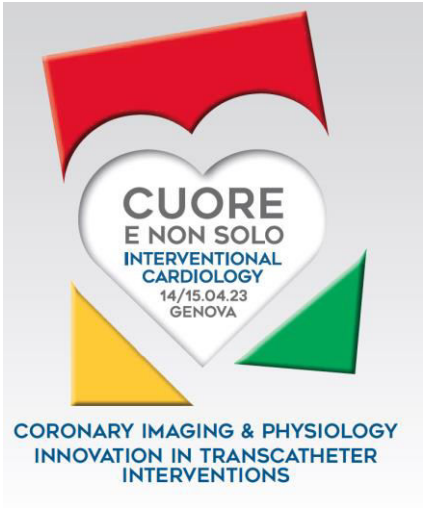


"Come usare l'imaging per guidare l'impianto e l'ottimizzazione dello stent?

Dott. Massimo Fineschi
Cardiologia Interventistica
Azienda Ospedaliero-Universitaria Senese
Siena

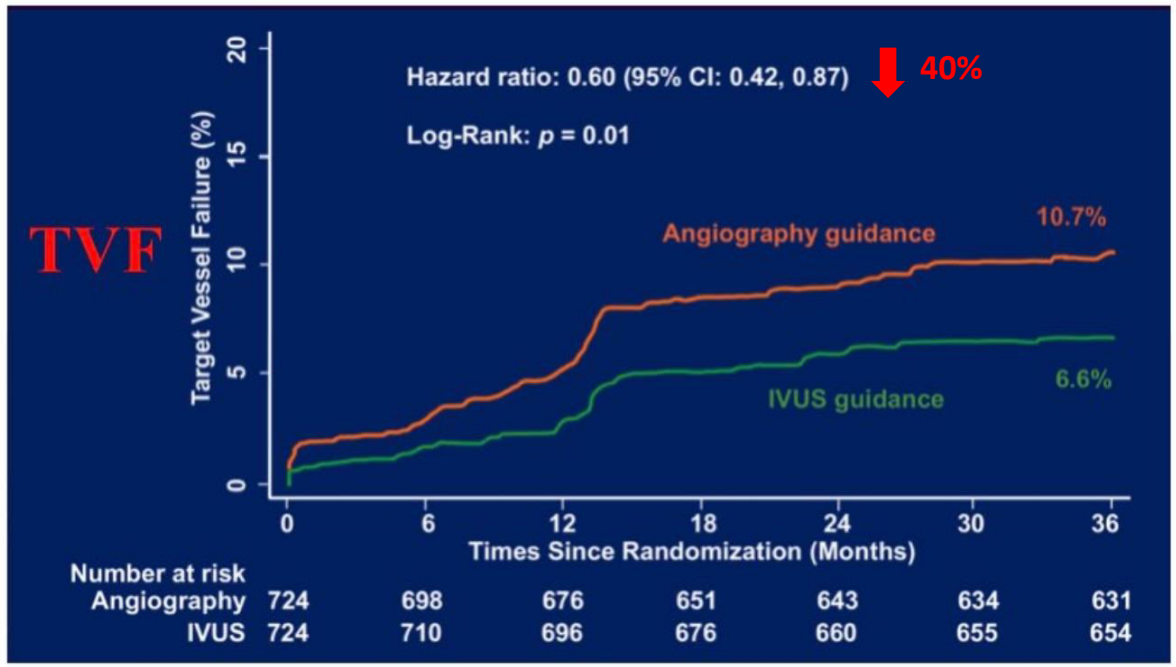
Clinical use of intracoronary imaging

- Randomized controlled trials and registries consistently support procedural and long-term benefit with the use of intravascular imaging (IVI) for percutaneous coronary intervention (PCI) guidance

- The benefits of intracoronary imaging depend largely on the interpretation and the operator's reaction to these findings. Imaging acquisition alone will not be sufficient to impact on outcome !

ULTIMATE

3-year Clinical FU



ORIGINAL ARTICLE FREE PREVIEW

Intravascular Imaging–Guided or Angiography-Guided Complex PCI

Joo Myung Lee, M.D., Ph.D., M.P.H., Ki Hong Choi, M.D., Ph.D., Young Bin Song, M.D., Ph.D., Jong-Young Lee, M.D., Ph.D., Seung-Jae Lee, M.D., Ph.D., Sang Yeub Lee, M.D., Ph.D., Sang Min Kim, M.D., Ph.D., Kyeong Ho Yun, M.D., Ph.D., Jae Young Cho, M.D., Ph.D., Chan Joon Kim, M.D., Ph.D., Hyo-Suk Ahn, M.D., Ph.D., Chang-Wook Nam, M.D., Ph.D., et al., for the RENOVATE-COMPLEX-PCI Investigators*

Objective: to investigate whether intravascular imaging PCI using IVUS or OCT would improve clinical outcomes compared with angiography guided PCI in patients with complex artery lesions

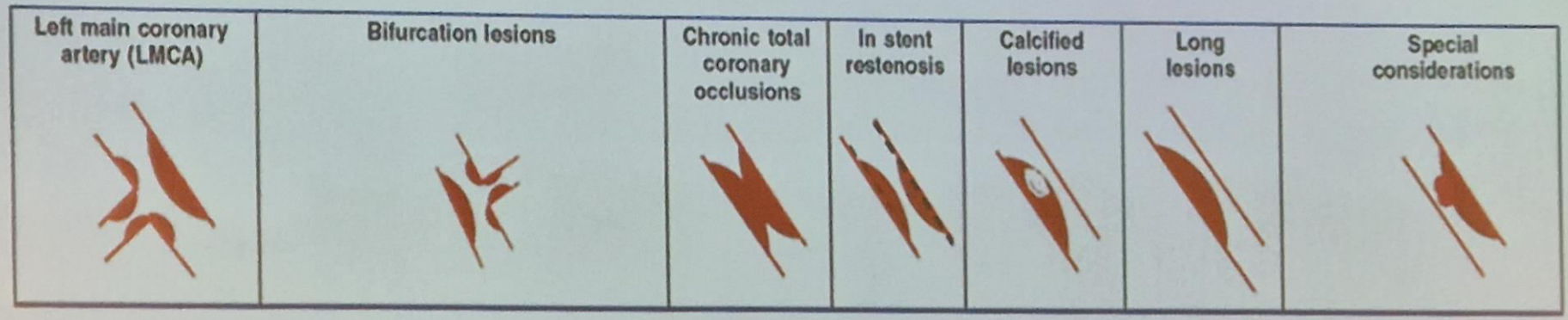
Primary Hypothesis

Intravascular imaging-guided PCI would reduce TVF compared with angiography-guided PCI
In treatment of patients with **complex coronary artery lesions**

Study design

RENOVATE-COMPLEX-PCI Trial (NCT03381872)

1,620 Patients with Complex Coronary Artery Lesions Undergoing PCI



Randomization (2:1) for Treatment Strategy of Target Lesions
(Stratified by acute coronary syndrome and participating centers)

Imaging-Guided Strategy	Angiography-Guided Strategy
N = 1,080	N = 540

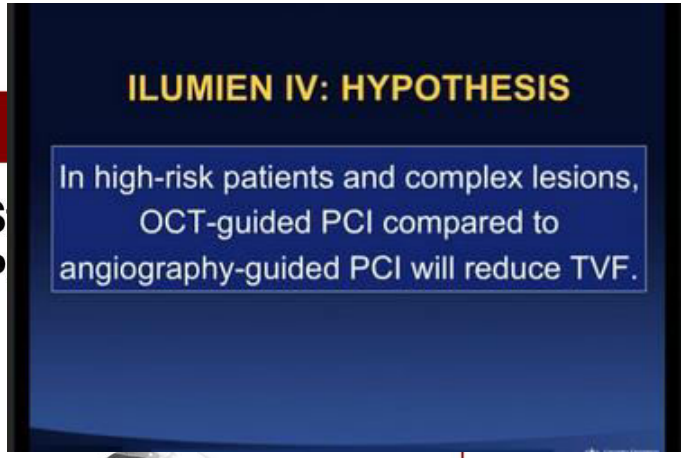
All patients were followed until 1 year after last patient enrollment.

ACC.23 TOGETHER WITH WCC

Lee JM, Choi KH, Song YB , Hahn JY, et al. NEJM 2023

EuroIntervention | **TOP CITED 2022** ☆☆☆

VISUAL ILLUSTRATION. Optical Coherence Tomography-guided Coronary S
Compared to Angiography: Design and Rationale of ILUMIEN IV: OPTIMAL P

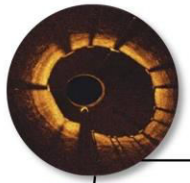


Pre-PCI angiography

High-risk patient and/or presence of one or more high-risk lesions. All inclusion and exclusion criteria met

Successful and uncomplicated treatment of all non-target vessel lesions, if any

Randomisation 1:1



OCT

OCT stent sizing guidance, per study protocl

OCT-guided optimisation, per study protocl

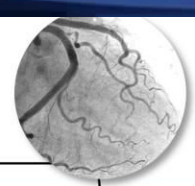
Post-PCI OCT

Inclusion

High-risk clinical characteristics
- Medically treated DM

High-risk target lesion
- ACS
- Long or multiple lesions (stent length >28 mm)
- Bifurcation with 2 planned stents
- Angiographic severe Ca^{2+}
- CTO (crossed and predilated)
- In-stent restenosis

Co-primary endpoints
- **Post-PCI minimal stent area** assessed by OCT in each randomised arm
- **Target vessel failure**, the composite of cardiac death, target vessel myocardial infarction, or ischaemia-driven target vessel revascularisation



Angiography

Angiography-guided PCI, per "local standard practice"

Angiographic optimisation, per "local standard practice"

