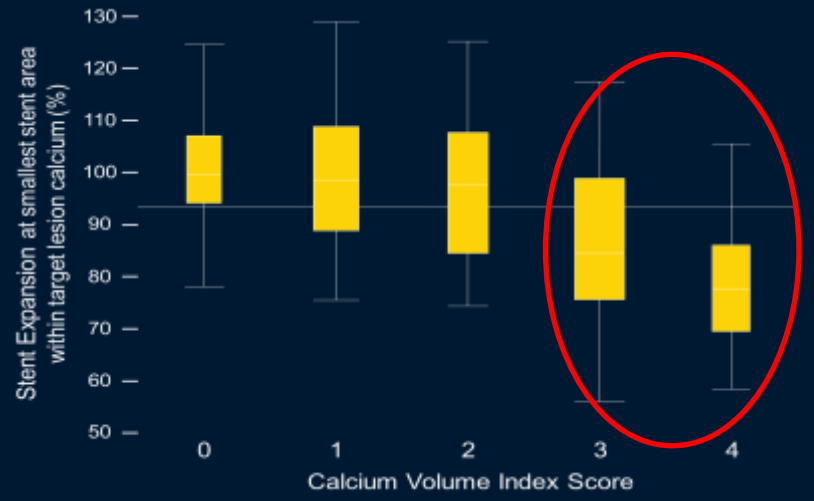
Influence of Ca^{2+} on Stent Expansion by OCT

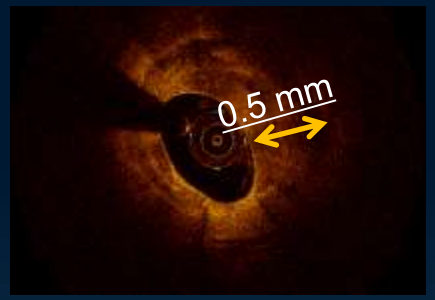
OCT-Based Calcium Volume Index Score[1]

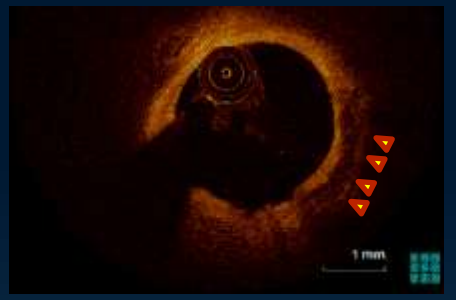
1. Maximum Calcium Angle (°)	≤ 90°	► 0 point
	90° < Angle ≤ 180°	► 1 point
	> 180°	► 2 points
2. Maximum Calcium Thickness (mm)	≤ 0.5 mm	► 0 point
	> 0.5 mm	► 1 point
3. Calcium Length (mm)	≤ 5.0 mm	► 0 point
	> 5.0 mm	► 1 point
Total score	**0 to 4 points**	

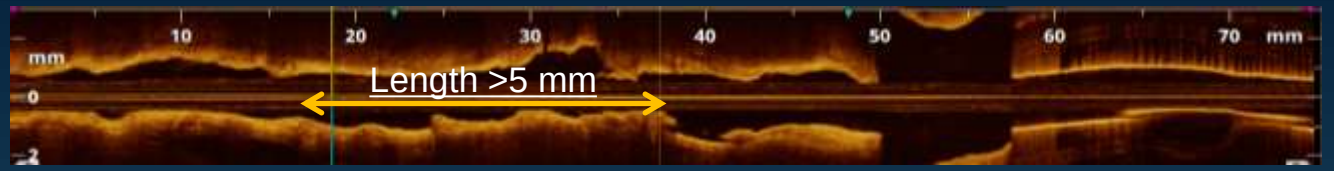
Rule of 5's

- 0.5 mm thickness
- 5.0 mm long
- 50% vessel arc





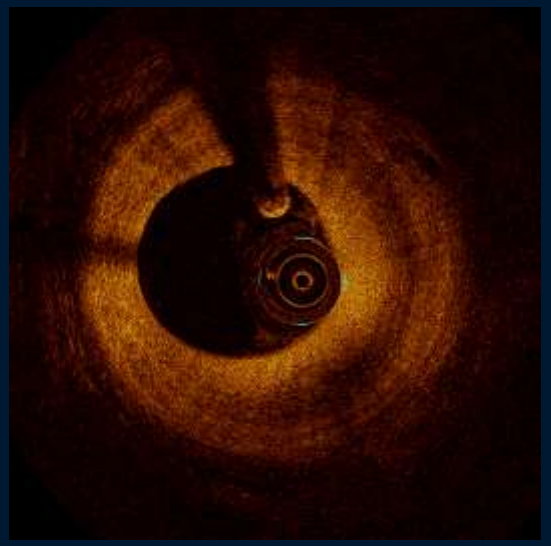




1. Fujino, A. et al. A new optical coherence tomography-based calcium scoring system to predict stent under expansion. *EuroIntervention*, April 2018; 13(18):e2182-e2189.

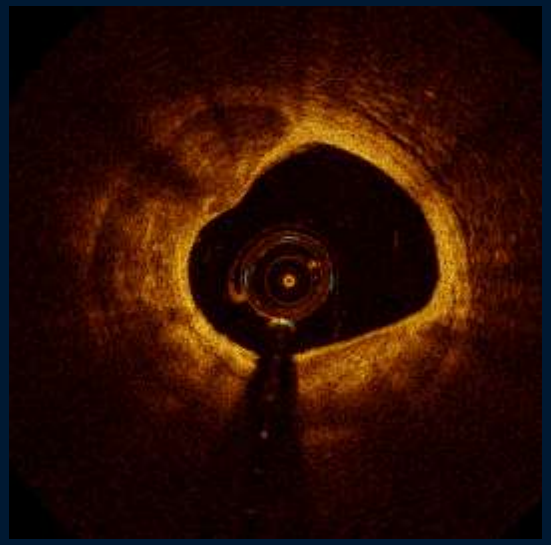
Morphology Guided Lesion Preparation

Lipidic



Fibrotic

Mild/Moderate Ca^{2+}



Severe Ca^{2+}

DIRECT STENTING[1]

COMPLIANT BALLOON[2]

NON-COMPLIANT BALLOON[3]

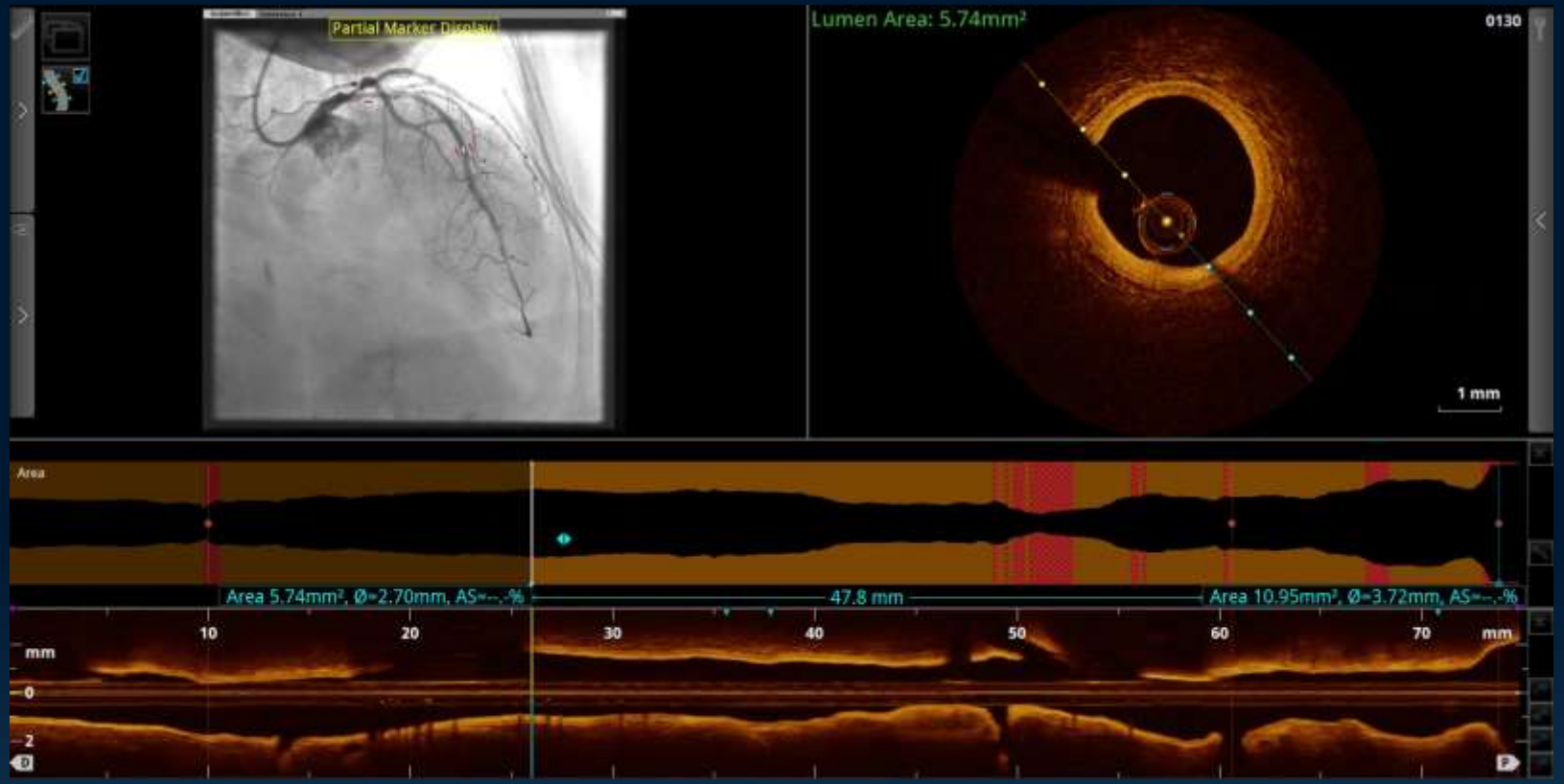
ATHERECTOMY OR IVL[4]

1. Taylor, A., et al. Efficacy and Safety of Direct Stenting in Coronary Angioplasty, J. Invasive Cardiology, 2000; 12(11); 2. Romagnoli, E., et al. Drug Eluting Stenting, JACC Cardiovascular Interventions, 2008; 1(1): 21-31; 3. Seyithanoglu, B., Compliant vs Non-compliant balloons. A Prospective Randomised Study, 1998; 39(1): 45-54; 4. Tomey, M., Current Status of Rotational Atherectomy, JACC Cardiovascular Interventions, 2014; 7(4): 345-354.

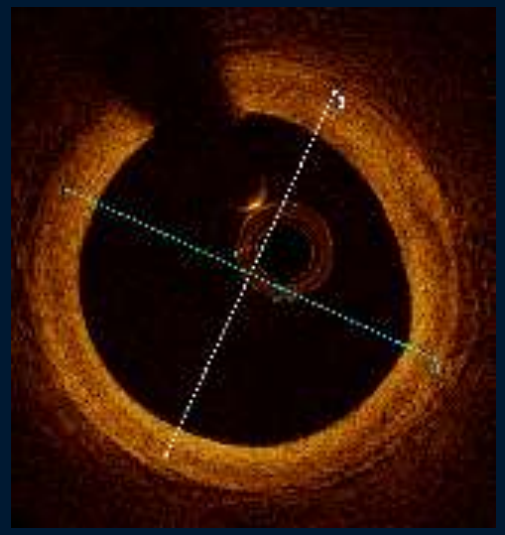
OCT-Guided Length

Identify:

- “Normal” reference segments
- Adjusted DES size

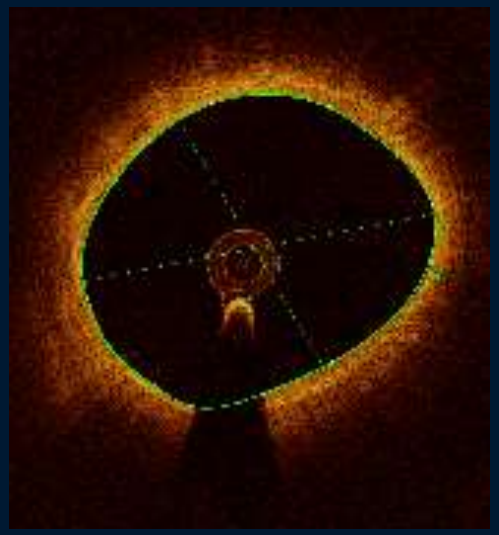


OCT Stent Sizing Algorithm



PRE-PCI OCT

- Can the EEL be identified at the distal reference segment to allow vessel diameter measurement?

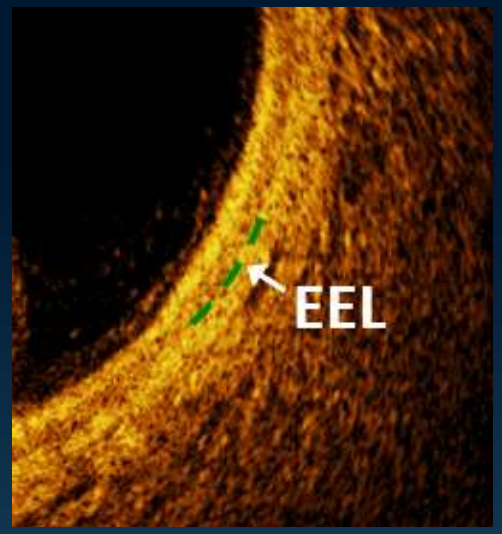


YES

Stent diameter decided by OCT measurement of mean EEL to EEL diameter rounded down to nearest stent size[1]

NO

Stent diameter decided by OCT measurement of mean lumen diameter rounded up to nearest stent size[2]

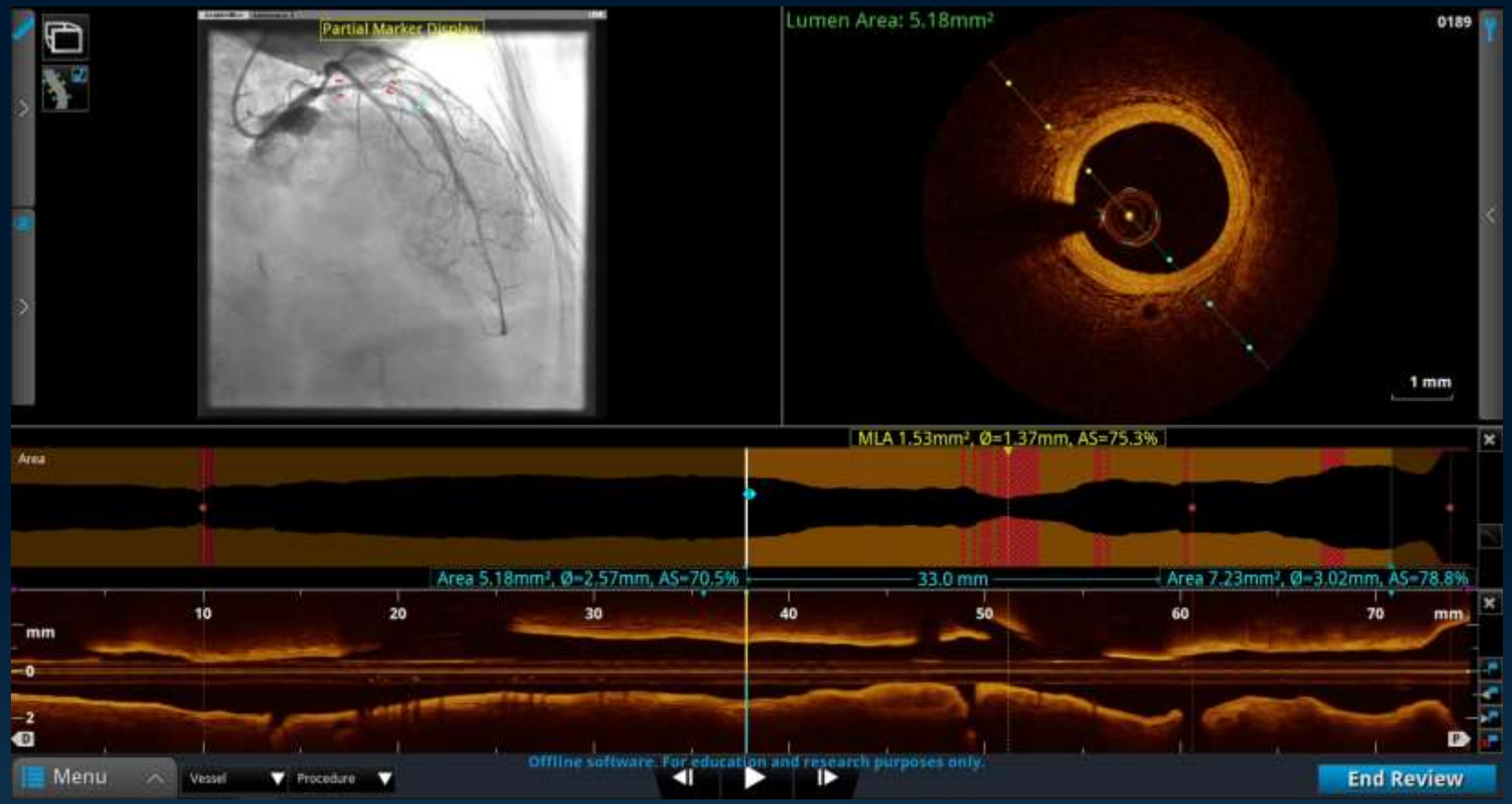


1. Ali, Z., et al., ILUMIEN III Study, Lancet Journal, 2016; 1-11. 2. Shlofmitz, E. et al. Algorithmic Approach for OCT Guided Stent Implantation During PCI. Intervent Cardiol Clin 7 (2018) 329-344.