Post-PCI OCT, blinded to investigator

Procedure complete

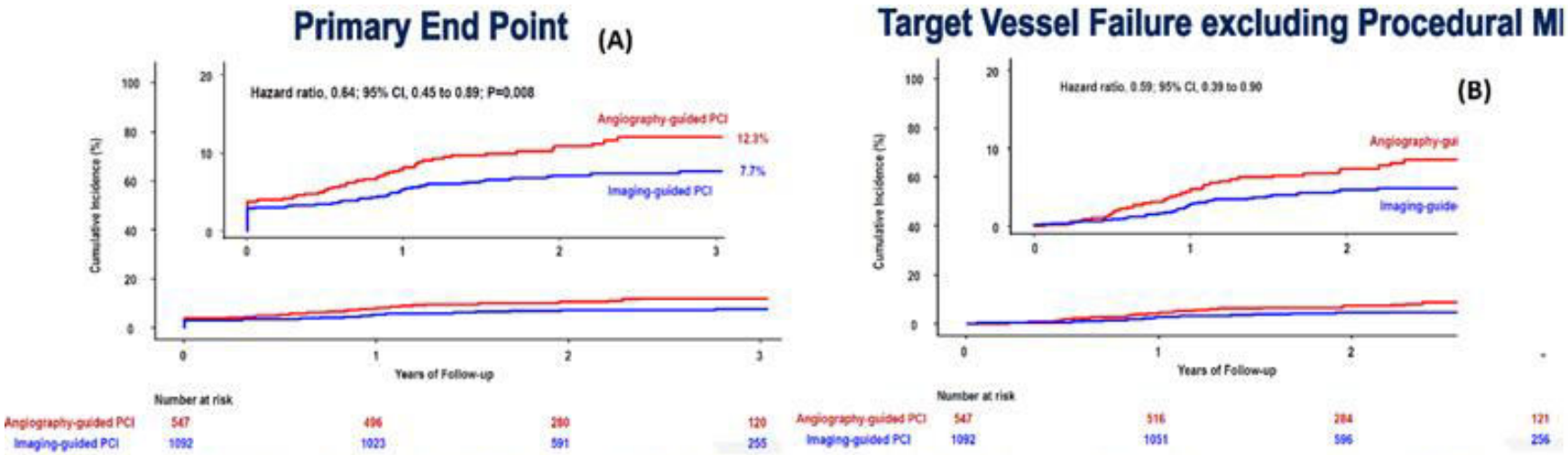
30-day, 1-year and 2-year follow-up in all patients

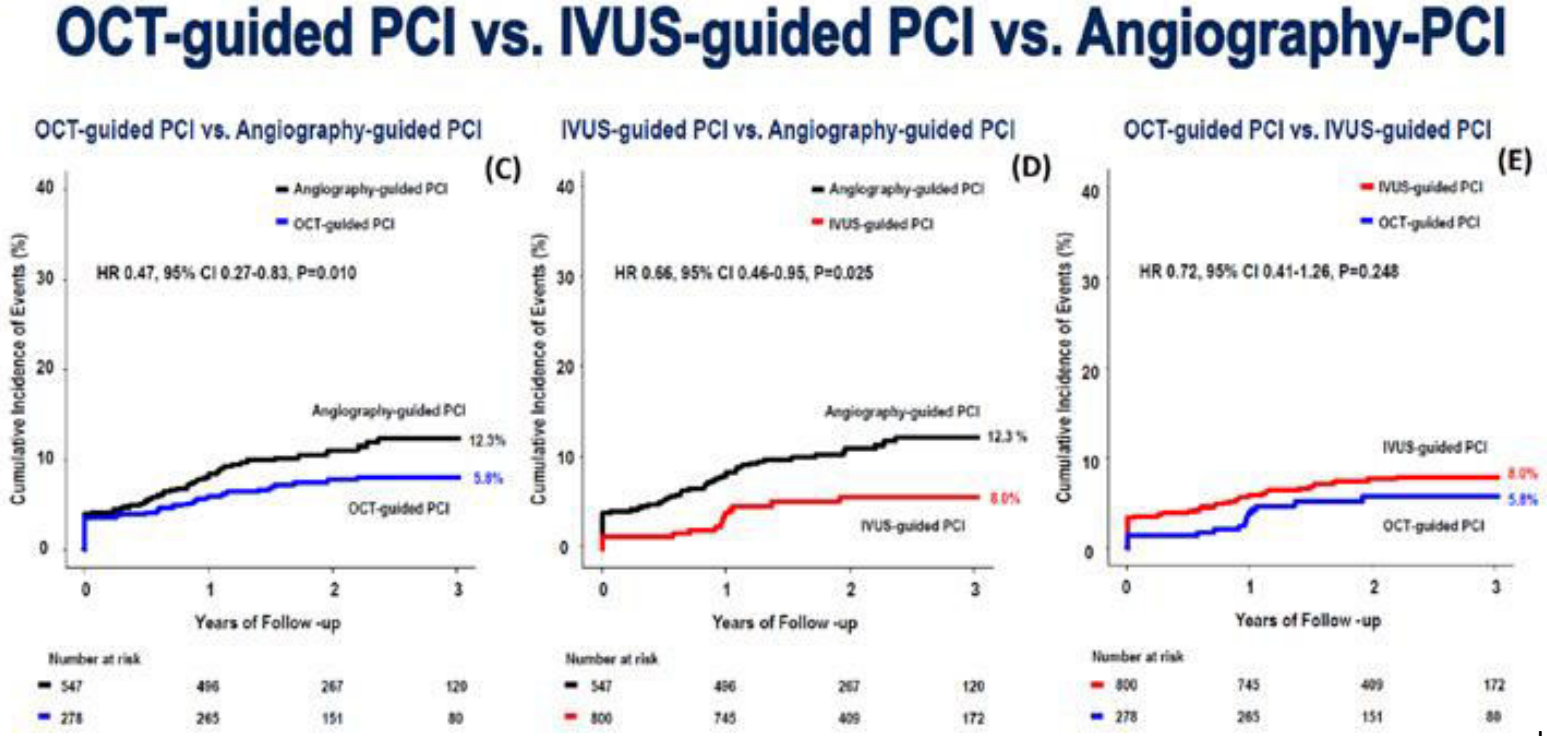
Primary clinical endpoint, maximum 2-year follow-up

Abbreviations: ACS, acute coronary syndrome; CTO, chronic total occlusion; DM, diabetes mellitus; OCT, optical coherence tomography; PCI, percutaneous coronary intervention.

Ali Z, et al. EuroIntervention 2021;16:1092-1099

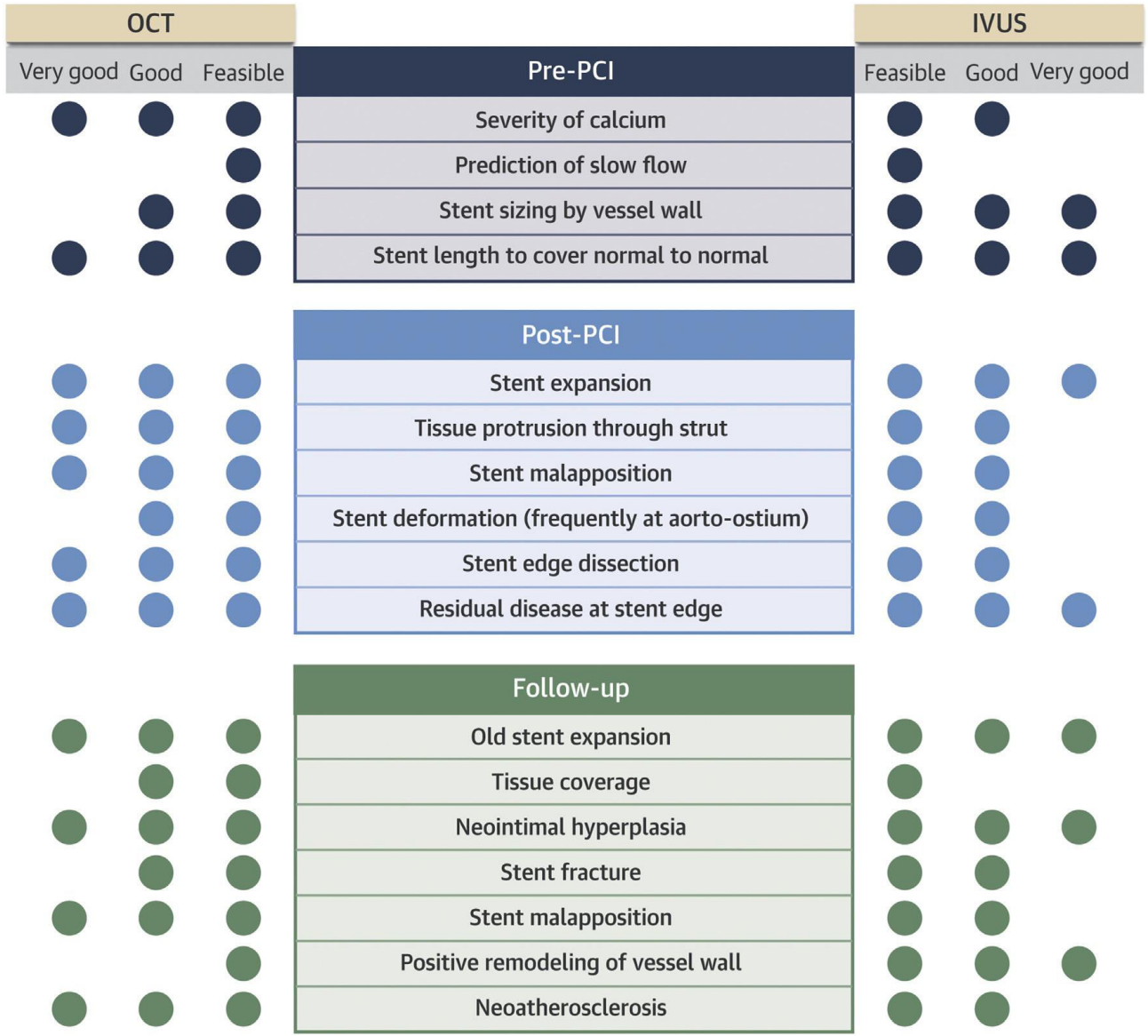
Use of intravascular optical coherence tomography or intravascular ultrasound to guide stent implantation. The choice is yours!





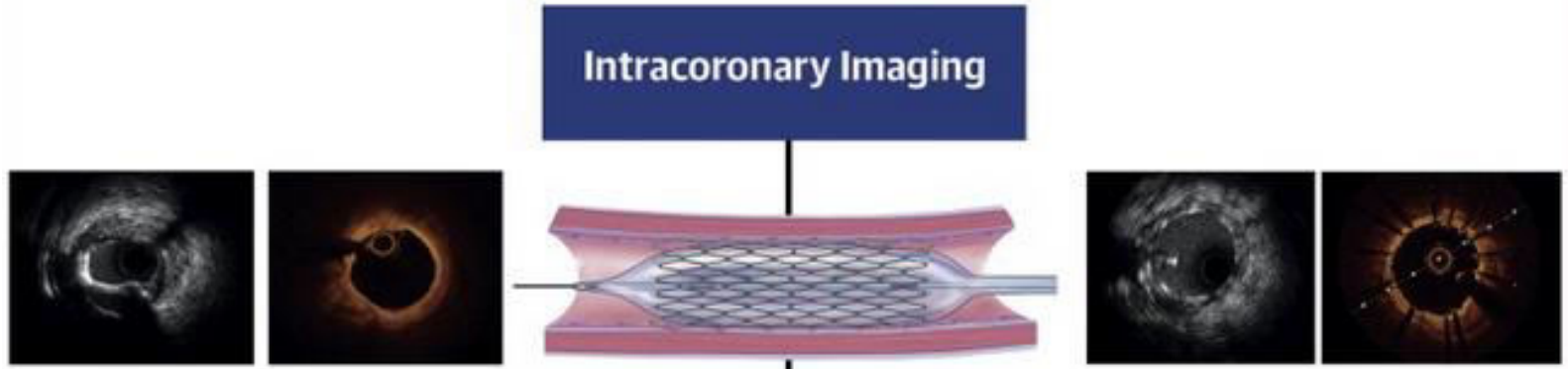
Lee JM,Choi KH,Song YB et al.NEJM2023

CENTRAL ILLUSTRATION IVUS and OCT: Similarities and Differences



Maehara, A. et al. J Am Coll Cardiol Img. 2017;10(12):1487-503.

CENTRAL ILLUSTRATION: Best Practice Summary for Use of Intracoronary Imaging



Preintervention Assessment	Lesion Preparation and Stent Deployment	Assessment of Postprocedure Endpoints and Complications
Assess plaque composition, lesion characteristics, and mechanisms of stent failure	Confirm landing zones	Identify stent underexpansion, deformation, and malapposition
Identify reference segments and landing zones	Prepare lesion (eg, angioplasty, atherectomy, lithotripsy)	Identify edge dissection, hematoma, and tissue protrusion
Choose stent size (length and diameter) and lesion preparation strategy	Determine success of preparation strategy and optimize stent expansion	Rule out geographic miss and inflow/outflow disease

Truesdell AG, et al. J Am Coll Cardiol. 2023;81(6):590-605.

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

1. Morphology
Assess Plaque Composition

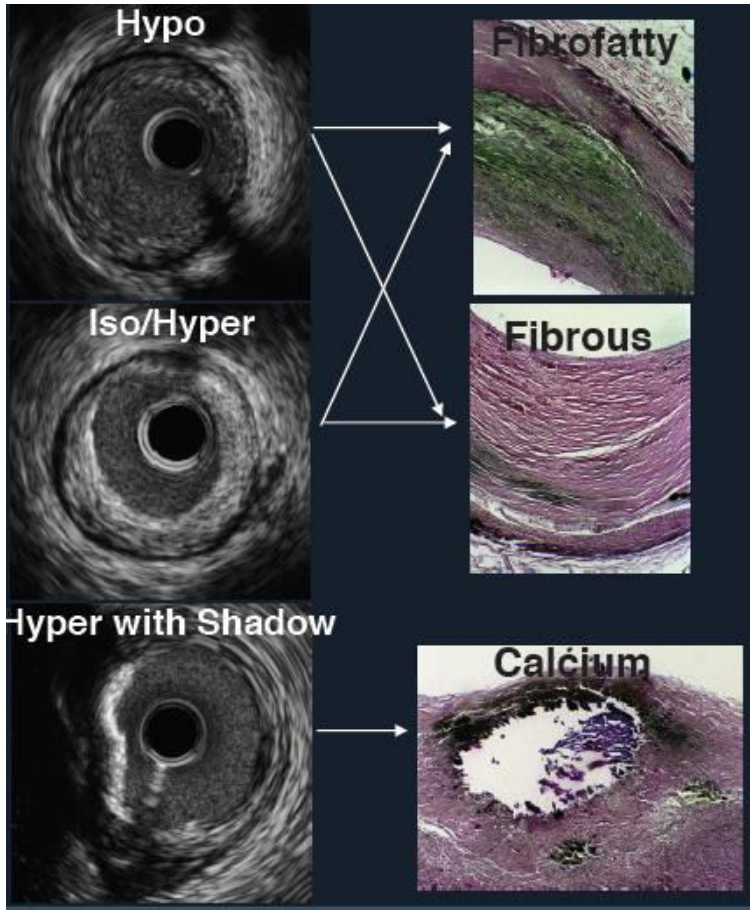
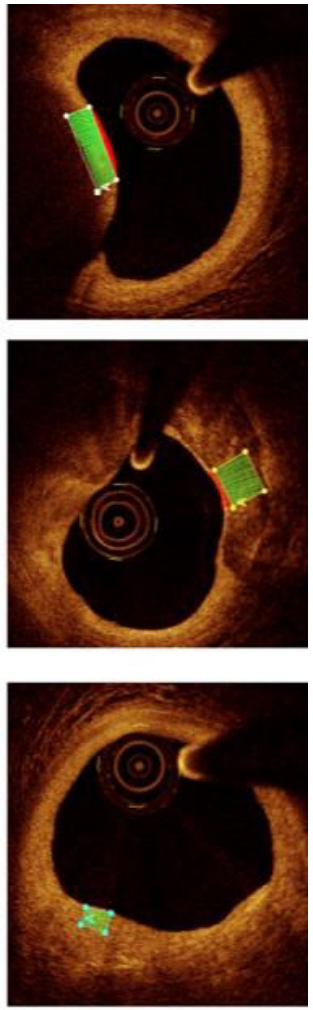


Table 2 Image characteristics of optical coherence tomography vs. IVUS

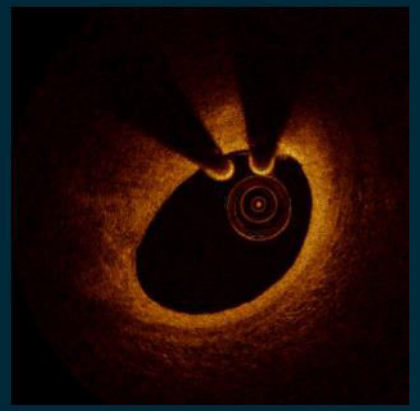
Tissue type	Image characteristics	
	OCT	IVUS
Fibre	Homogeneous High reflectivity Low attenuation	Homogeneous High reflectivity
Calcium	Sharp edges Low reflectivity Low attenuation	Very high reflectivity Shadowing
Lipid	Diffuse edges High reflectivity High attenuation	Low backscatter
Red thrombus	Medium reflectivity High attenuation	Medium-high reflectivit
White thrombus	Medium reflectivity Low attenuation	

OCT, optical coherence tomography.



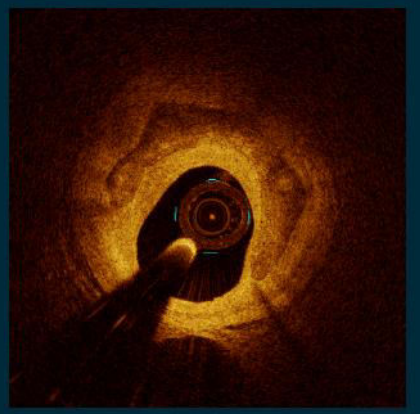
OCT **penetration** is due to plaque composition: penetration maximal for fibrotic tissue and progressively less for lipid and thrombus.