OCT-Guided Diameter

Measure:

- EEL-EEL, if possible
- Mean lumen diameter, if no EEL-EEL



Modern OCT Guided PCI Workflow | MLD MAX

- Each OCT run serves a separate purpose. The pre-PCI run helps determine the PCI strategy, and the post-PCI run allows for optimization of the stent as needed.

Pre-PCI OCT | Strategize

- **M**ORPHOLOGY
- **L**ENGTH
- **D**IAMETER

Post-PCI OCT | Optimize

- **M**EDIAL DISSECTION
- **A**PPOSITION
- E**X**PANSION

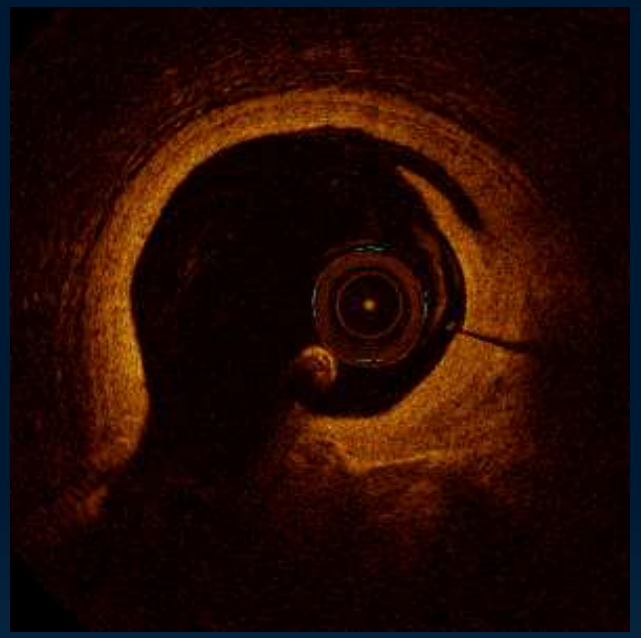
Dissections

Address Significant Dissection[1]

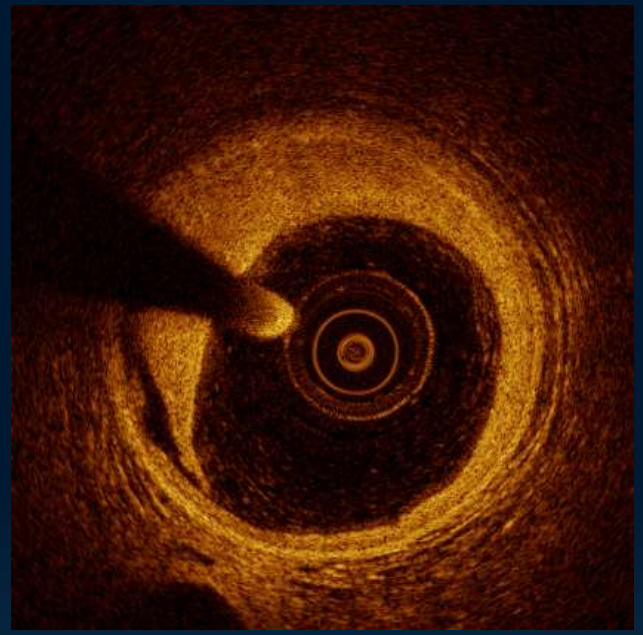
Dissection penetrates medial layer, and is greater than 1 quadrant arc

Common Practice[1,2]

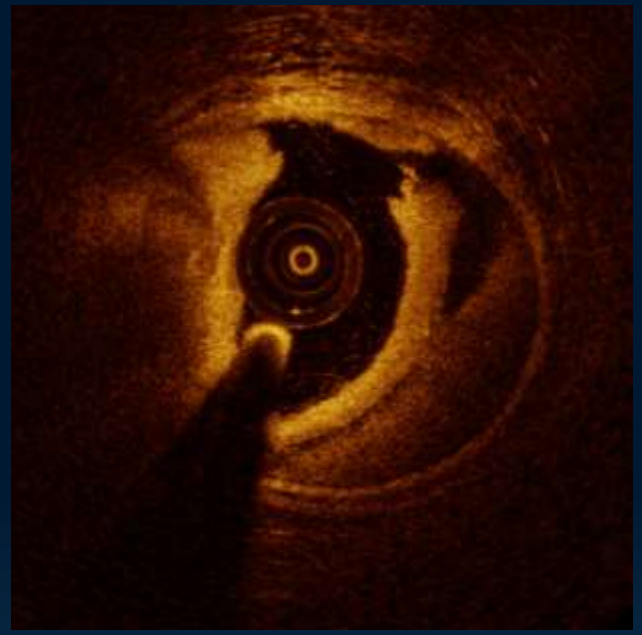
Place additional stent (particularly for distal dissections)



Intimal



Medial



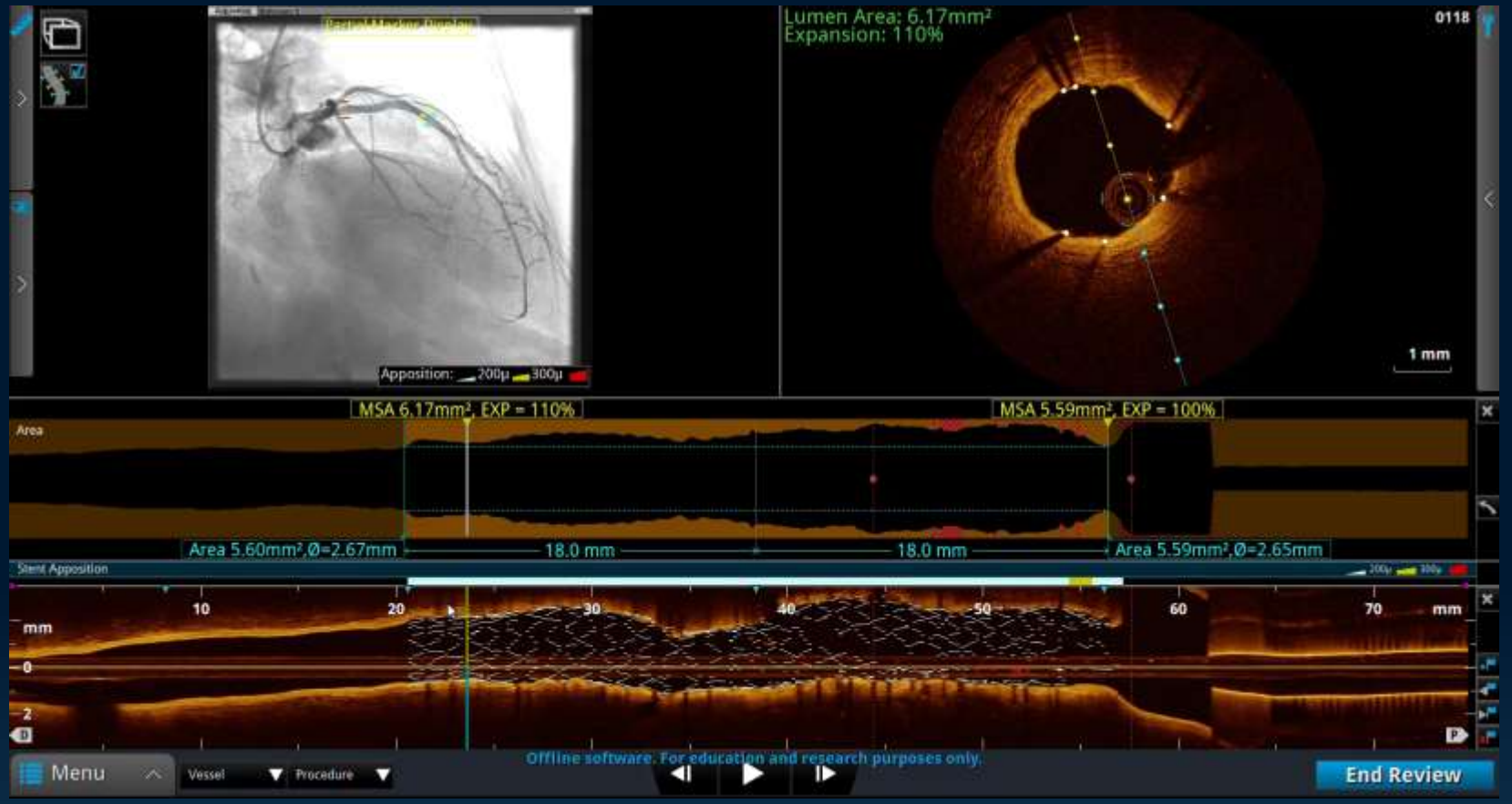
Intramural Hematoma

1. Kubo, T. et al. Application of Optical Coherence Tomography in Percutaneous Coronary Intervention. *Circulation Journal*, September 2012: Vol. 76, 2076-2083; 2. Ali, Z. et al. ILUMIEN III: Optimize PCI. *Lancet* 2016, 388:2618-2628.

OCT-Guided Dissection Detection

Identify:

- Edge dissections
- Reference segment disease



edge dissection (arc ≥ 60°, length ≥ 3mm)	(+)	additional stent implantation
	(-)	procedure complete

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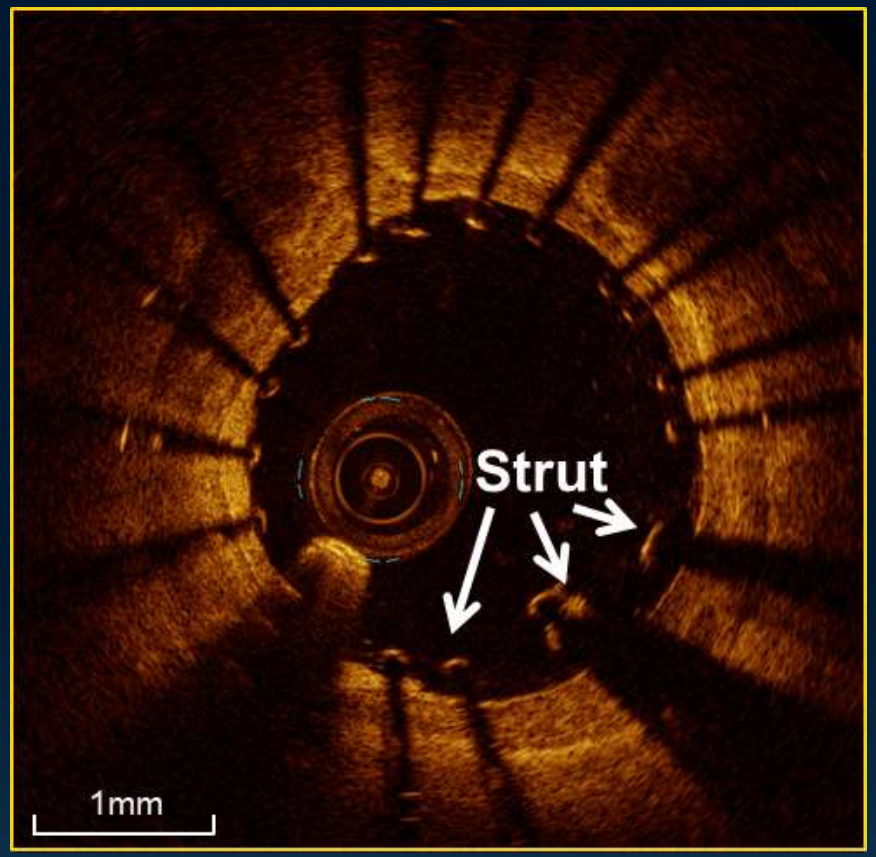
Apposition

If the stent struts are in contact with the artery wall, the stent is apposed



Address Gross Malapposition

- Longer than 3 mm,[1] and ≥0.3 mm from wall[2]

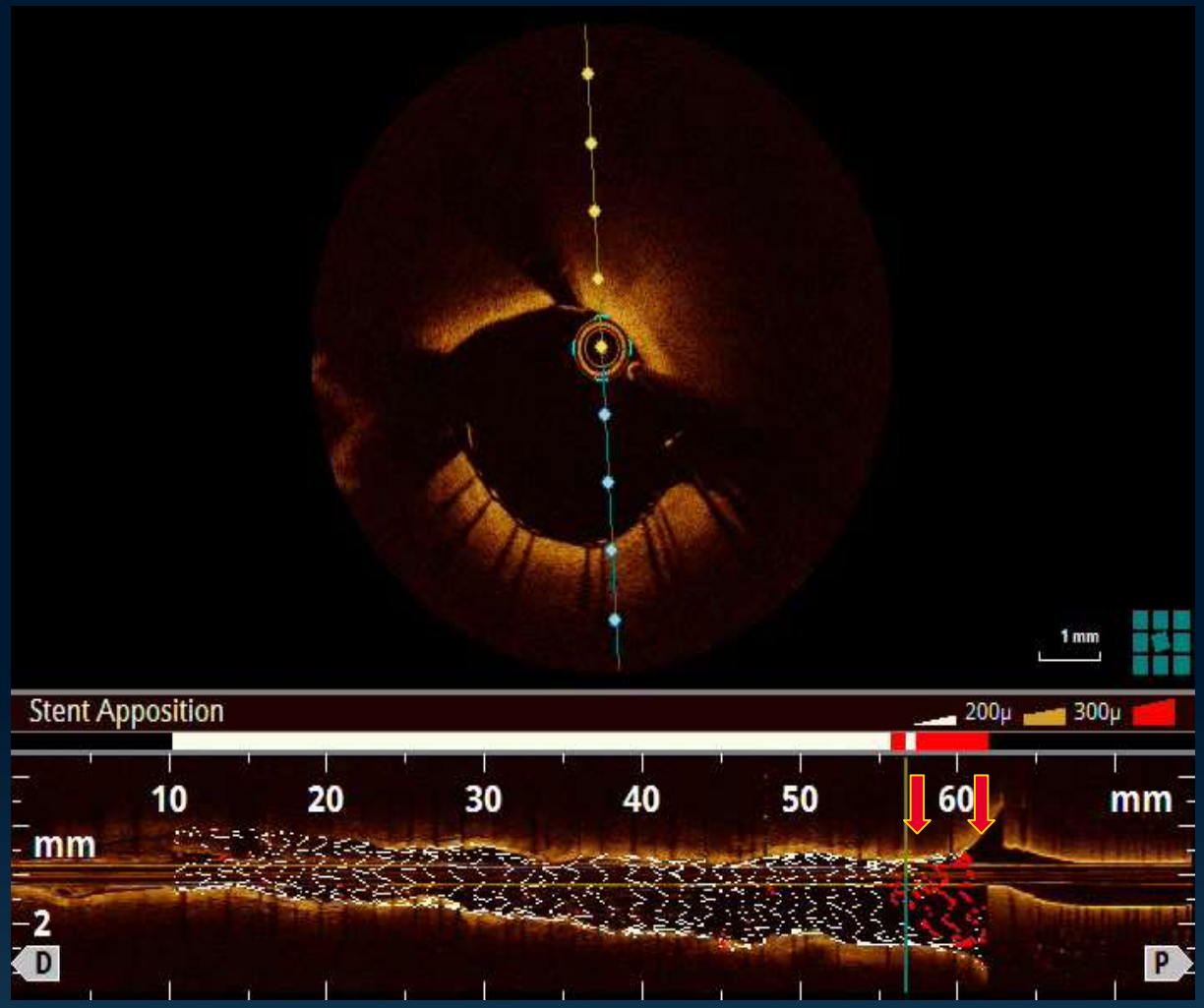
Common Practice[3]

- Dilate with semi-compliant balloon at low pressure

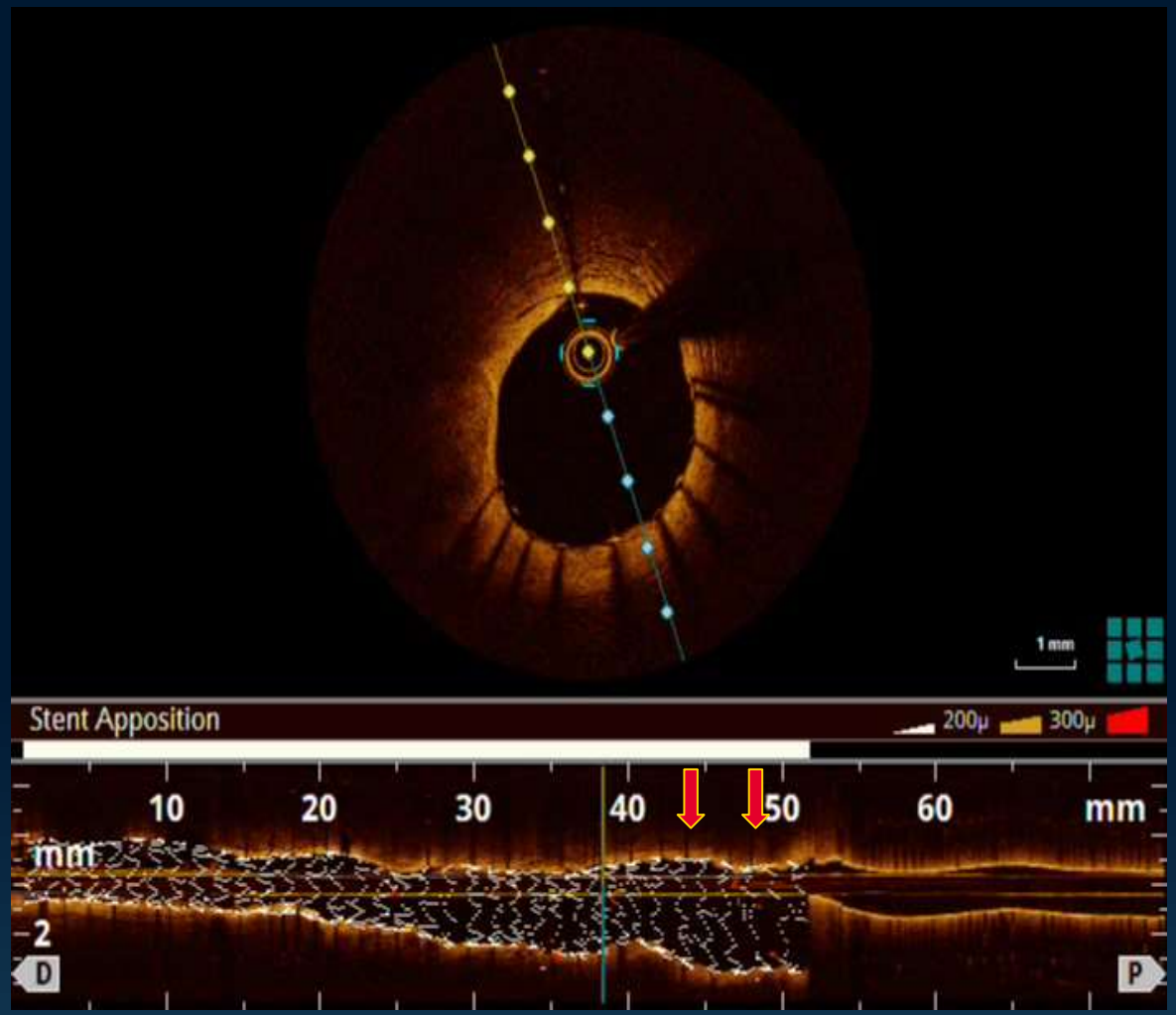
1. Ali, Z. et al. ILUMIEN III: Optimize PCI. *Lancet* 2016, 388:2618-2628. 2. Souteyrand, G. et al. PESTO French Registry. *European Heart Journal*, 2016:37:1208-1216.
3. Kubo, T. et al. Application of Optical Coherence Tomography in Percutaneous Coronary Intervention. *Circulation Journal*, September 2012: Vol. 76, 2076-2083.

Apposition Indicator

OCT AUTOMATICALLY DETECTS MALAPPOSITION



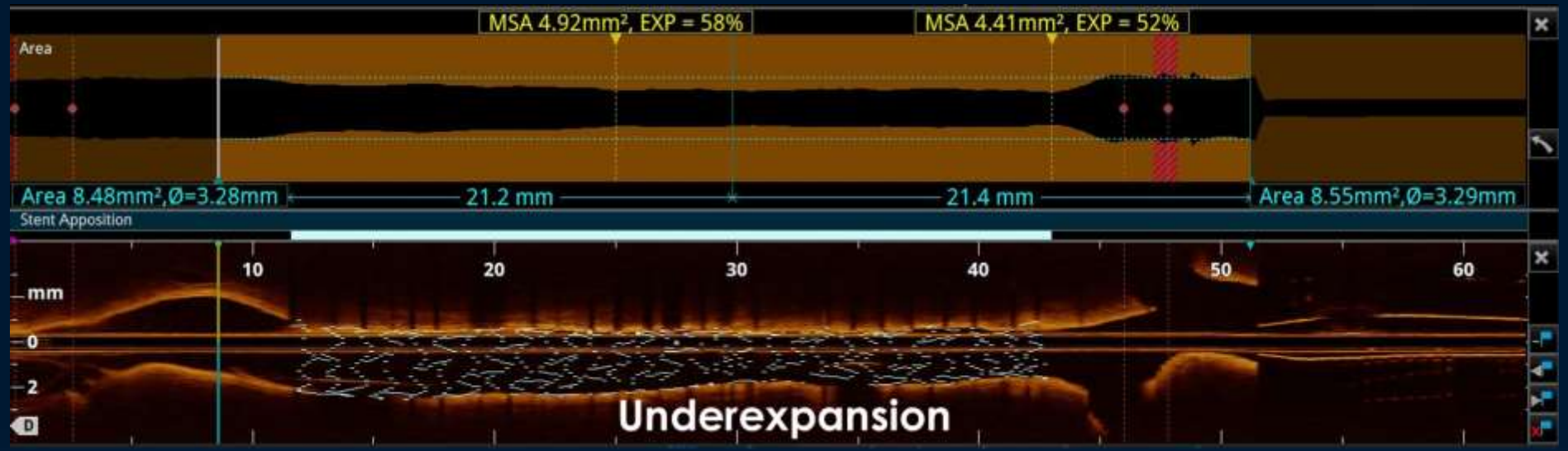
DES 3.5*23 / 2.75*28



4.5mm NC Trek

eXpansion

If the stent is expanding the lumen, holding the lesion close to, or greater than, the normal reference segment, the stent is expanded.



GOAL

ACCEPTABLE = MSA ≥ 80% OF MEAN REFERENCE LUMEN AREA[1]

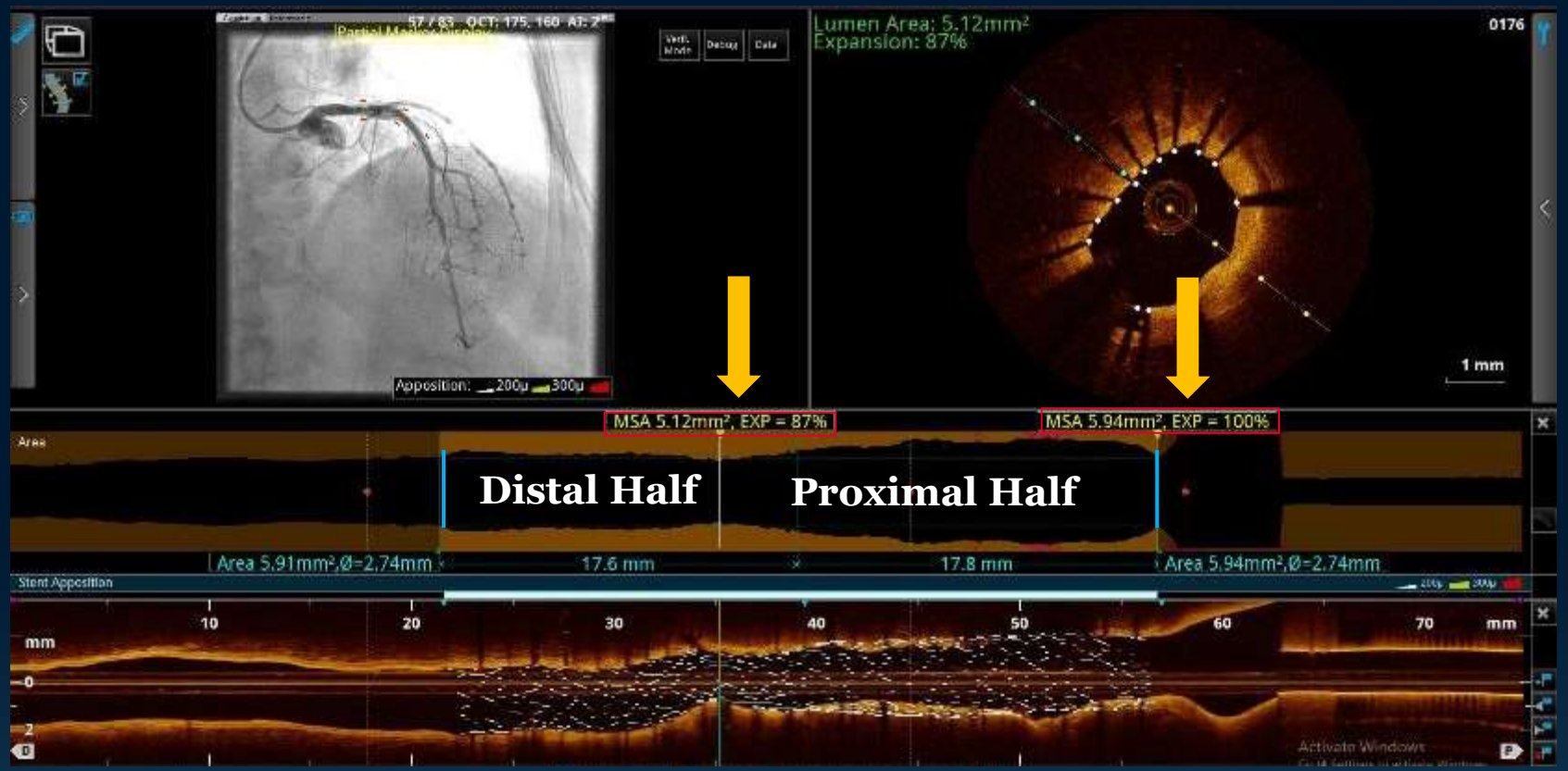
OPTIMAL = MSA ≥ 90% OF MEAN REFERENCE LUMEN AREA[1]

1. Kubo, T. et al. Application of Optical Coherence Tomography in Percutaneous Coronary Intervention. *Circulation Journal*, September 2012: Vol. 76, 2076-2083; Meneveau, N. et al. DOCTORS Study. *Circulation*, September 2016, 134:906-917.; Zhang, J. et al. The ULTIMATE Trial. *Journal of the American College of Cardiology*, Dec 2018: Vol 72, No 24:3126-37.; Russo, R. et al. The AVID Trial. *Circ Cardiovasc Intervent*, April 2009; 2:113-123.; De Jaegere, P. et al. MUSIC Study. *European Heart Journal*, February 1998:19,1214-1223.