Morphology Guided Lesion Preparation

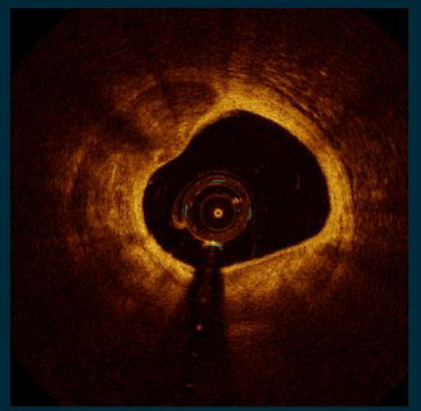


Lipidic

Fibrotic



Mild/Moderate Ca^{2+}



Severe Ca^{2+}

DIRECT STENTING[1]

COMPLIANT BALLOON[2]

NON-COMPLIANT BALLOON[3]

ATHERECTOMY OR IVL[4]

THE CALCIUM PROBLEM

ABSENCE OF INTRAVASCULAR IMAGING

↓

UNDERESTIMATION OF CALCIUM

↓

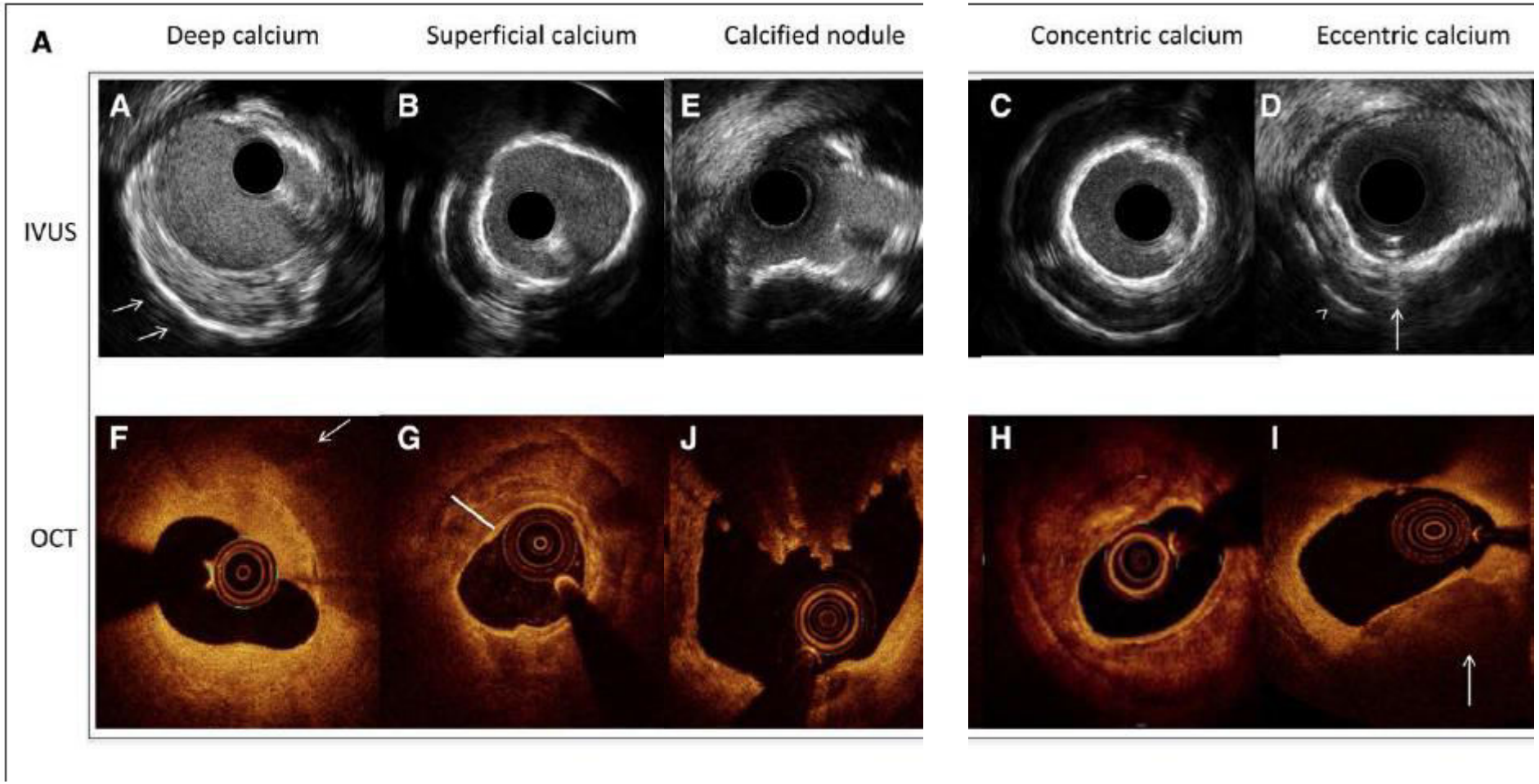
INCREASED LIKELIHOOD OF IMPROPER VESSEL PREP

↓

- **STENT UNDEREXPANSION**
- **INCREASE RISK OF COMPLICATIONS**
- **STENT MALAPPOSITION**
- **MORE STENTS**
- **LONGER PROCEDURES**

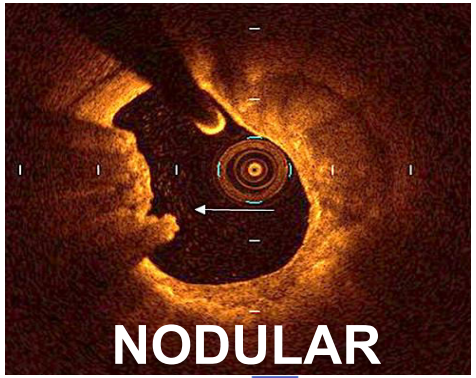
PRE-PCI detection af calcium

DEFINE TYPE CALCIUM…



DEFINE TYPE CALCIUM…

ROLE FOR CALCIUM MODIFICATION



NON- ROLE
NC/SCORING/CUTTING

ROLE
ROTATIONAL/ORBITAL/
LITHOTRIPSY/EXCIMER
LASER

TRADITIONAL ATHERECTOMY
ROTATIONAL/ORBITAL

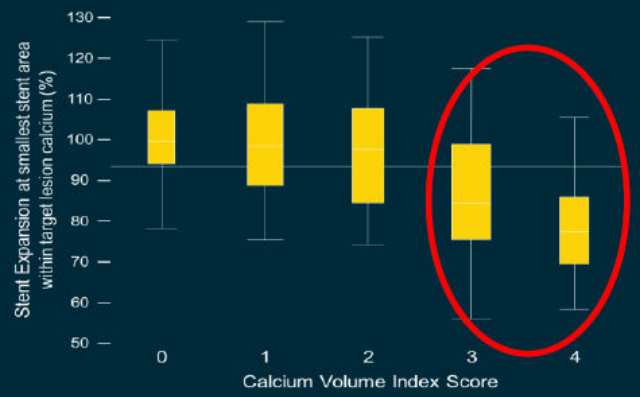
Influence of Ca^{2+} on Stent Expansion by OCT

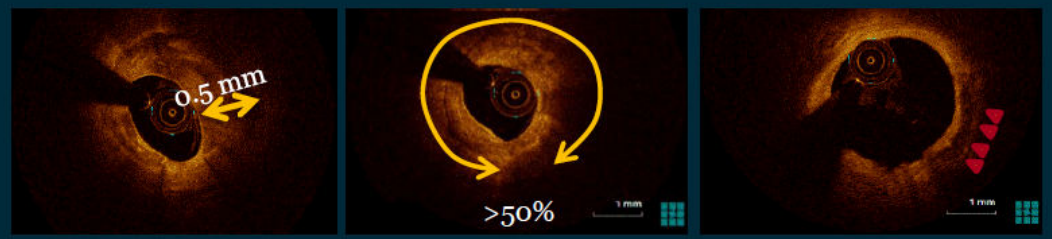
OCT-Based Calcium Volume Index Score[1]