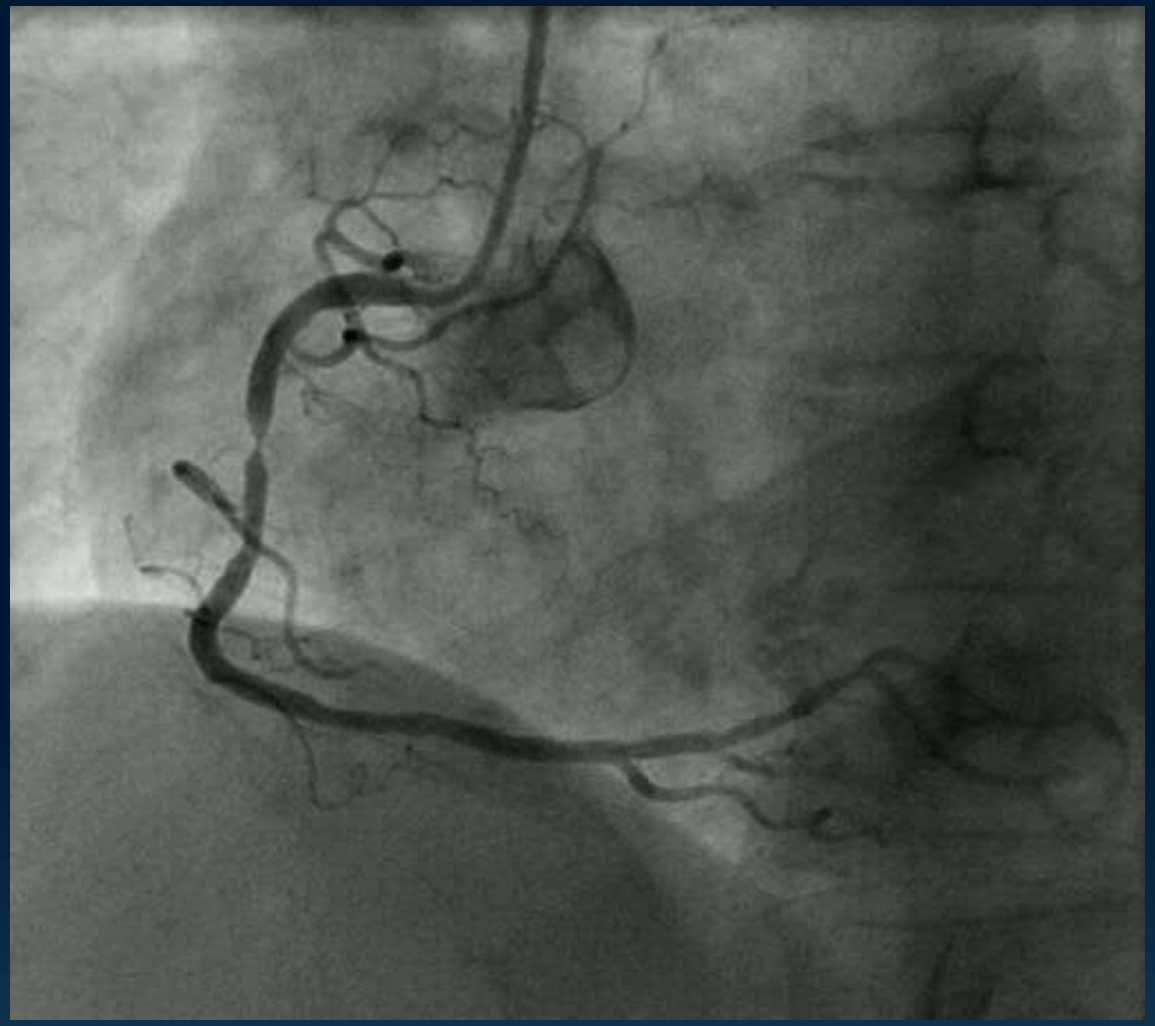
Determine Expansion / MSA - Dual

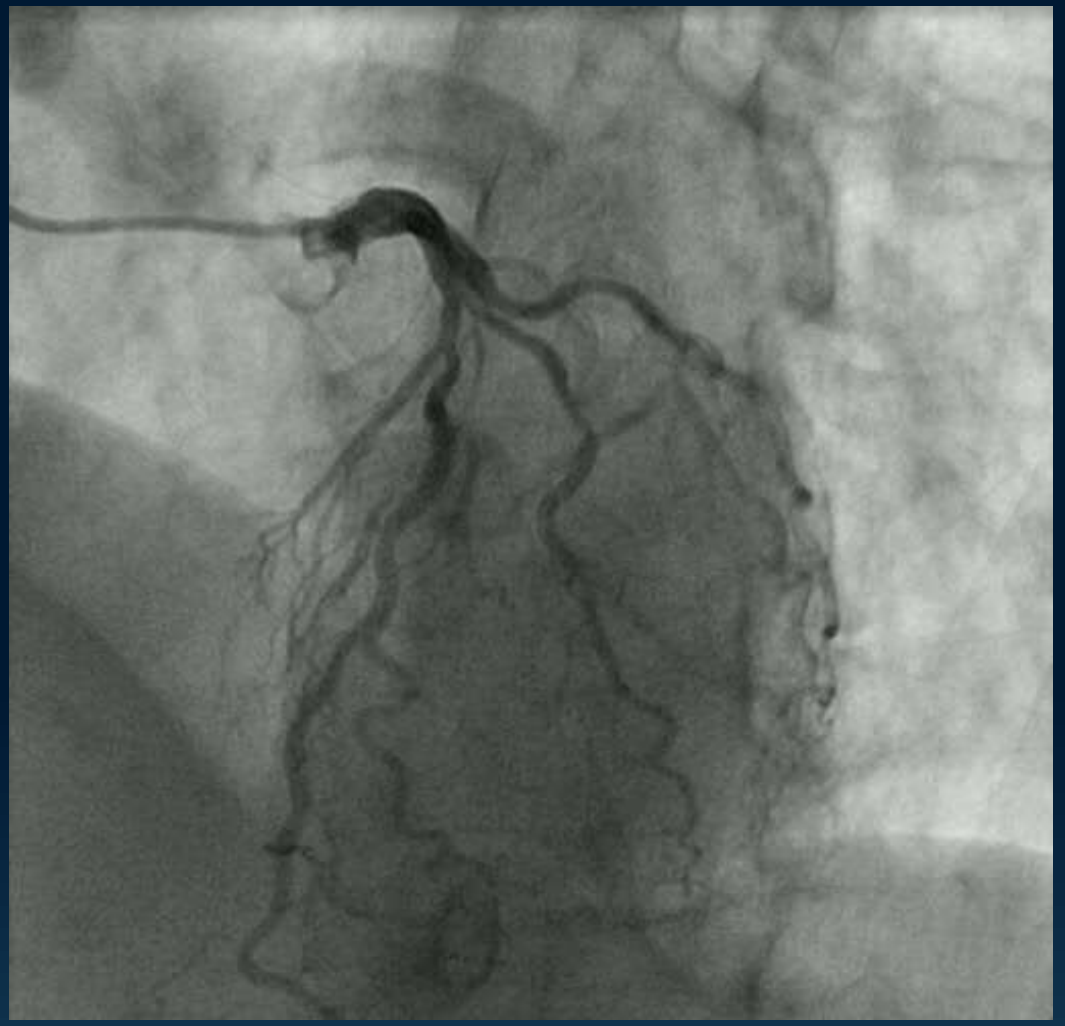
Fully automated expansion display

- ROI automatically detected
- Expansion automatically displayed



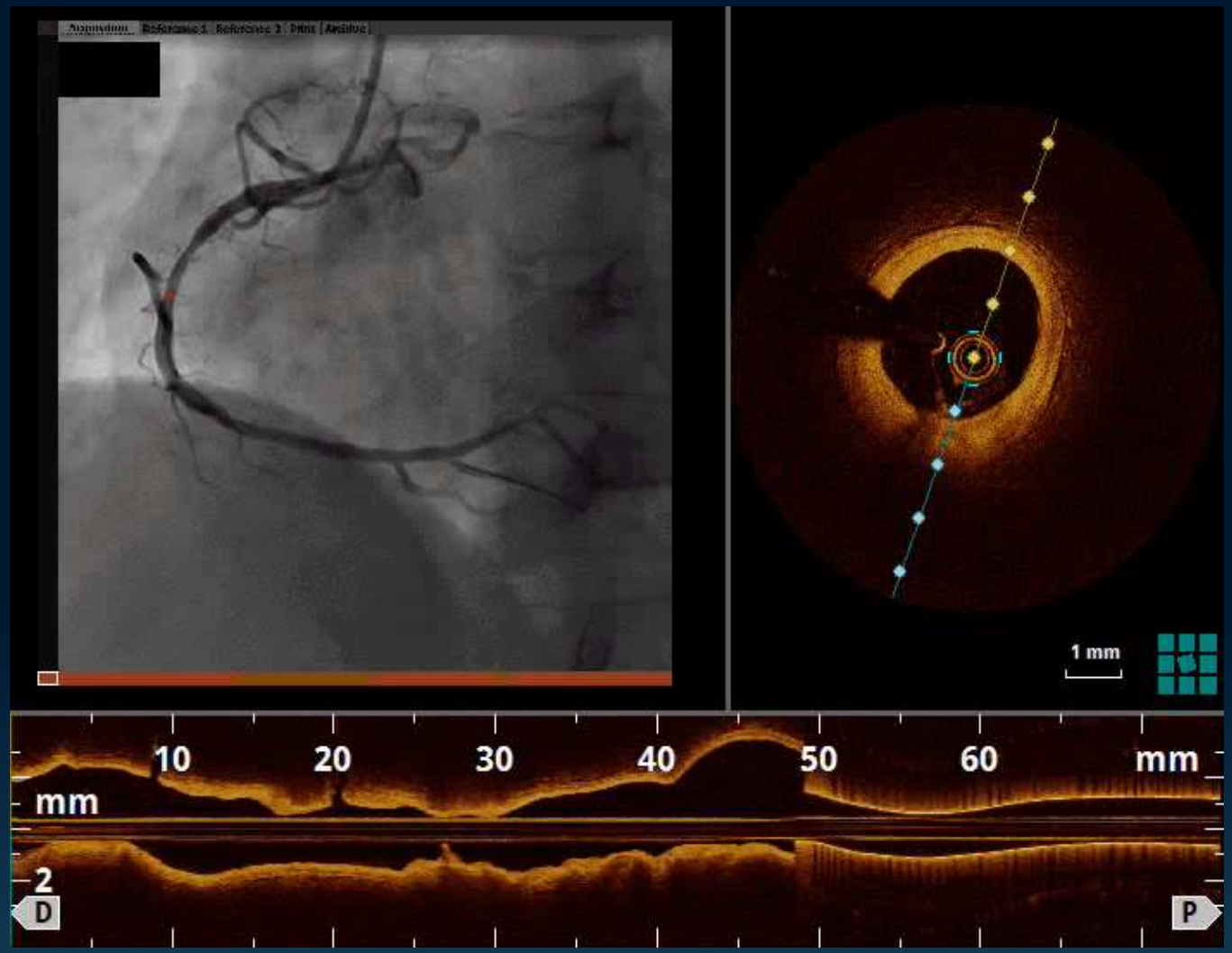
Case based OCT-guided PCI Step-by-Step





57/M NSTEMI CAG: mid RCA culprit lesion

Case based OCT-guided PCI Step-by-Step



POBA 2.5x15mm

Pre-PCI OCT | Strategize

MORPHOLOGY

Lipid rich plaque

Balloon induced dissection

Red thrombus

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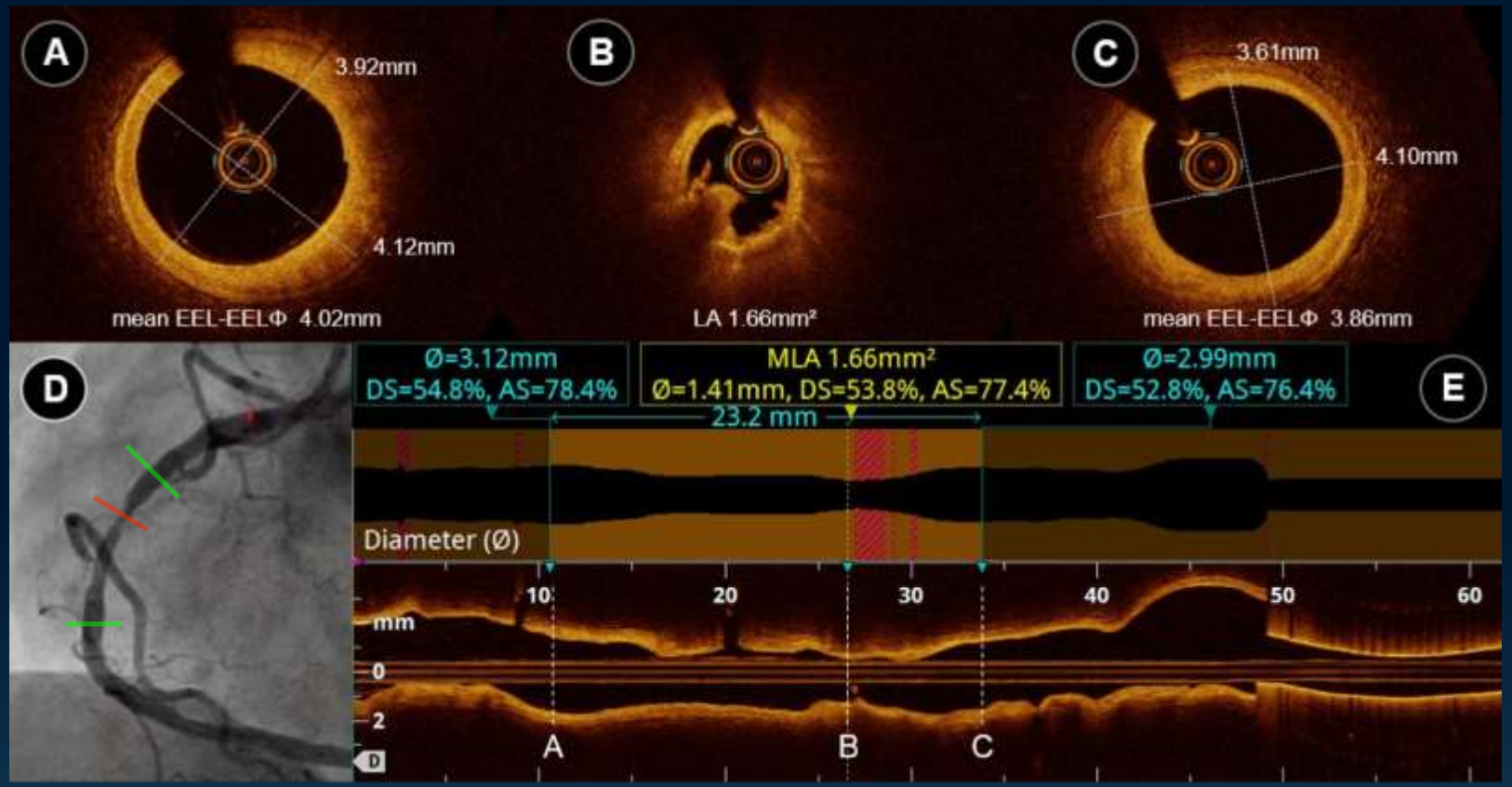
Case based OCT-guided PCI Step-by-Step



Pre-PCI OCT | Strategize

LENGTH

Lesion length 23.2mm

DIAMETER

EEL criteria 3.86
Lumen criteria 3.06

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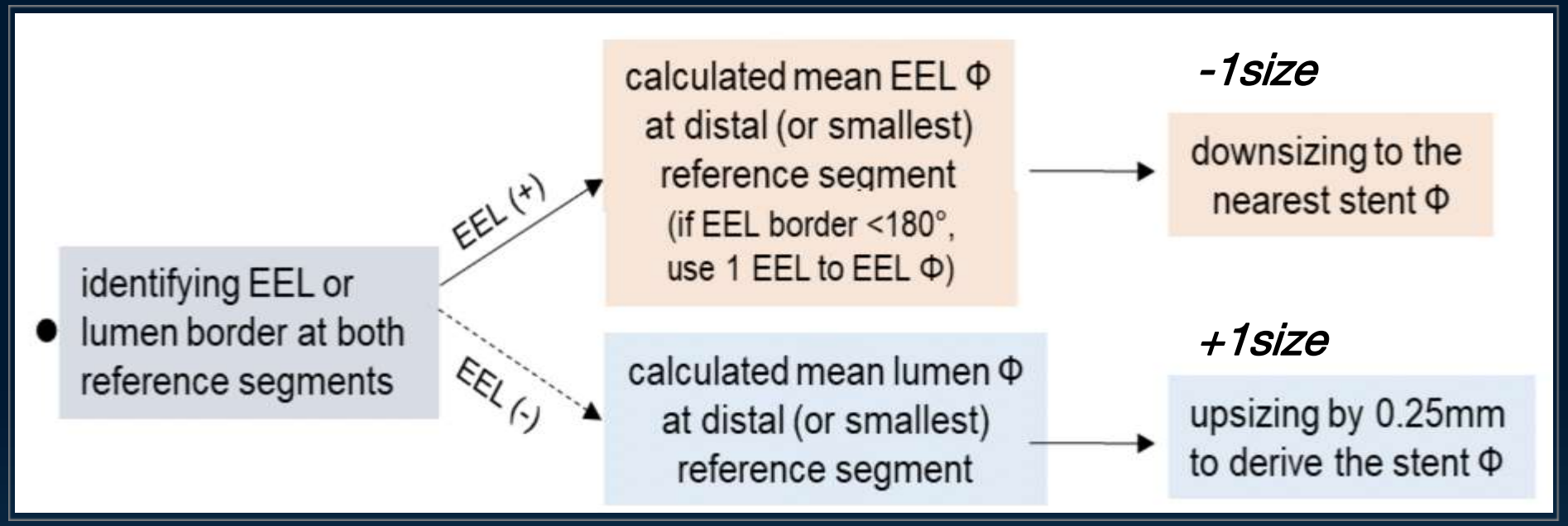
Case based OCT-guided PCI Step-by-Step

Pre-PCI OCT | Strategize



LENGTH

Lesion length 23.2mm

DIAMETER

EEL criteria 3.86
Lumen criteria 3.06

=> Stent Size 3.5 x 28mm

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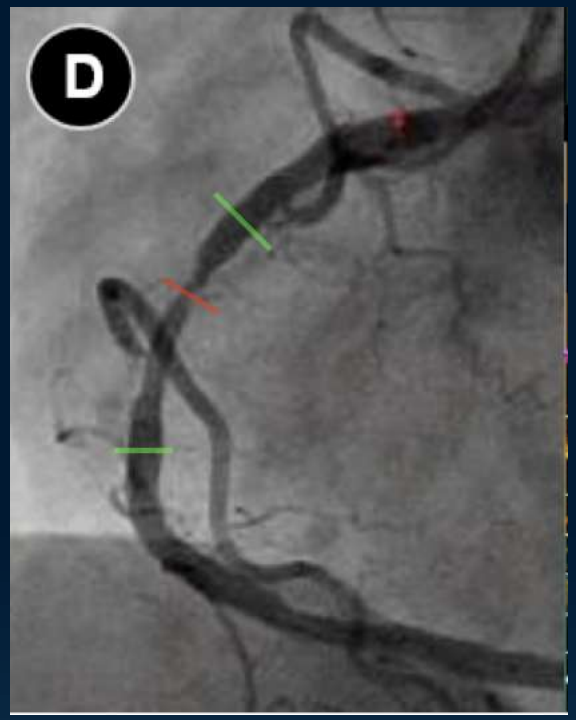
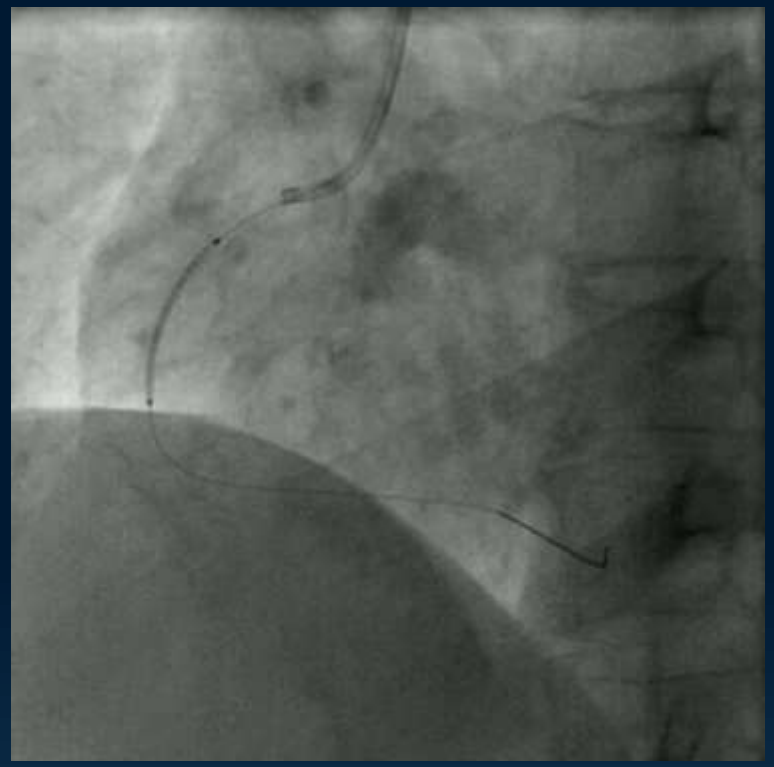
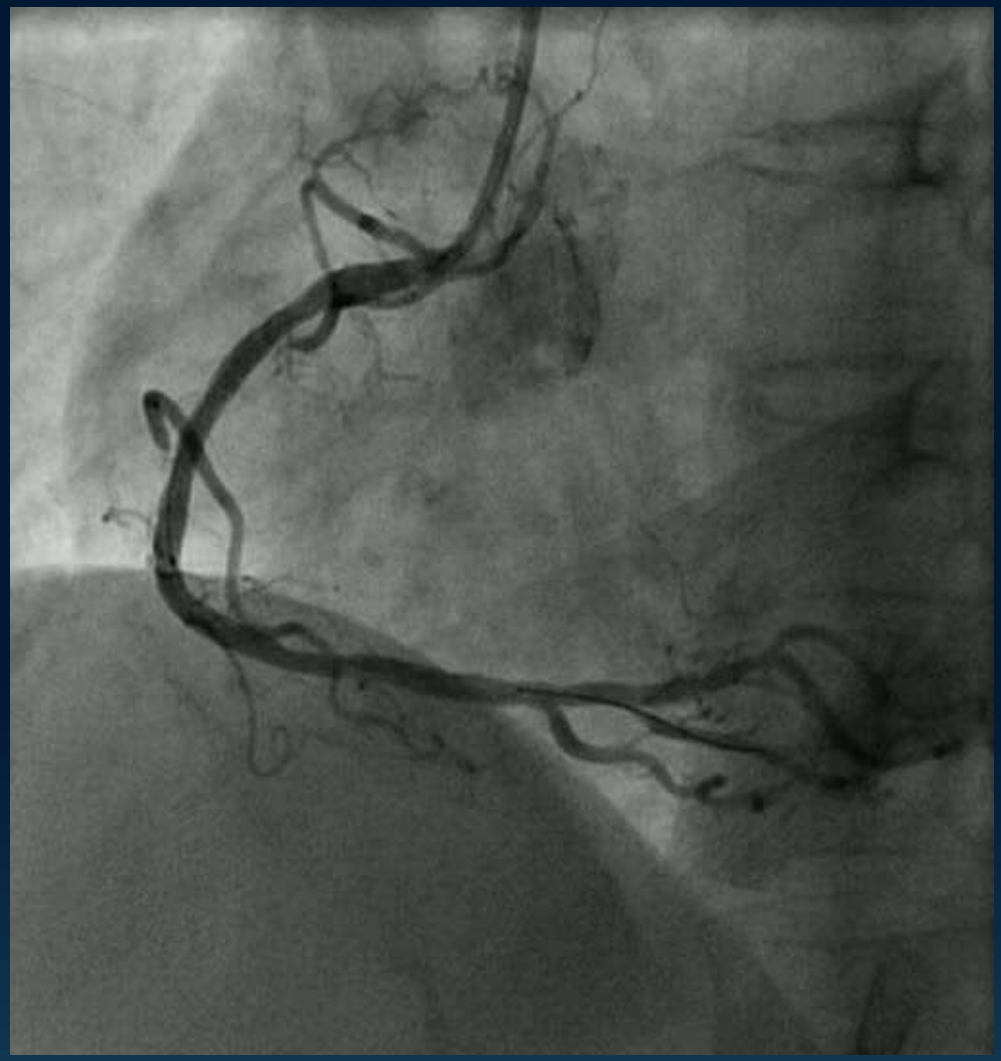
Case based OCT-guided PCI Step-by-Step







DS 10% by QCA

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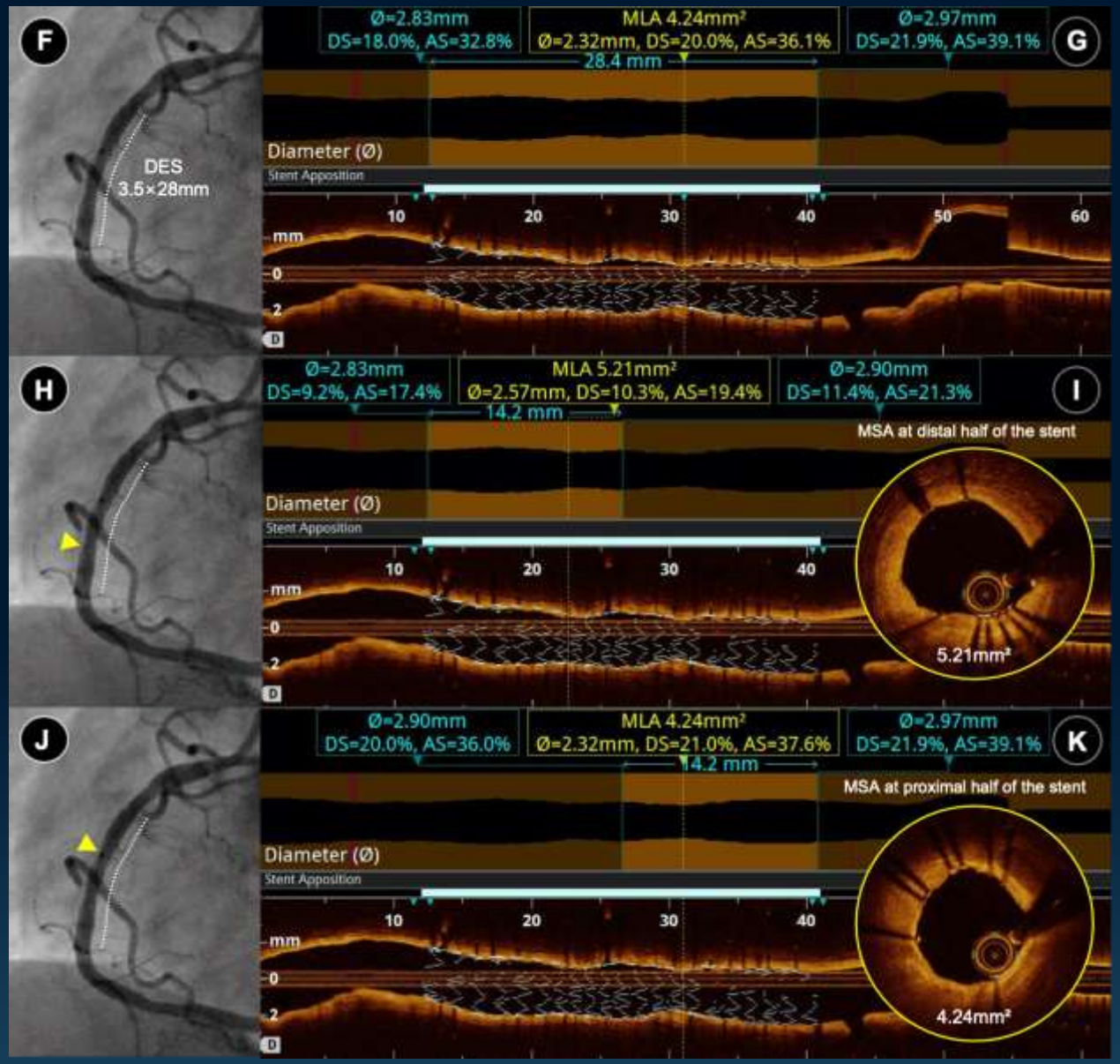
Case based OCT-guided PCI Step-by-Step



Post-PCI OCT | Optimize

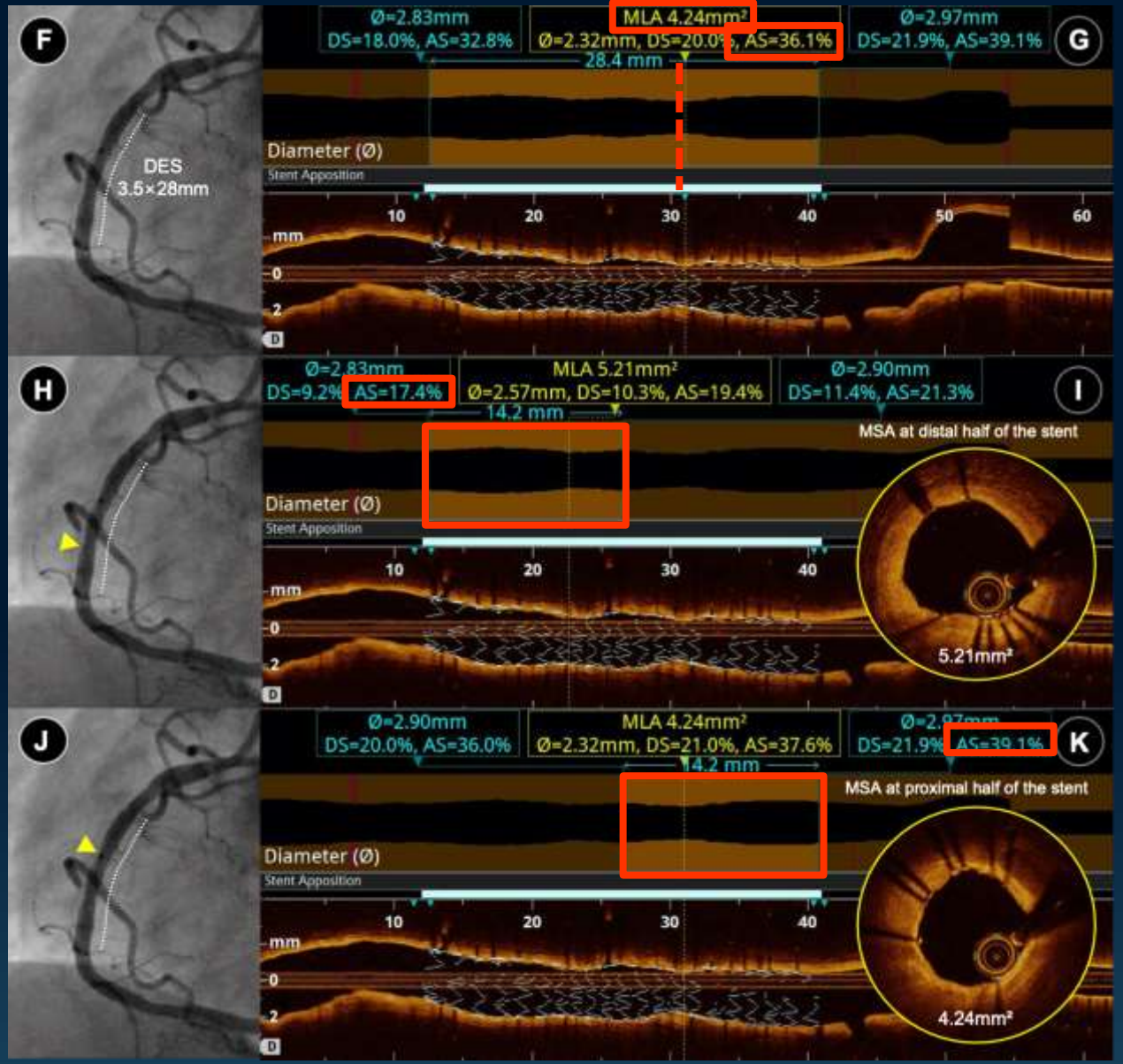
MEDIAL DISSECTION

No dissection stent proximal and distal edge

APPOSITION

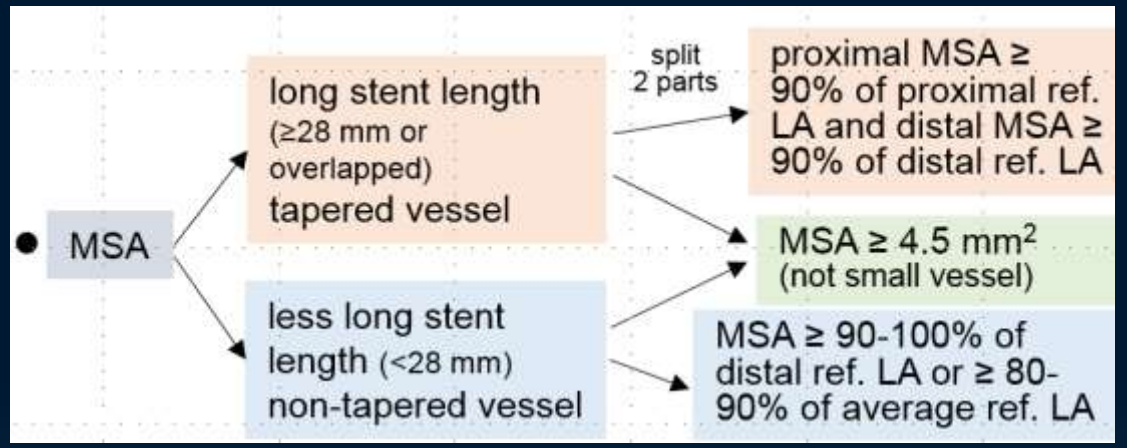
No malapposition stent proximal and distal edge

Case based OCT-guided PCI Step-by-Step



Post-PCI OCT | Optimize

eXPANSION



MSA 4.24mm²

Distal AS = 17.4%, Proximal AS 39.1%

MSA/average ref. lumen = 63.9%

AS(area stenosis) = (1-MSA/mean ref. area)*100

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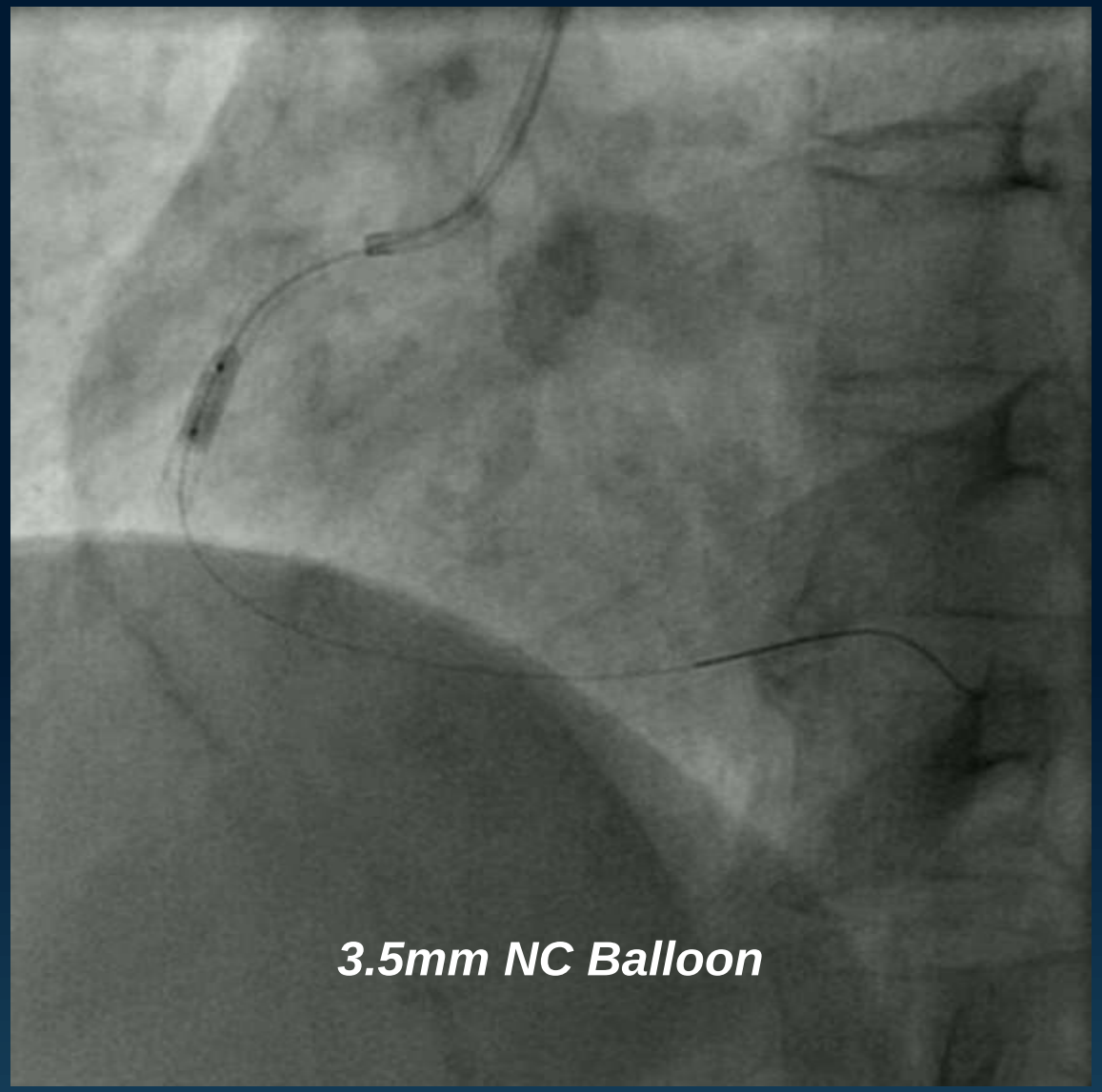
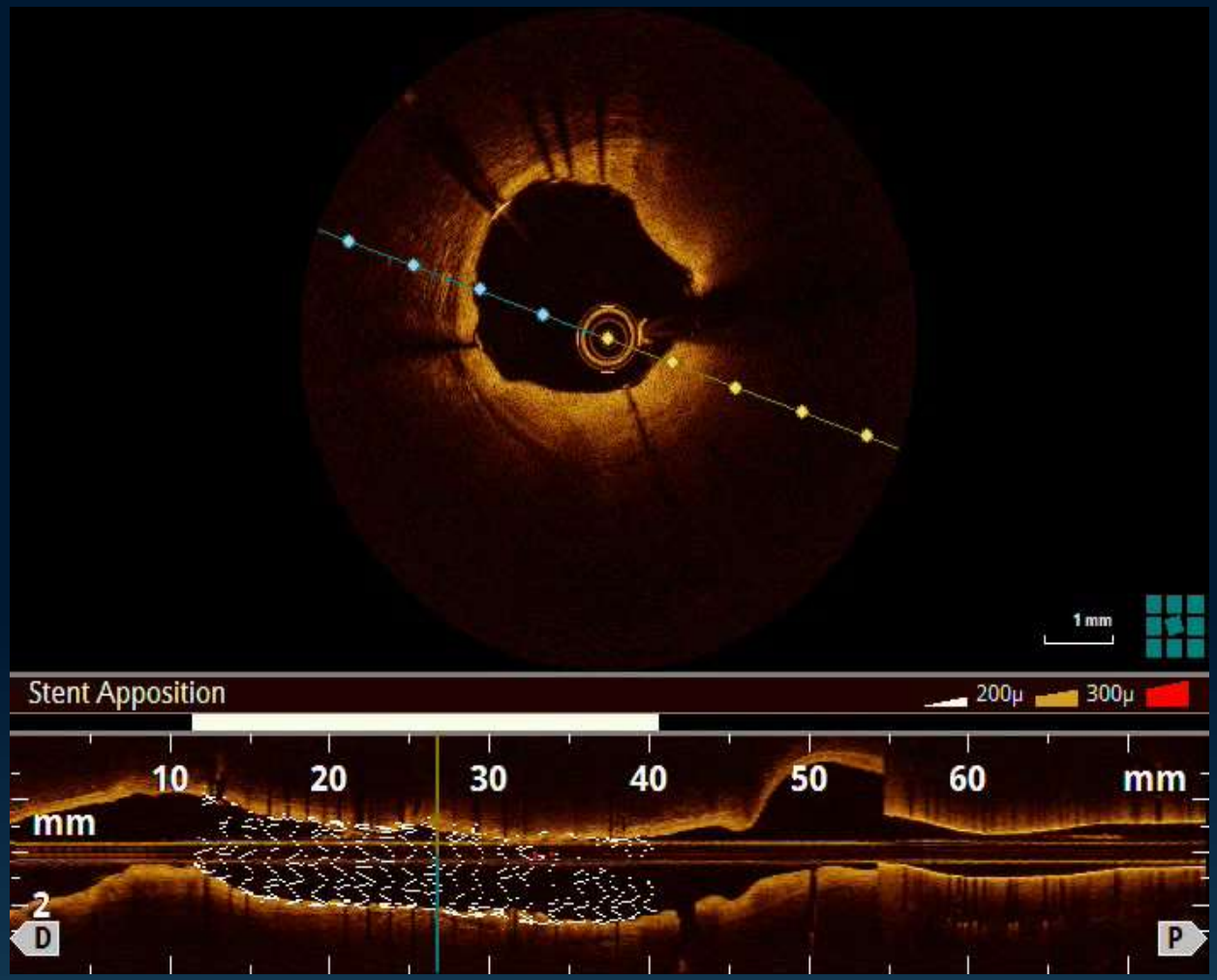
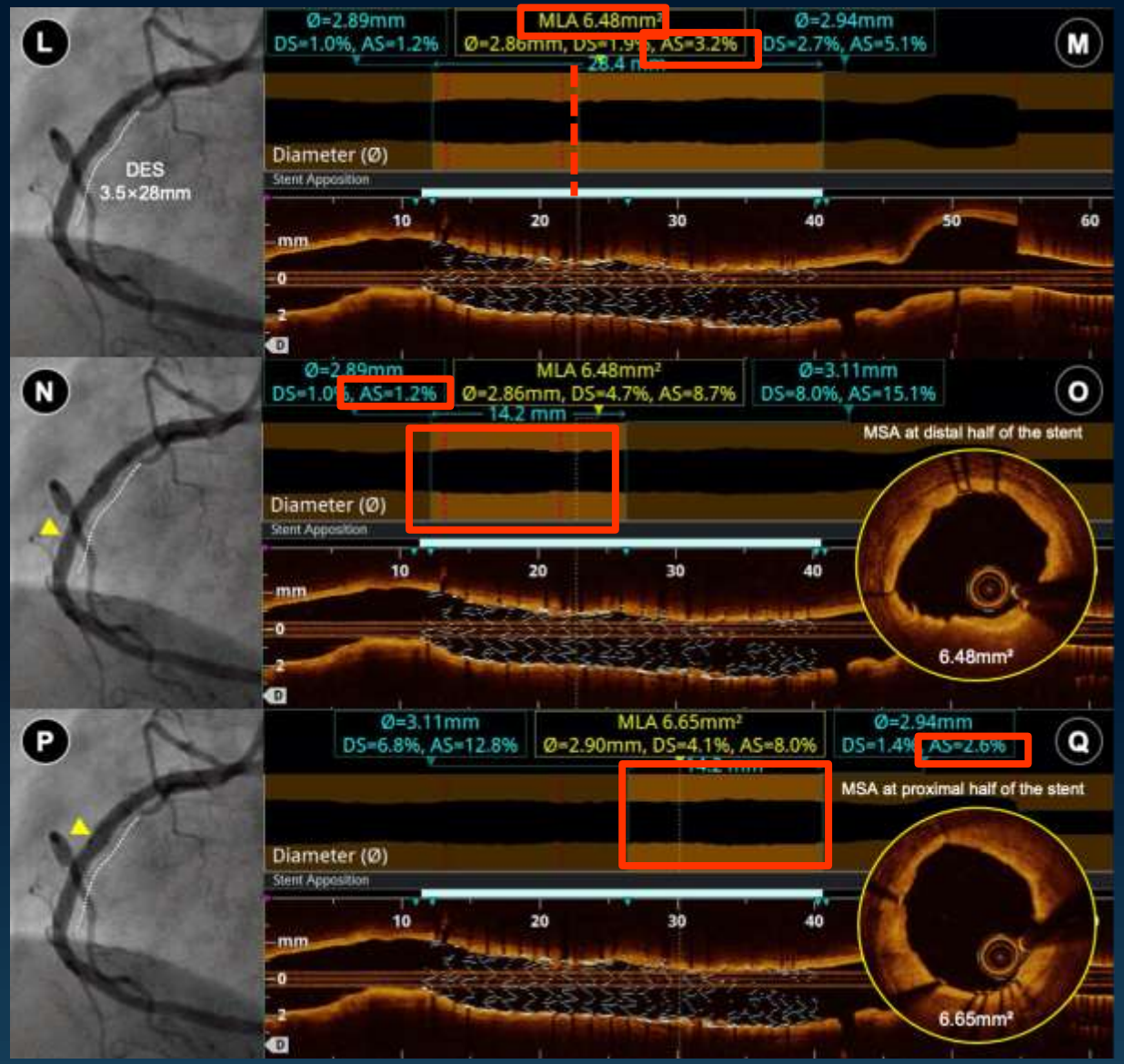
Case based OCT-guided PCI Step-by-Step