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

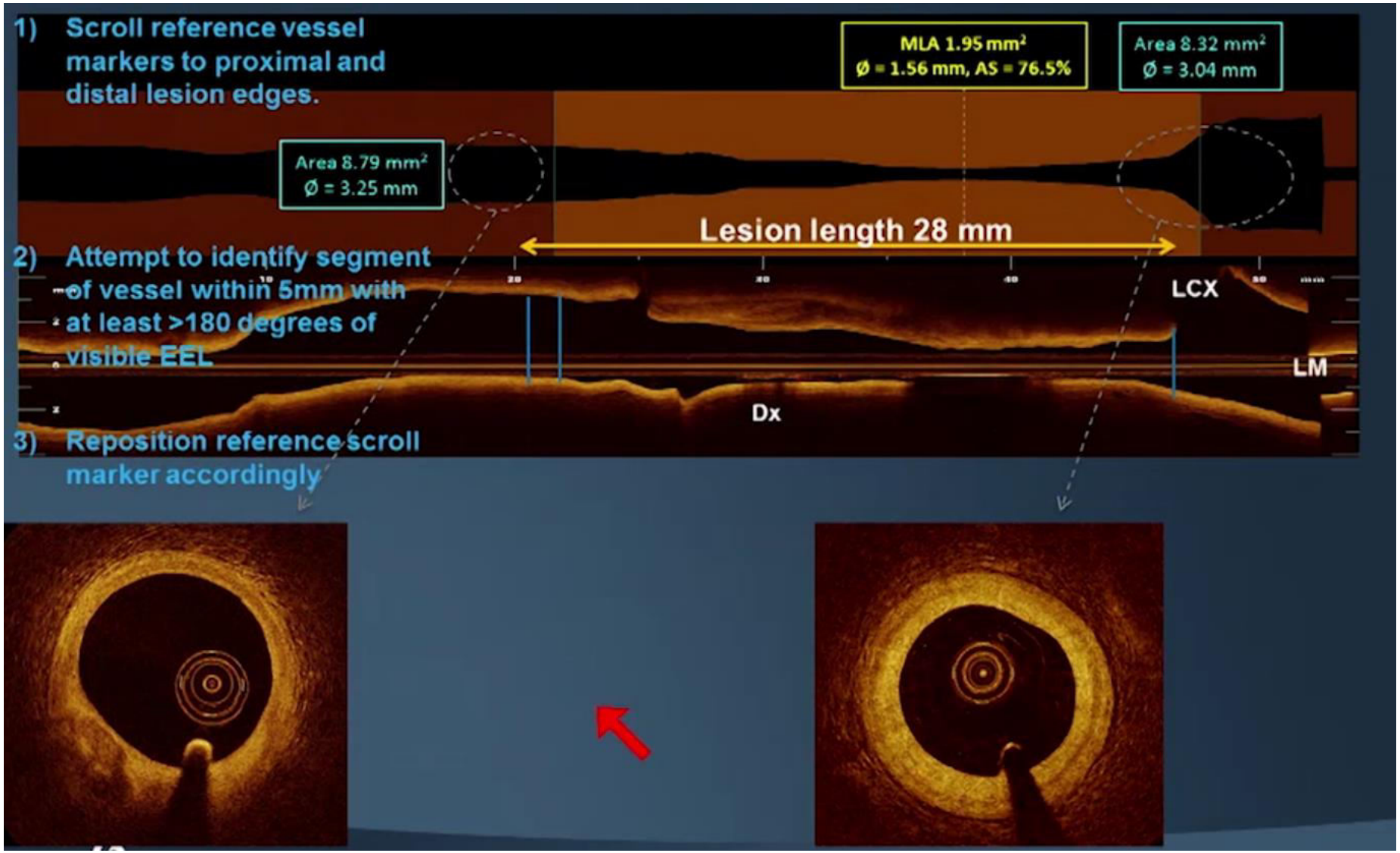




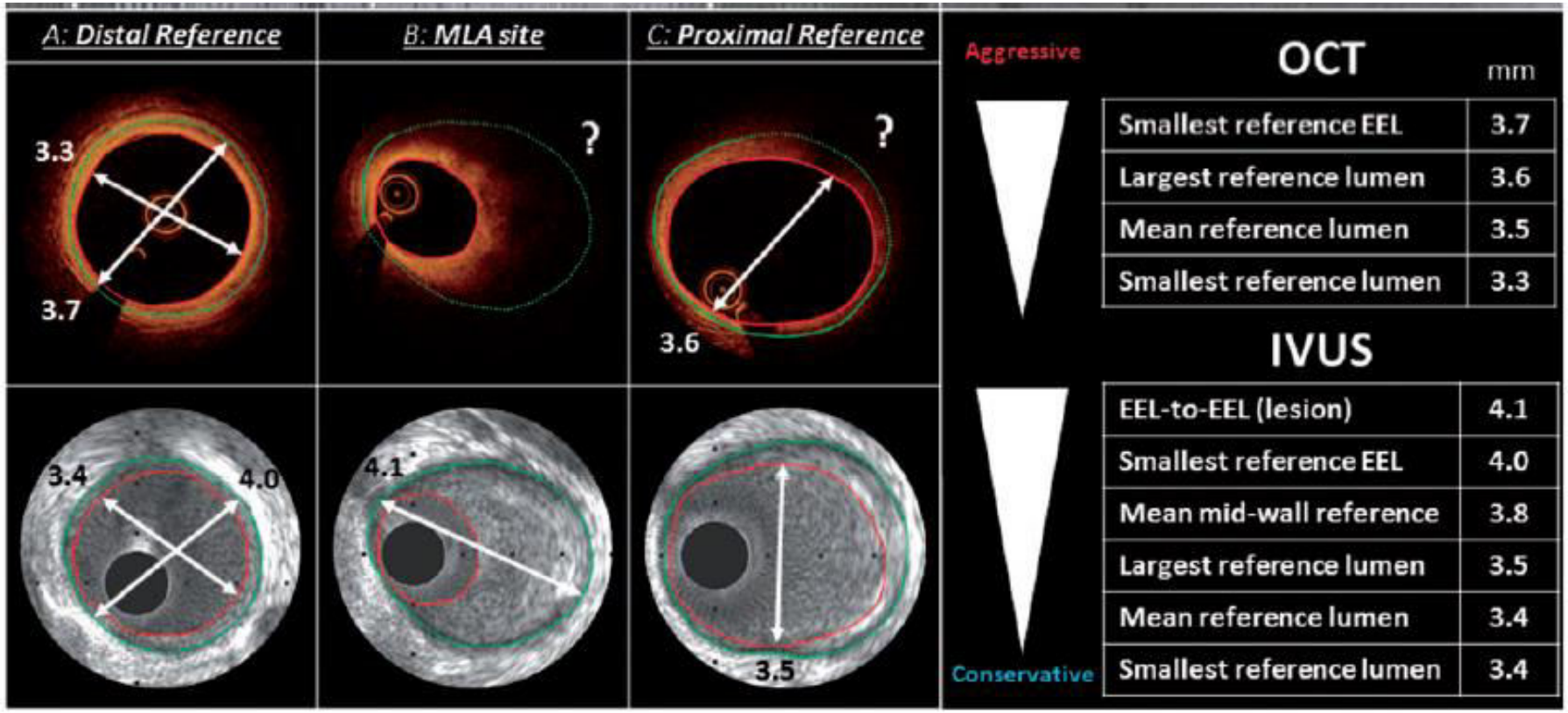
1. Fujino, A. et al. A new optical coherence tomography-based calcium scoring system to predict stent under expansion. *EuroIntervention*, April 2018; 13(18):e2182-e2189.

2.Identify Reference Segments (Prox & Dist)

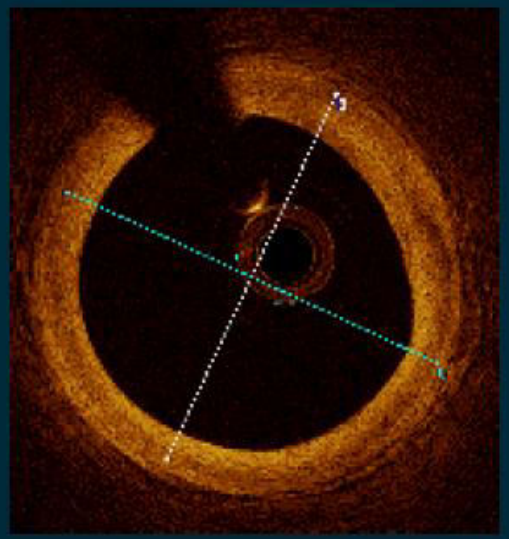
Choose Stent Length: avoidance the landing zone within an area of residual plaque burden >50% and particularly lipid-rich plaque



3.Diameter
Choose Stent Size (vessel size assessment)

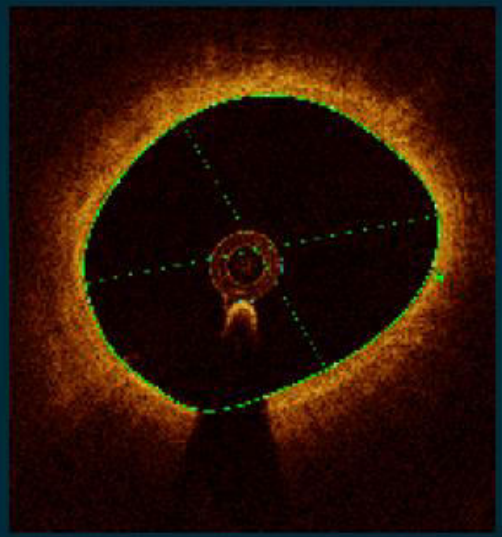


OCT Stent Sizing Algorithm



PRE-PCI OCT

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

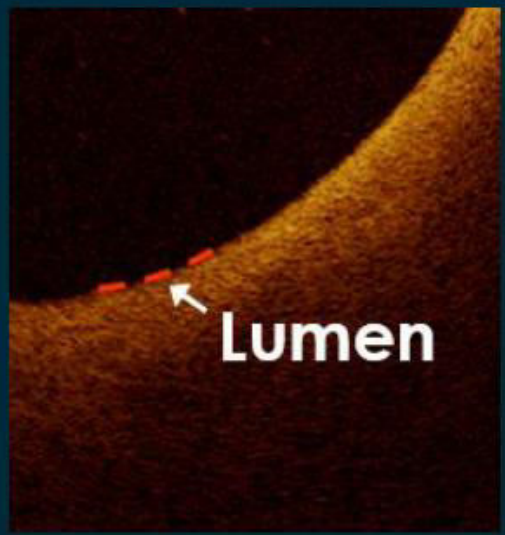


YES

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.