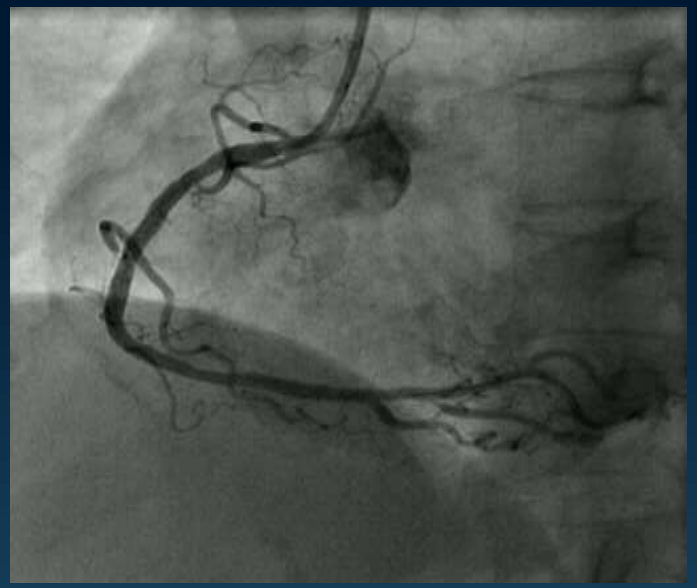
Case based OCT-guided PCI Step-by-Step



Post-PCI OCT | Optimize

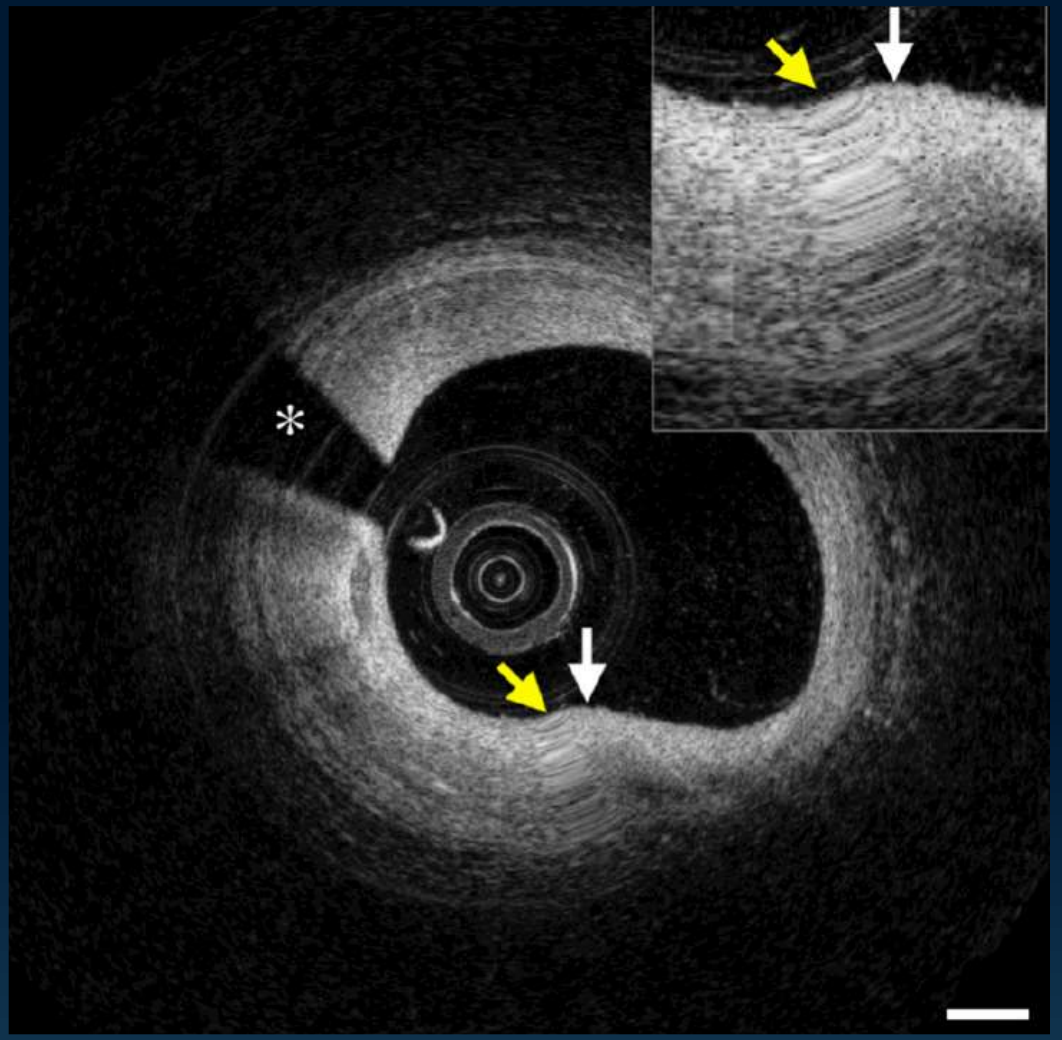
eXPANSION

MSA 6.48mm²
Distal AS = 1.2%, Proximal AS = 2.6%
MSA/average ref. lumen = 96.8%
AS= (1-MSA/mean ref. area)*100



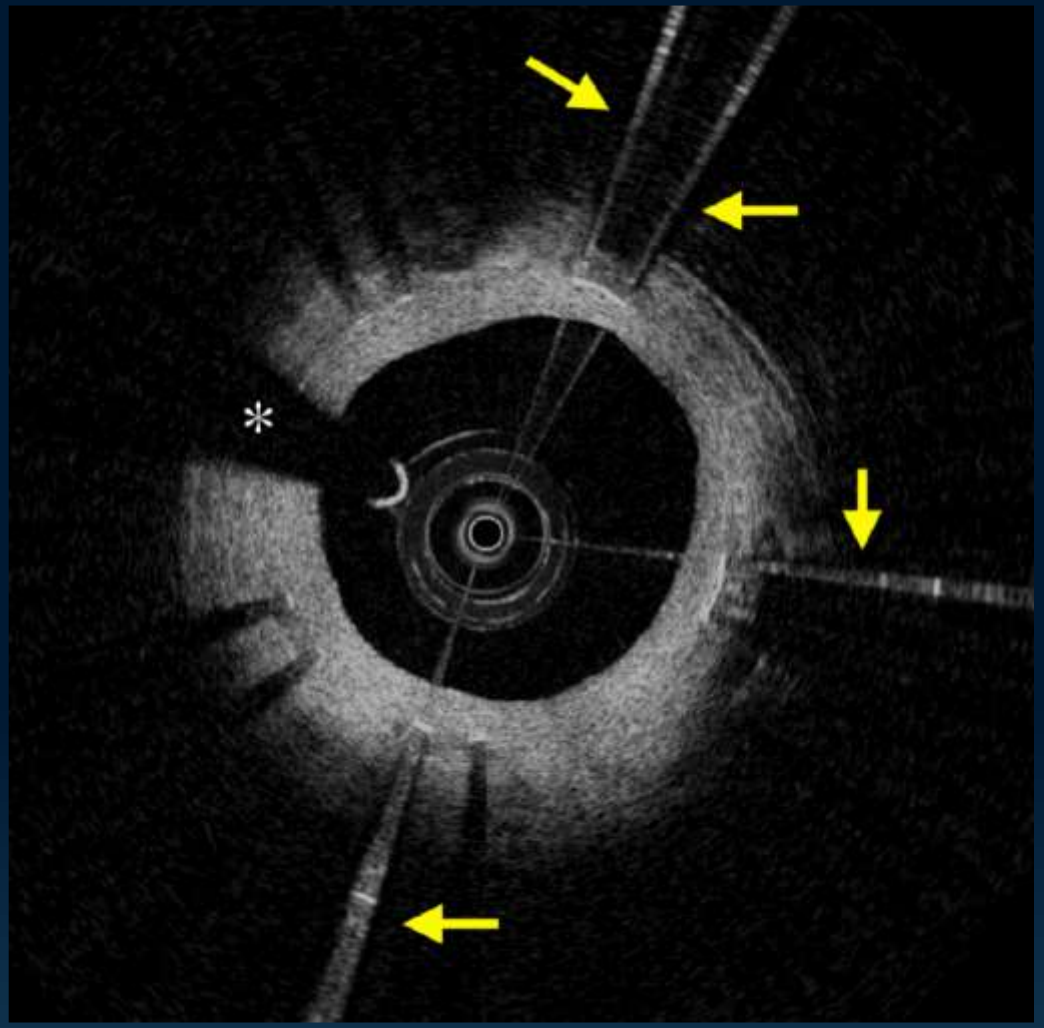
MSA >4.5mm²
Proximal and distal MSA > 90% of distal ref. LA

Artifact – Non-uniform rotational distorsion



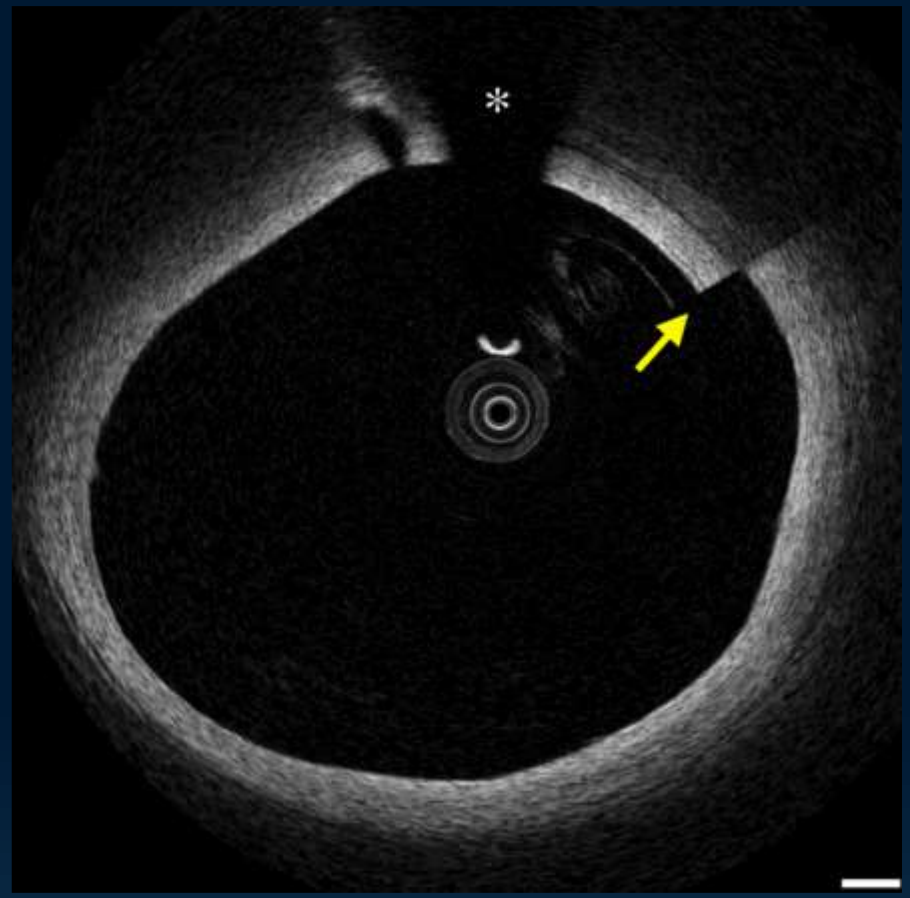
• Consequence of mechanical catheter systems that arises from binding of the drive cable or rotating optical components during image acquisition

Artifact – Saturation



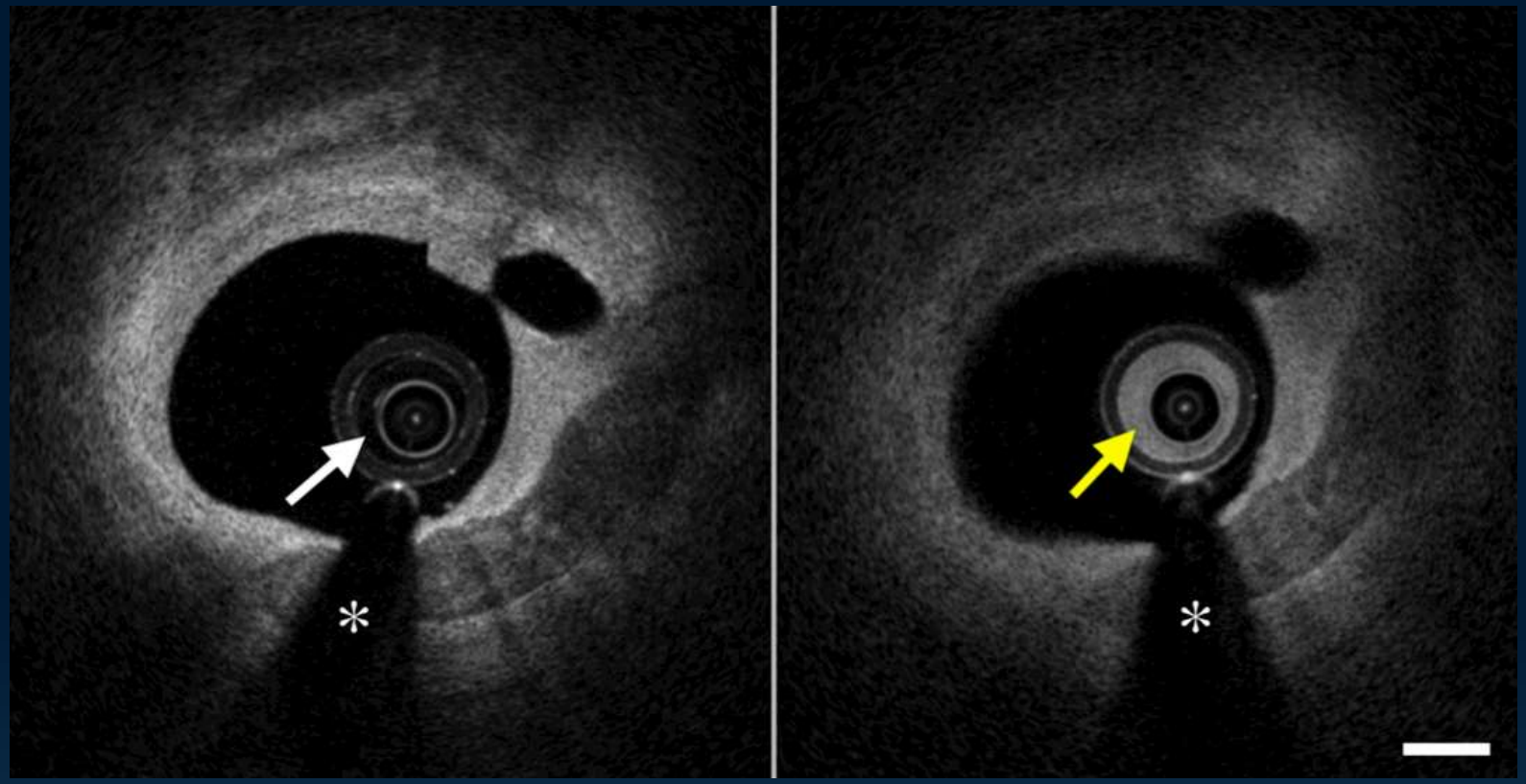
- When a high reflector is encountered by OCT light, it may be backscattered at too high an intensity to be accurately detected by the detector.