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

SECTION 4

Medial Dissection

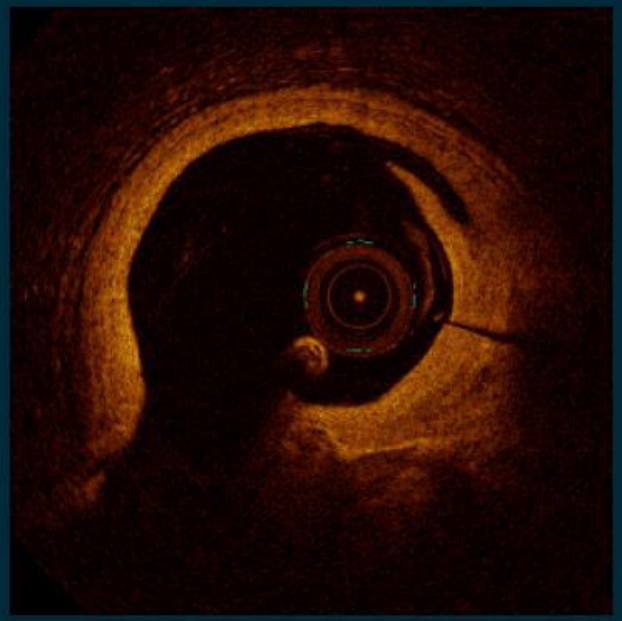
Dissections

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

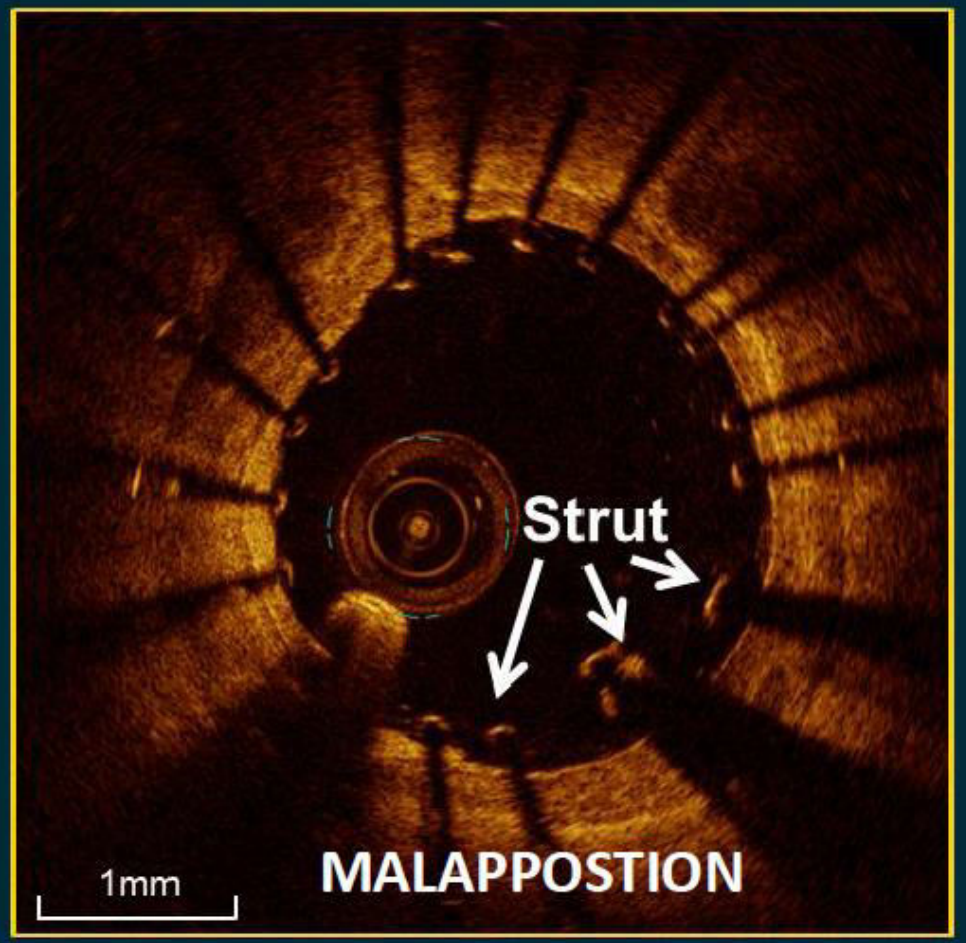
Edge Dissection: no major edge dissection in the proximal or distal reference segments defined as a location that is 5 mm from the edge of the stent,extends to the medial layer with potential to provide flow disturbance (defined as ≥60° of the circumference of the vessel at site of dissection and/or ≥ 3mm in lenght of the dissection flap

SECTION 5

Apposition

Apposition

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



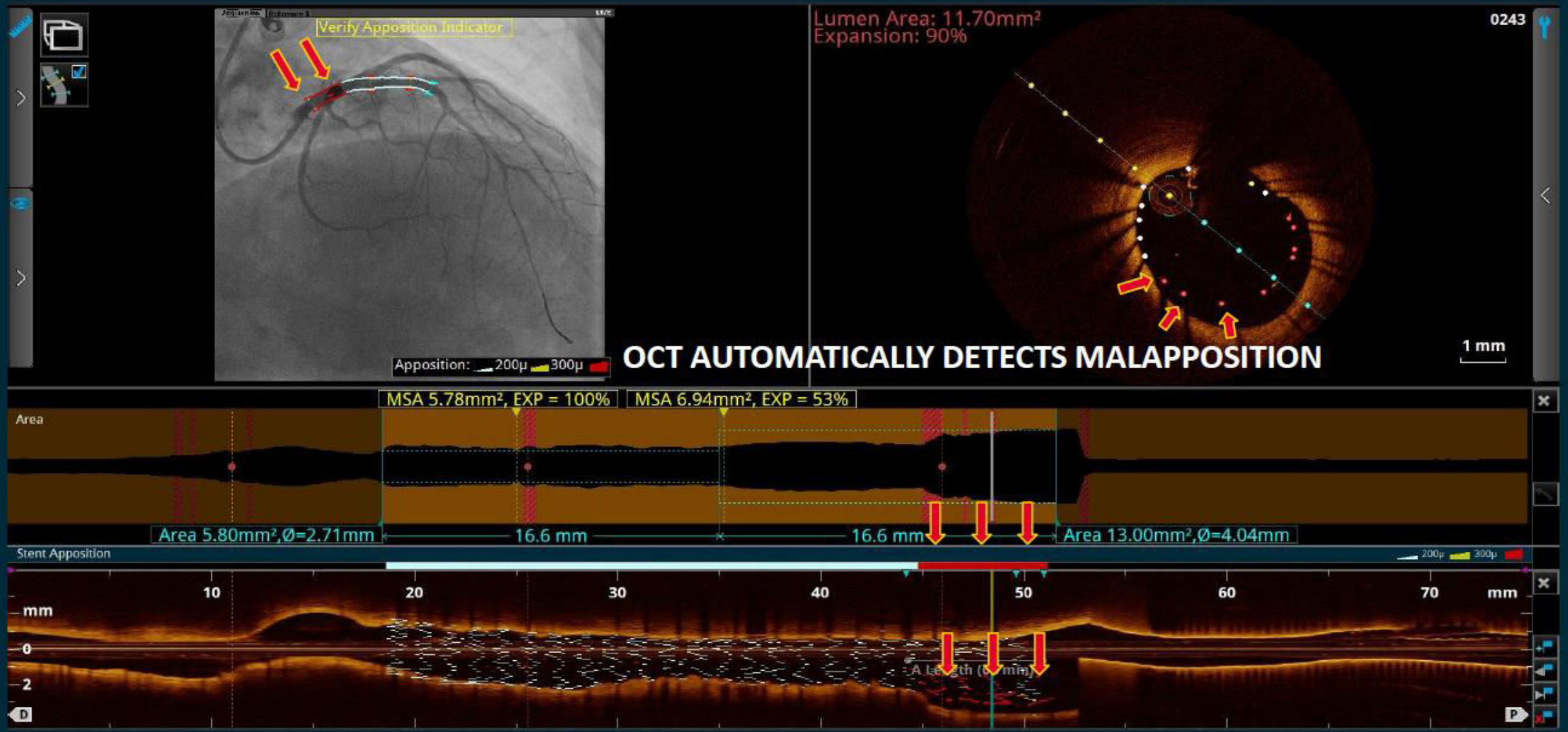
Address Gross Malapposition

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

Common Practice[3]

- Dilate with semi-compliant balloon at low pressure

Apposition Indicator



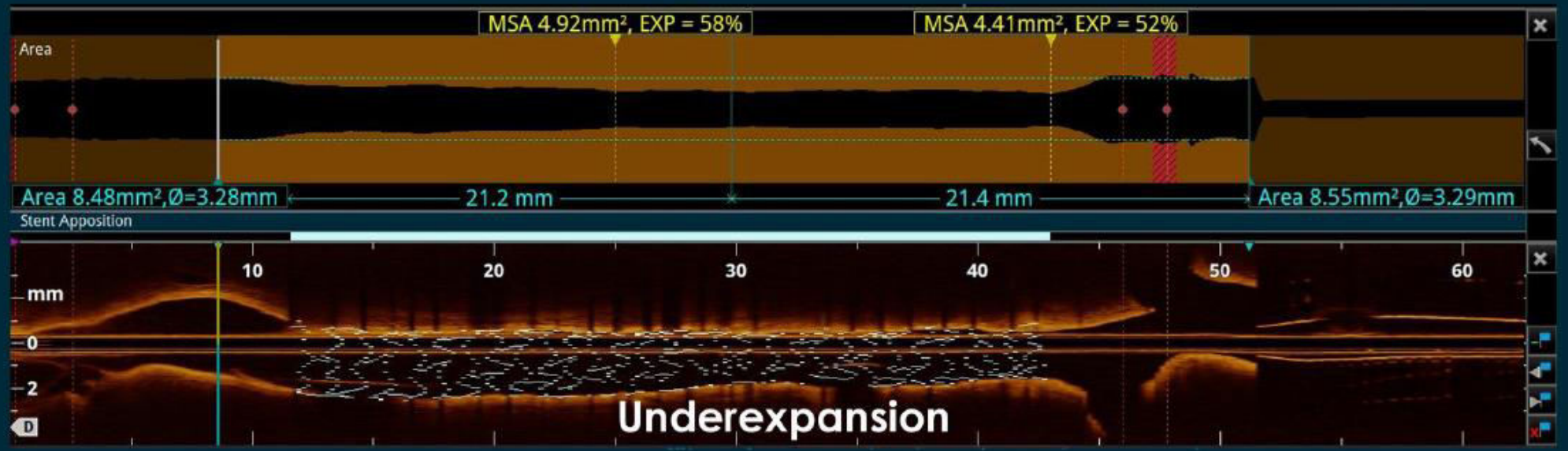
SECTION 6

eXpansion

Stent underexpansion is established as a major predictor of stent failure (restenosis/thrombosis)
Stent expansion describes the minimum stent CSA either as an absolute measure (absolute expansion) or compared with the predefinite reference area (relative expansion: prox-dist-average)

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

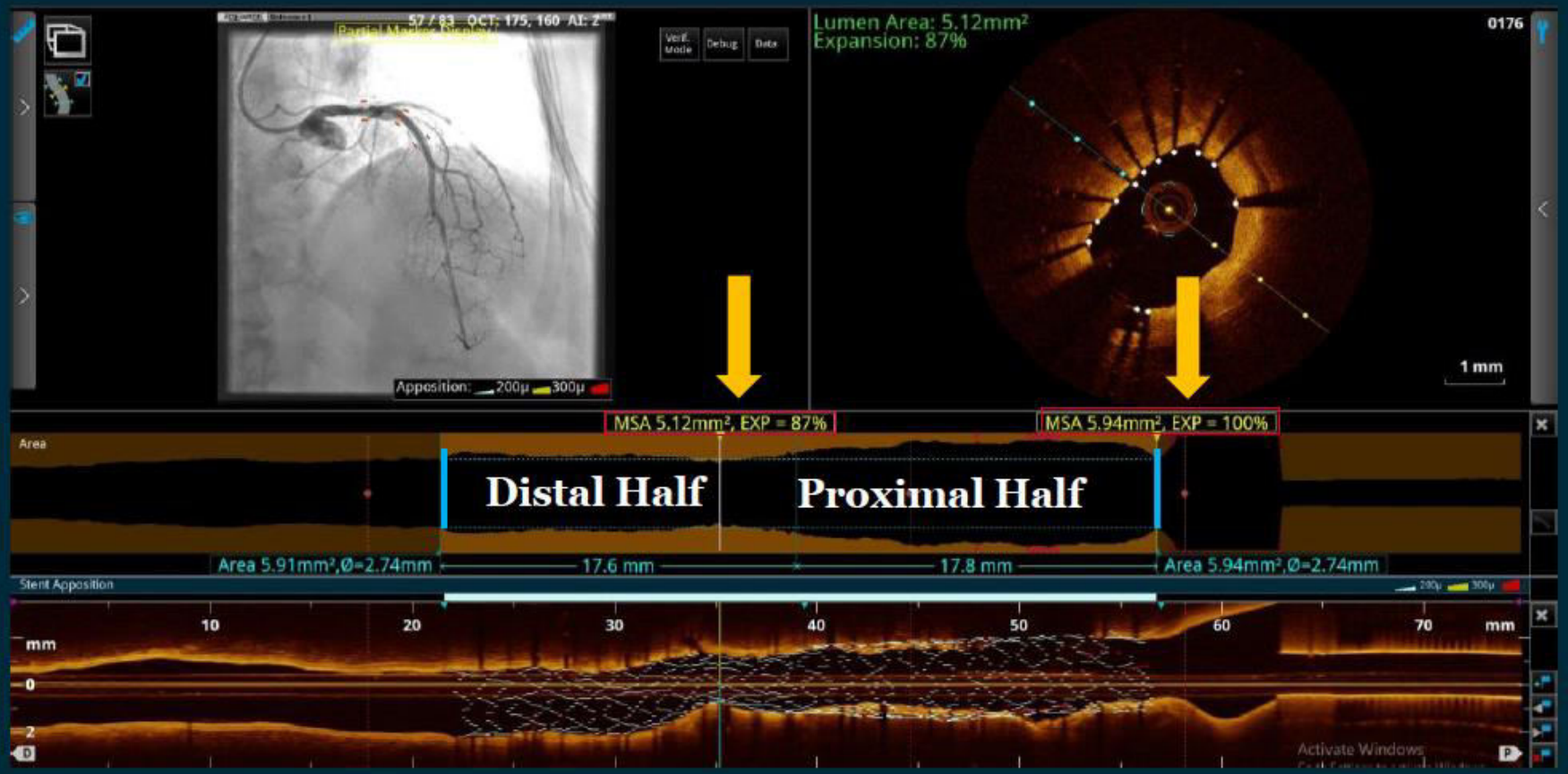
ACCEPTABLE = MSA ≥ 80% OF MEAN REFERENCE LUMEN AREA[1]

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

Determine Expansion / MSA - Dual

Fully automated expansion display

- ROI automatically detected
- Expansion automatically displayed

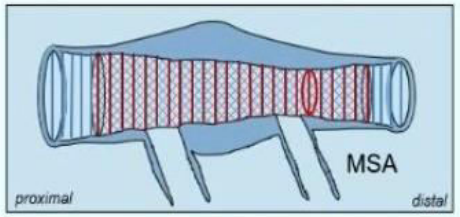


- **Determine your proximal half MSA compared to your proximal reference**
- **Determine your distal half MSA compared to your distal reference**

Definitions of 10 stent expansion indexes

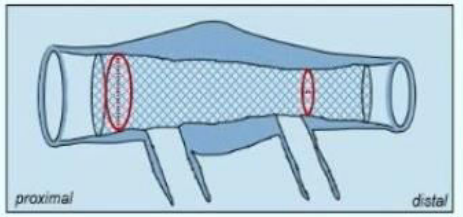
MSA

Minimum stent area in the entire stent



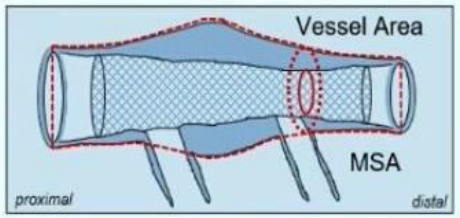
Stent Asymmetry

$$\frac{\text{Minimum Stent Diameter in the entire stent}}{\text{Maximum Stent Diameter in the entire stent}}$$



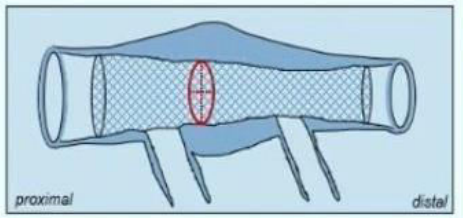
MSA/Vessel Area Stent Exp

$$\frac{\text{MSA}}{\text{Vessel Area at MSA}} \times 100$$



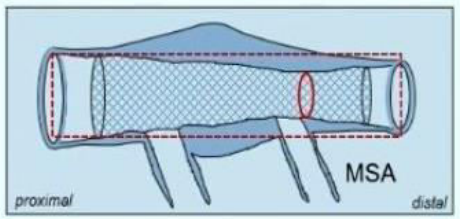
Stent Eccentricity

$$\text{Minimum of } \frac{\text{Minimum Stent Diameter}}{\text{Maximum Stent Diameter}}$$



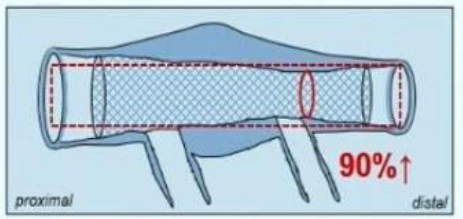
Conventional Stent Exp

$$\frac{\text{MSA}}{\text{Average of Proxi and Dist RLA}} \times 100$$



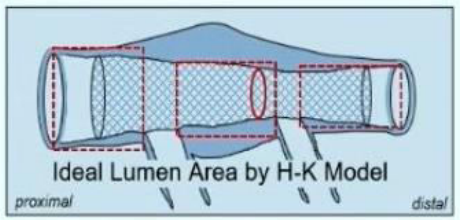
IVUS-XPL Criteria

Minimum Lumen Area
>90% of distal reference lumen area



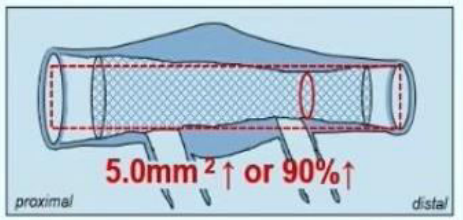
Minimum Stent Exp by H-K Model

$$\text{Minimum of } \frac{\text{Stent Area}}{\text{Ideal Lumen Area}} \times 100$$



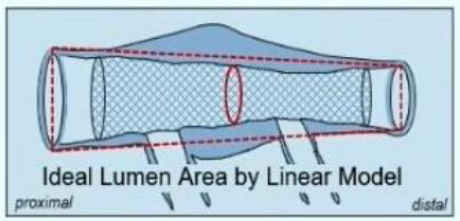
ULTIMATE Criteria

minimum lumen area
>5.0mm^2 or
>90% of distal reference lumen area



Minimum Stent Exp by Linear Model

$$\text{Minimum of } \frac{\text{Stent Area}}{\text{Ideal Lumen Area}} \times 100$$