Artifact – Seam line

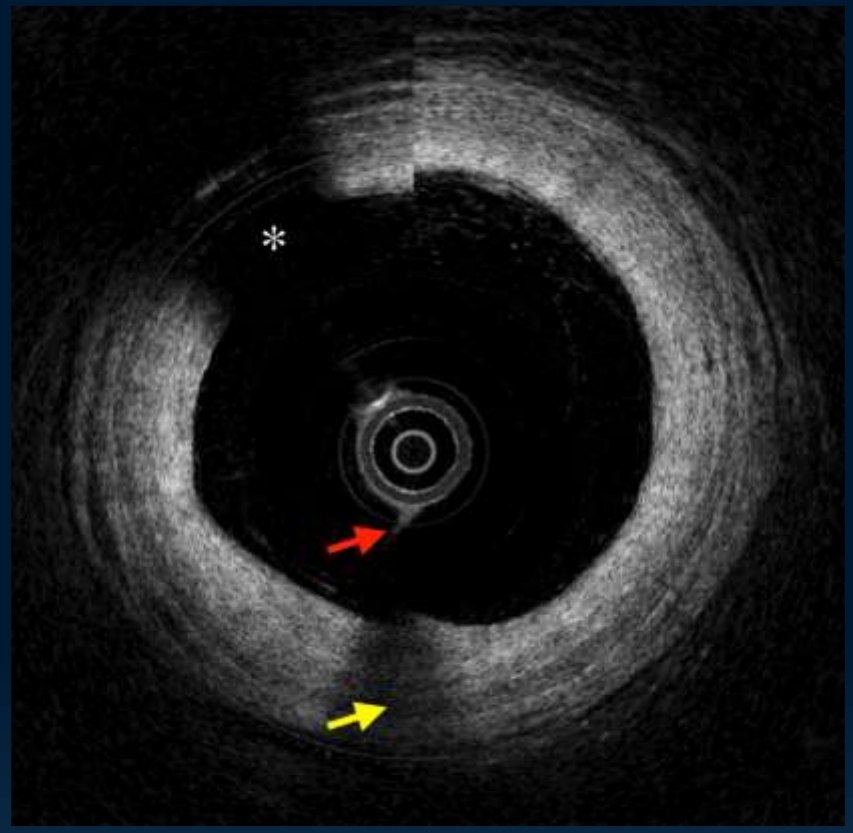


- discontinuity in luminal surface that is caused by artery motion that occurs during the time between the first and last A-line of a cross-sectional image.
- Result of rapid artery or imaging wire movement leading to misalignment of the lumen border.

Artifact – Shadowing

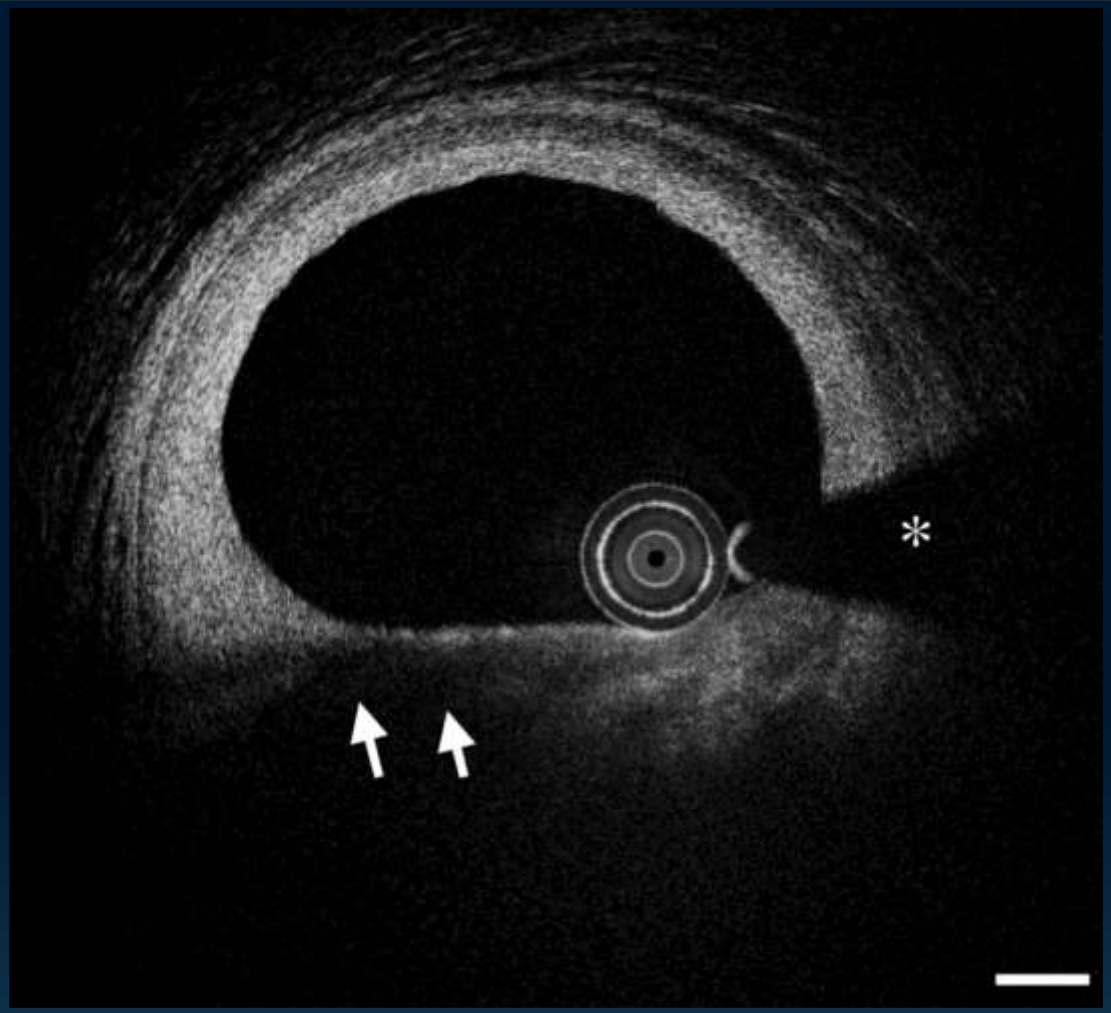


• Shadowing caused by blood inside of catheter. Right panel shows a high OCT signal from within the catheter



• Tissue adherent to the catheter (red arrow), likely a small thrombus, attenuates the OCT signal at greater depths.

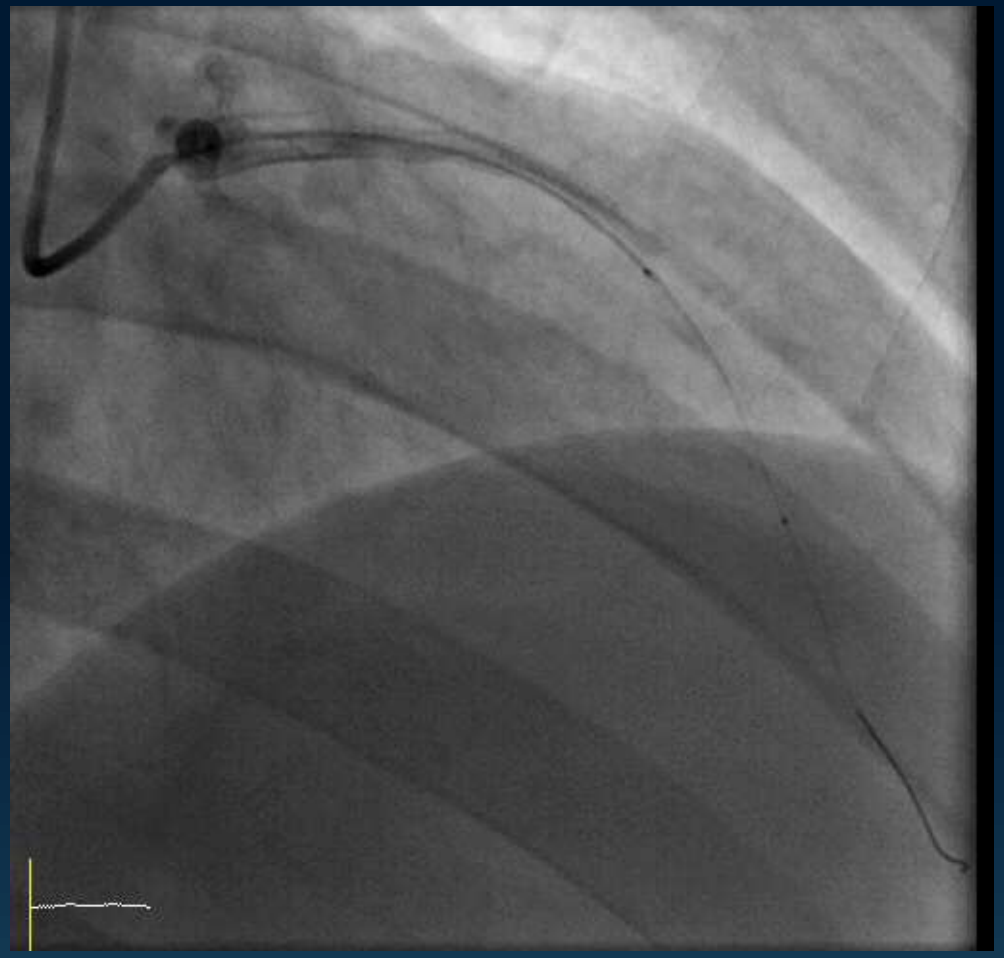
Artifact – Tangential signal dropout

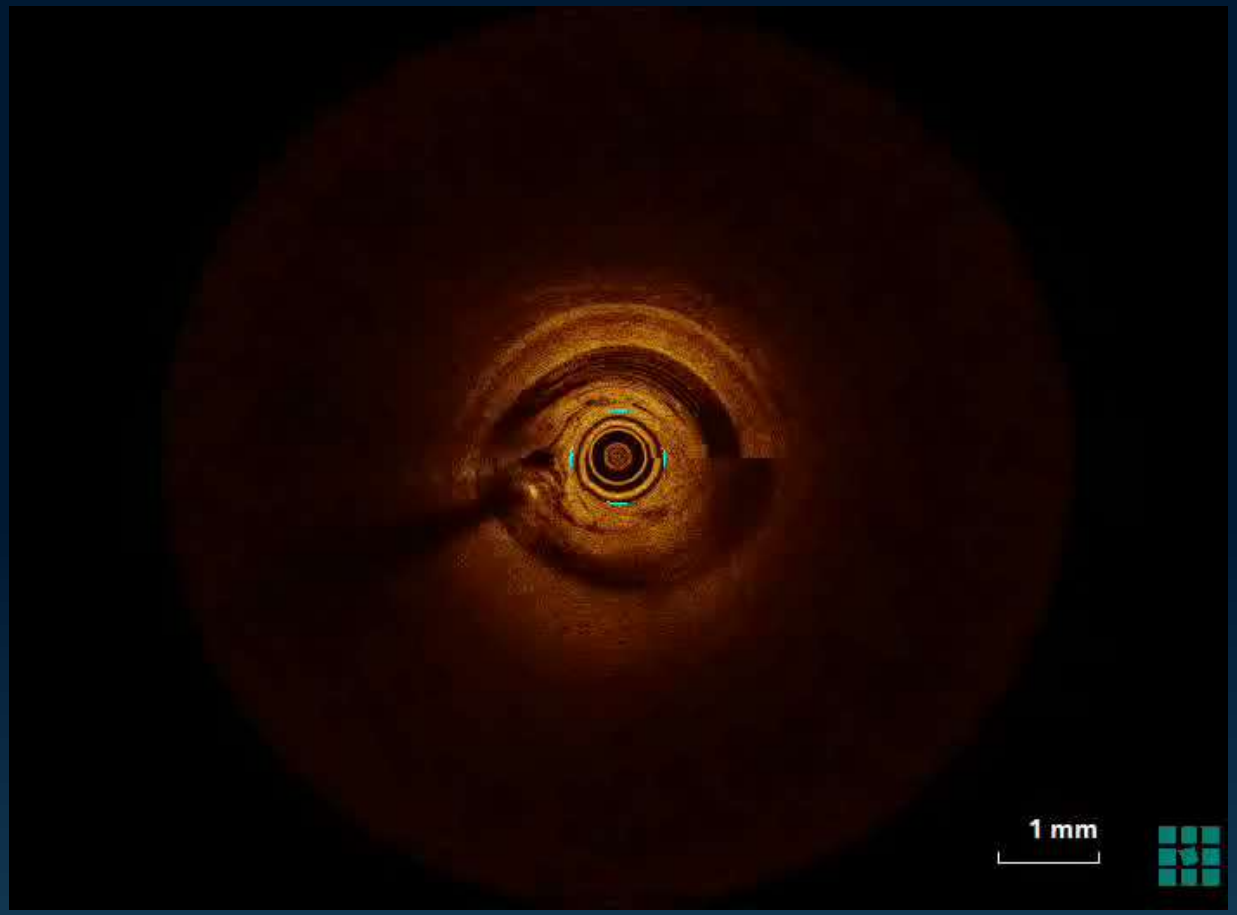


• When the catheter is located near the vessel wall, the optical beam can be directed nearly parallel to the tissue surface. In these situation, artery wall may appear signal poor below the luminal surface.

Limitation of OCT and Trouble shooting

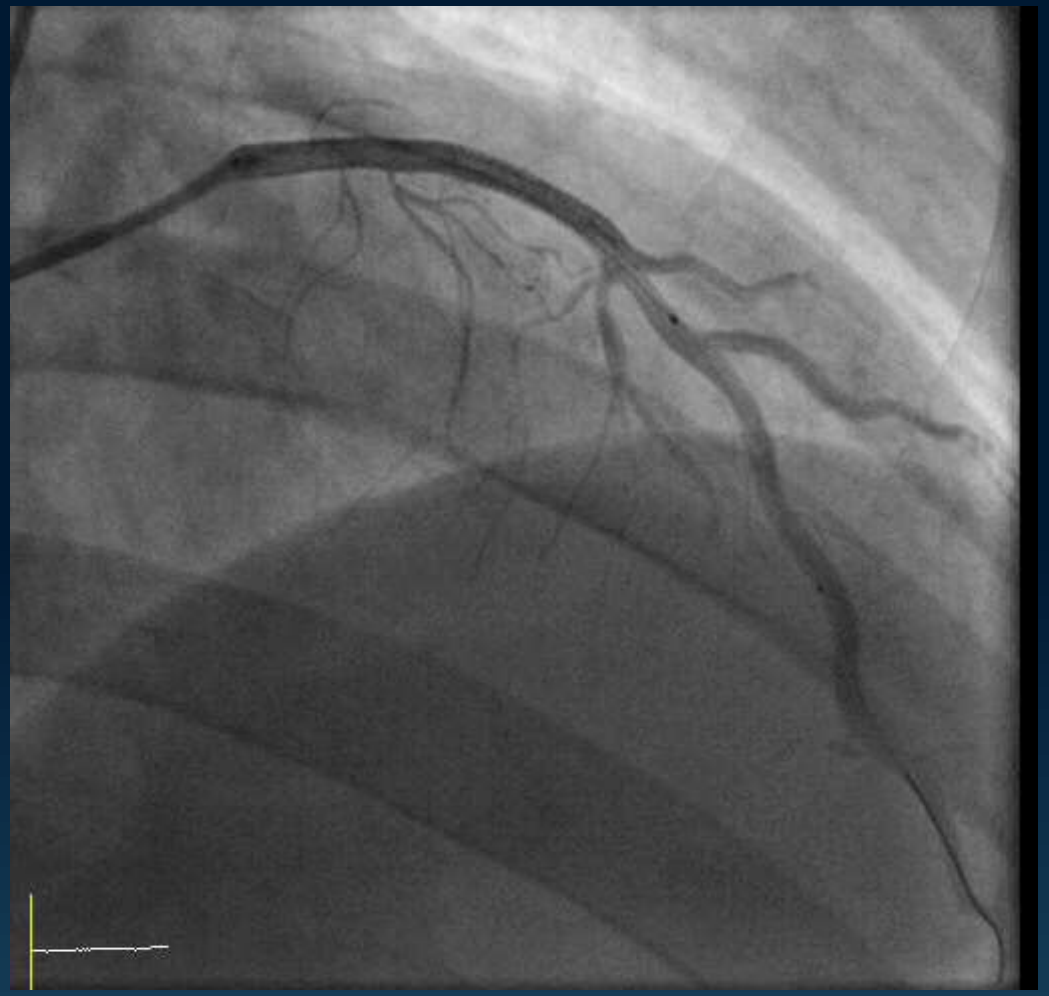
Poor OCT images

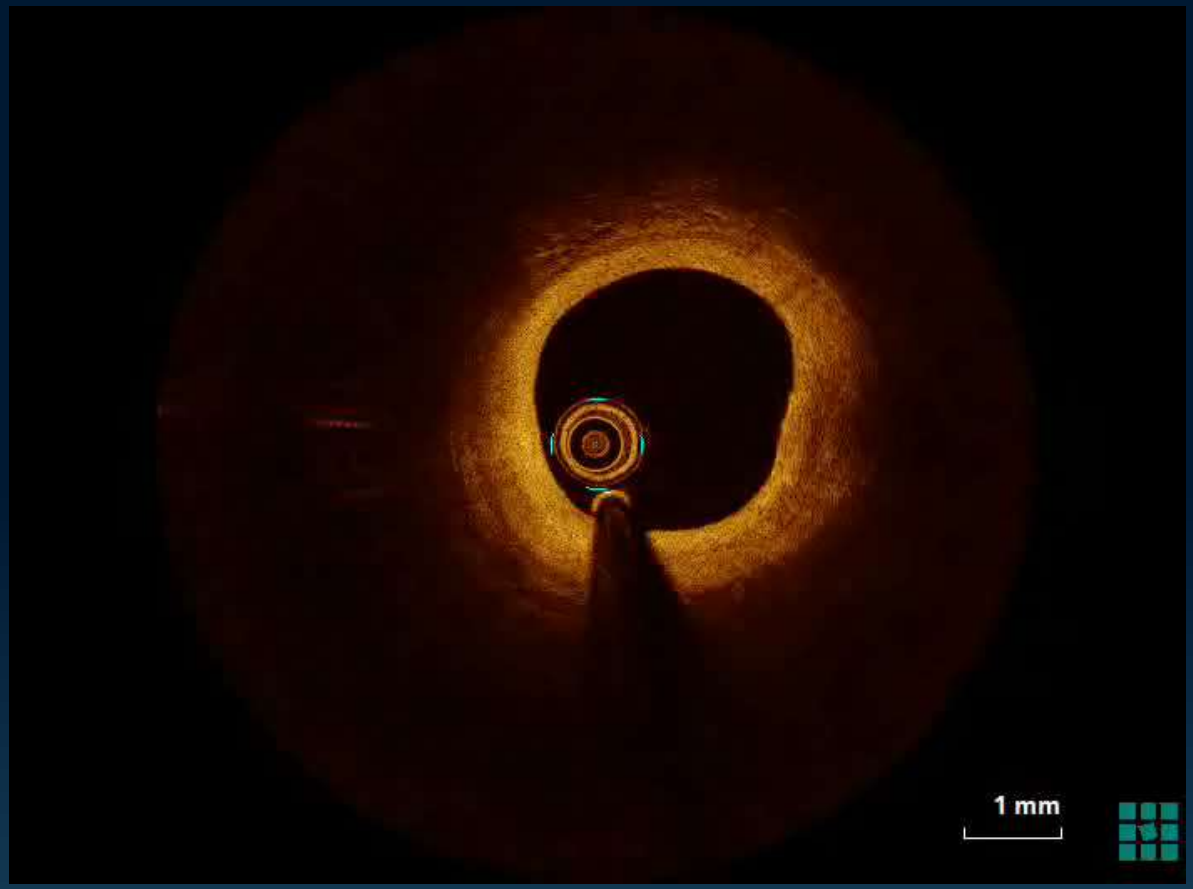




Limitation of OCT and Trouble shooting

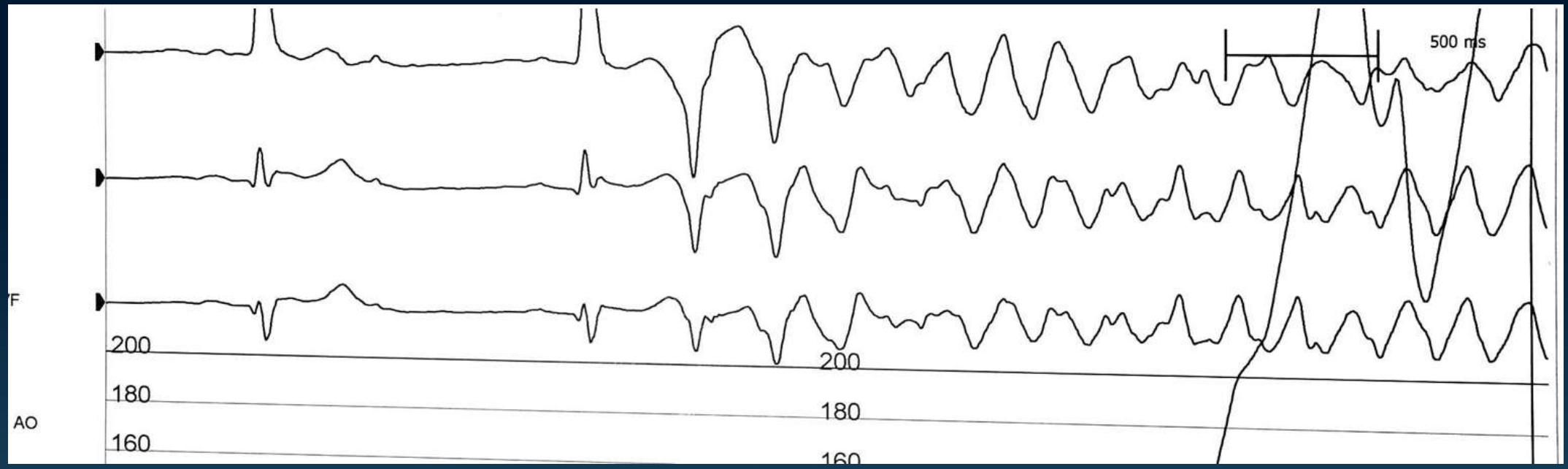
Poor PS OCT images => Coaxial alignment





Limitation of OCT and Trouble shooting

Arrhythmia after OCT



Limitation of OCT and Trouble shooting

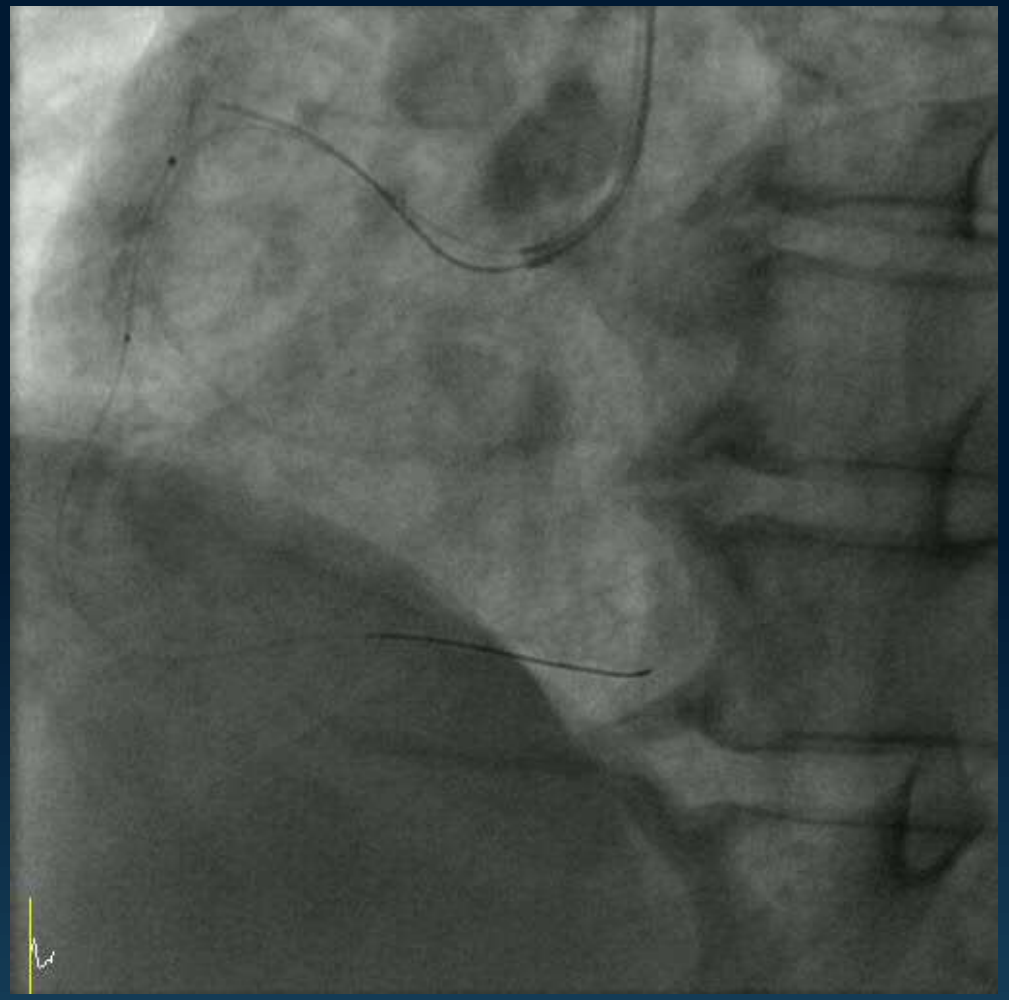
Arrhythmia after OCT => Prepare Defibrillation before procedure

- prolonged blood flow impairment

    1. deep intubated guiding catheter
    2. catheter damping
    3. Examination of dominant coronary artery

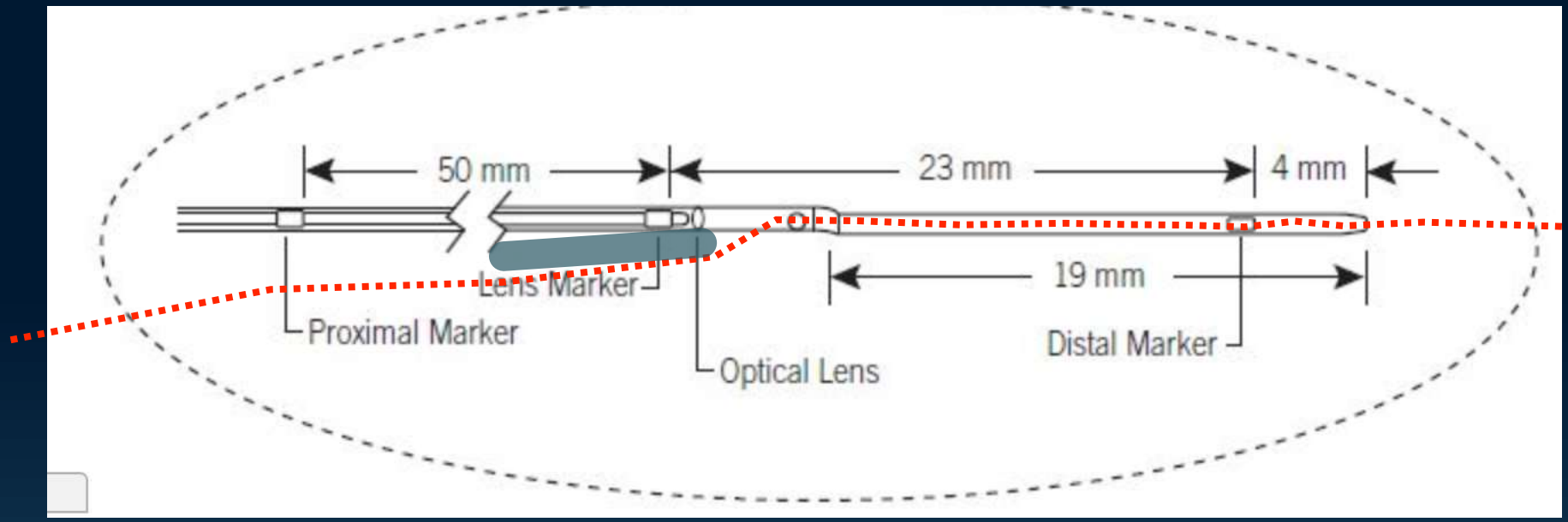
Limitation of OCT and Trouble shooting

OCT catheter kinking

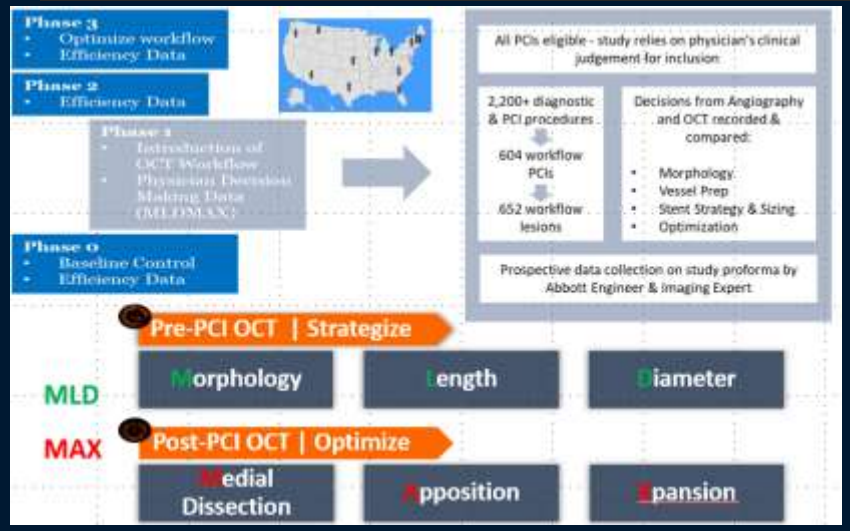


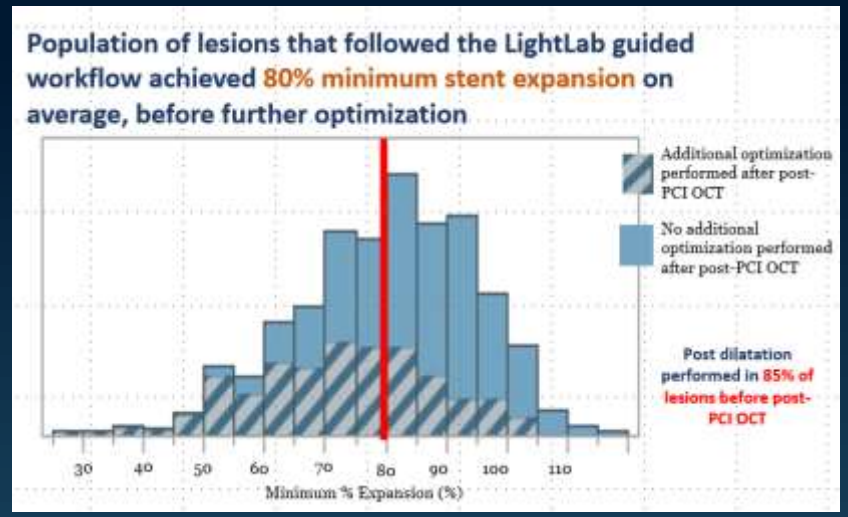
Limitation of OCT and Trouble shooting

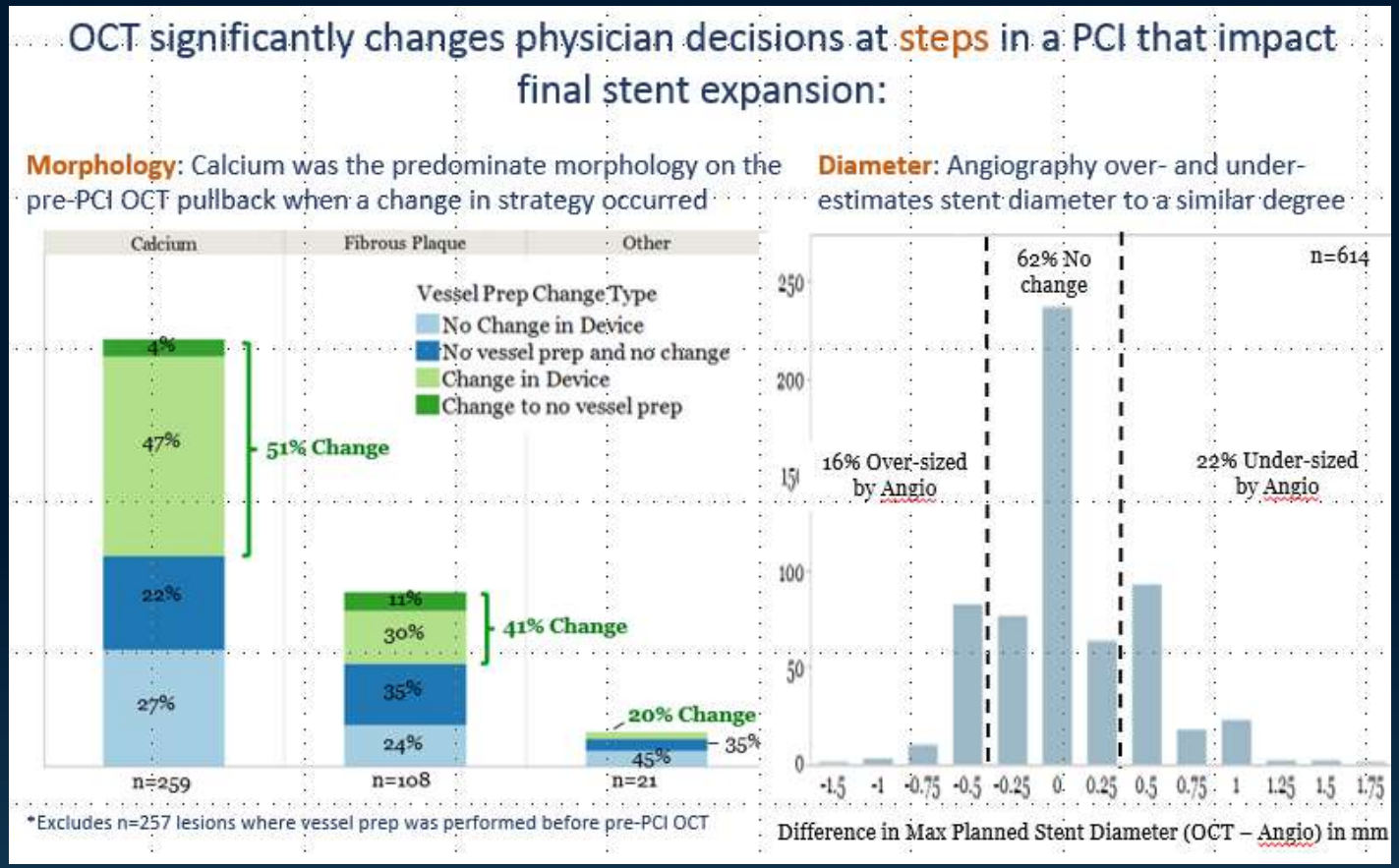
OCT catheter kinking => slowly remove device or wire and OCT device totally removed



Analysis of changes in decision-making process during OCT-guided PCI







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Conclusion

- The contemporary MLD MAX concept makes it easy for physicians to access OCT-guided PCI.
- OCT-guided PCI shows a tendency to obtain a larger MSA by changing physician's decision, especially in post-stent expansion.
- Well experienced OCT-guided PCI can expect a better future clinical outcome.

Thank you for your attention