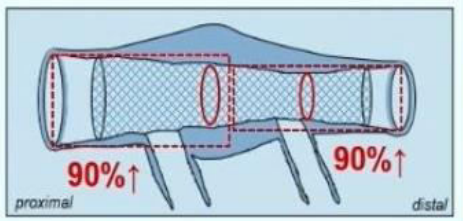


ILUMIEN IV Criteria

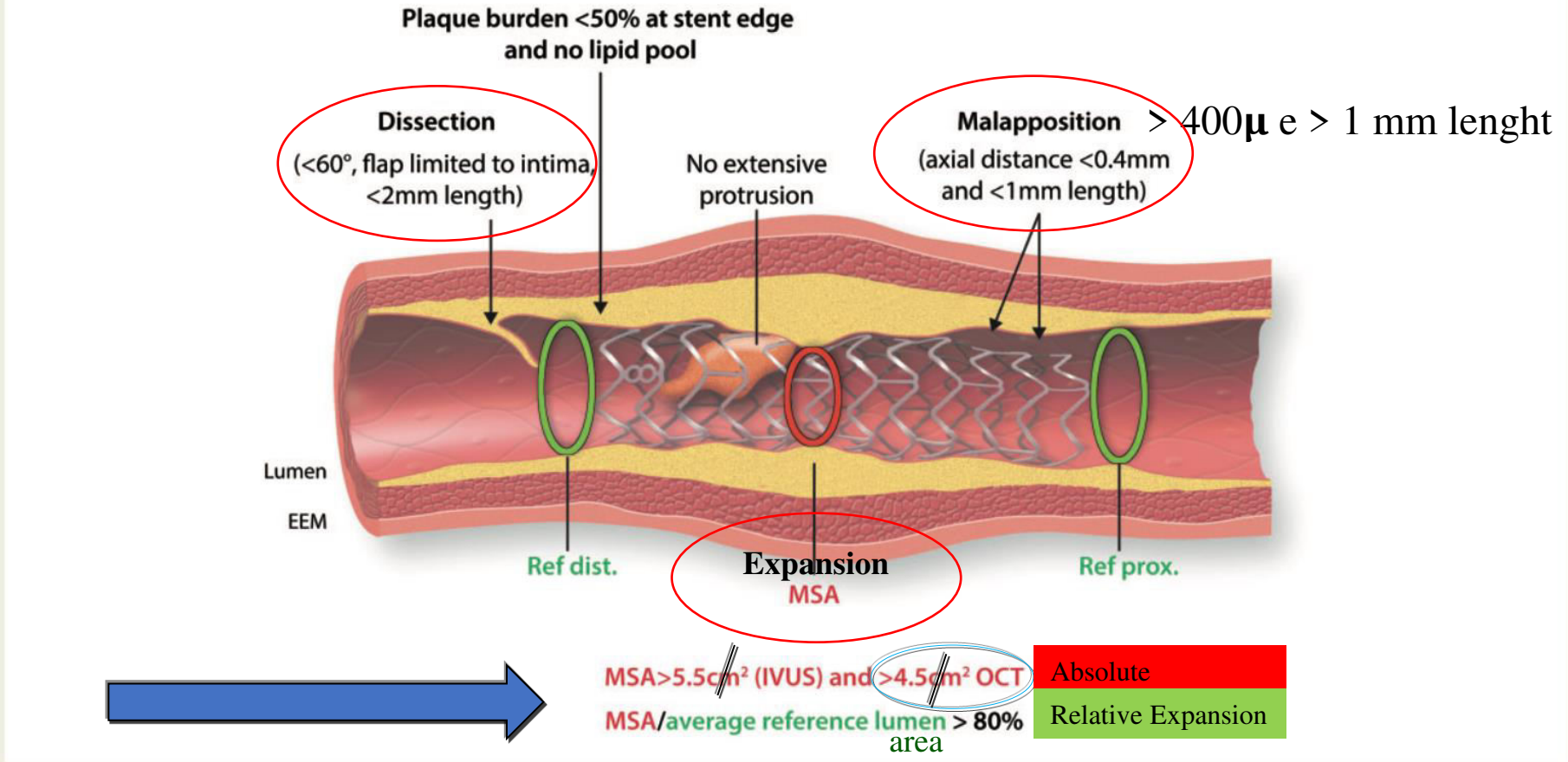
$$\frac{\text{Proximal MSA}}{\text{Proximal Reference Lumen Area}} \times 100 \ (\geq 90\%)$$

And

$$\frac{\text{Distal MSA}}{\text{Distal Reference Lumen Area}} \times 100 \ (\geq 90\%)$$



Post-Procedural Assessment and Complication



> 400µ e > 1 mm lenght

Take home figure Summary of post-percutaneous coronary intervention optimization targets. The most relevant targets to be achieved following stent implantation in non-LM lesions are shown. These include optimal stent expansion (absolute as well as relative to reference lumen diameter); avoidance of landing zone in plaque burden >50% or lipid rich tissue; avoidance of large malapposition regions, irregular tissue protrusion, and dissections. Thresholds provided reflect the consensus of this group. Some are based on consistent and robust prospective data (e.g. stent expansion, landing zone) and others are less established (e.g. malapposition).

Conclusion

- The interventional community is moving towards comprehensive approaches in PCI, integrating anatomical information with imaging and function
- Integration of routine IVI for PCI has the potential to improve procedural safety and clinical outcomes.

No excuse for not using !

Table. OCT Definitions of ACS Culprit Lesions

Lesion type	Description
Plaque erosion	Intact fibrous cap; with or without luminal thrombosis; underlying plaque can be lipid, fibrous, or intimal thickening; calcification rare
Definite OCT-erosion	Luminal thrombus; intact fibrous cap; underlying plaque visible
Probable OCT-erosion	(a) Absence of luminal thrombus; irregular luminal surface (b) Luminal thrombus; attenuation of underlying plaque by thrombus; no superficial lipid or calcification immediately proximal or distal to the site of thrombus
Plaque rupture	Lipid plaque with cap disruption; with or without luminal thrombus; cavity may exist
Calcified nodule	Disrupted fibrous cap; protruding nodular calcification with underlying fibrocalcific plaque; luminal thrombus; superficial calcium; substantive calcium proximal and/or distal to lesion

ACS, acute coronary syndrome; OCT, optical coherence tomography.

- The presence of a large amount of thrombus doesen't allows to detect the underlying structure.Plaque morphology is defined unclassifiable when OCT is unable to visualize clearly the lesion type because of an excess of thrombus obscuring the underlying structure.
- The inability to classify with OCT the culprit plaque has been reported in one quarter of the case,sometimes manual trombectomy before OCT could allows a better visualization
- **In this case we can only speculate the presence of erosion because normal vessel wall architecture was preserved proximal and distal to the lesion**

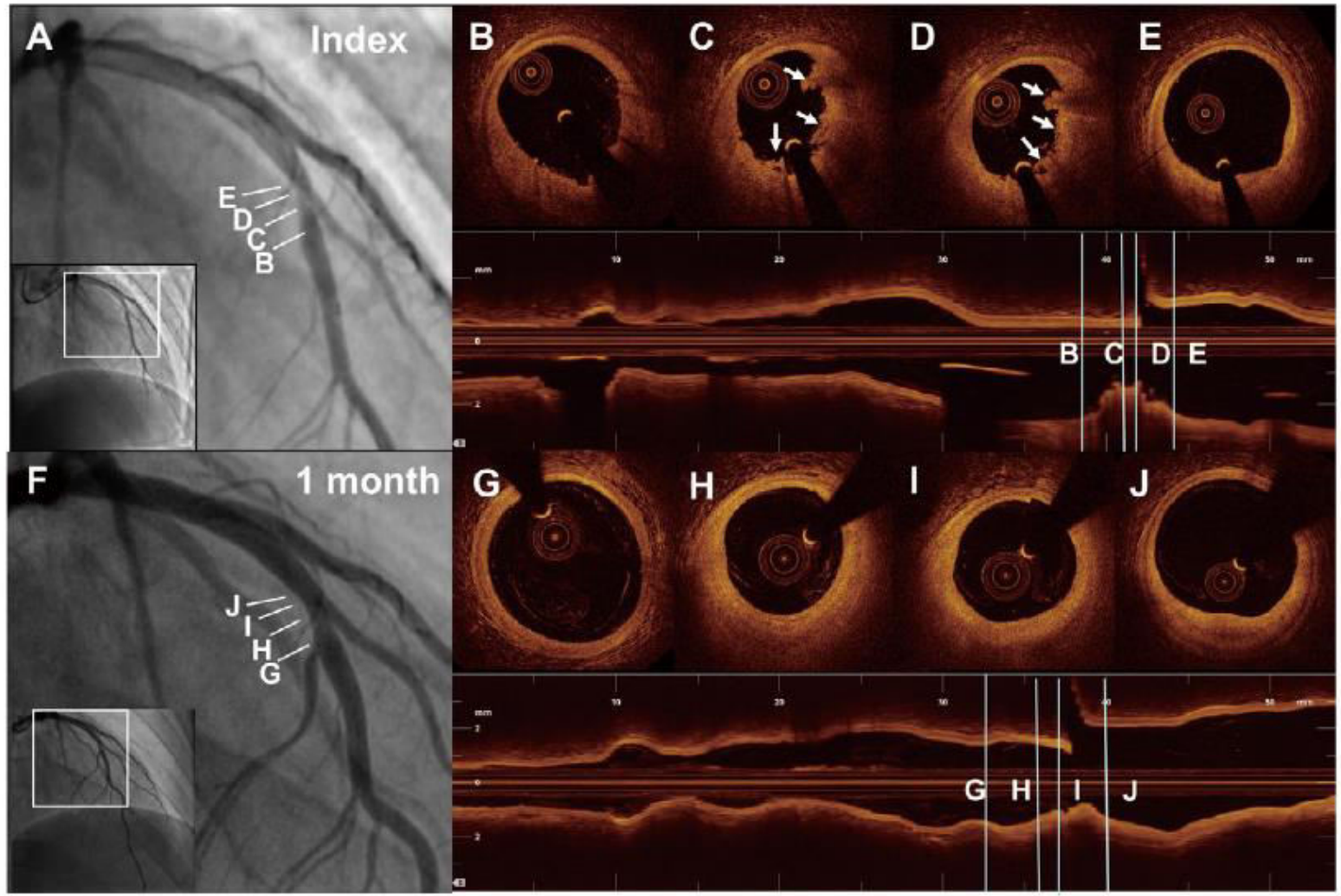


Figure 3. Representative case of ST-segment elevation myocardial infarction (STEMI) caused by plaque erosion in a 27-year-old man. Baseline angiogram (**A**) shows a total occluded lesion in the mid left anterior descending artery (LAD). After thrombus aspiration, residual stenosis on the angiogram (**A**) at the culprit site was mild (40%). Serial optical coherence tomography (OCT) cross-sectional images from distal to proximal (**B**–**E**) of the culprit lesion indicate plaque erosion with white thrombus (arrows). After 1 month of treatment with antithrombotic agents, angiogram (**F**) shows a 30% stenosis, and OCT images (**G**–**J**) show no visible thrombus overlying a fibrous plaque.

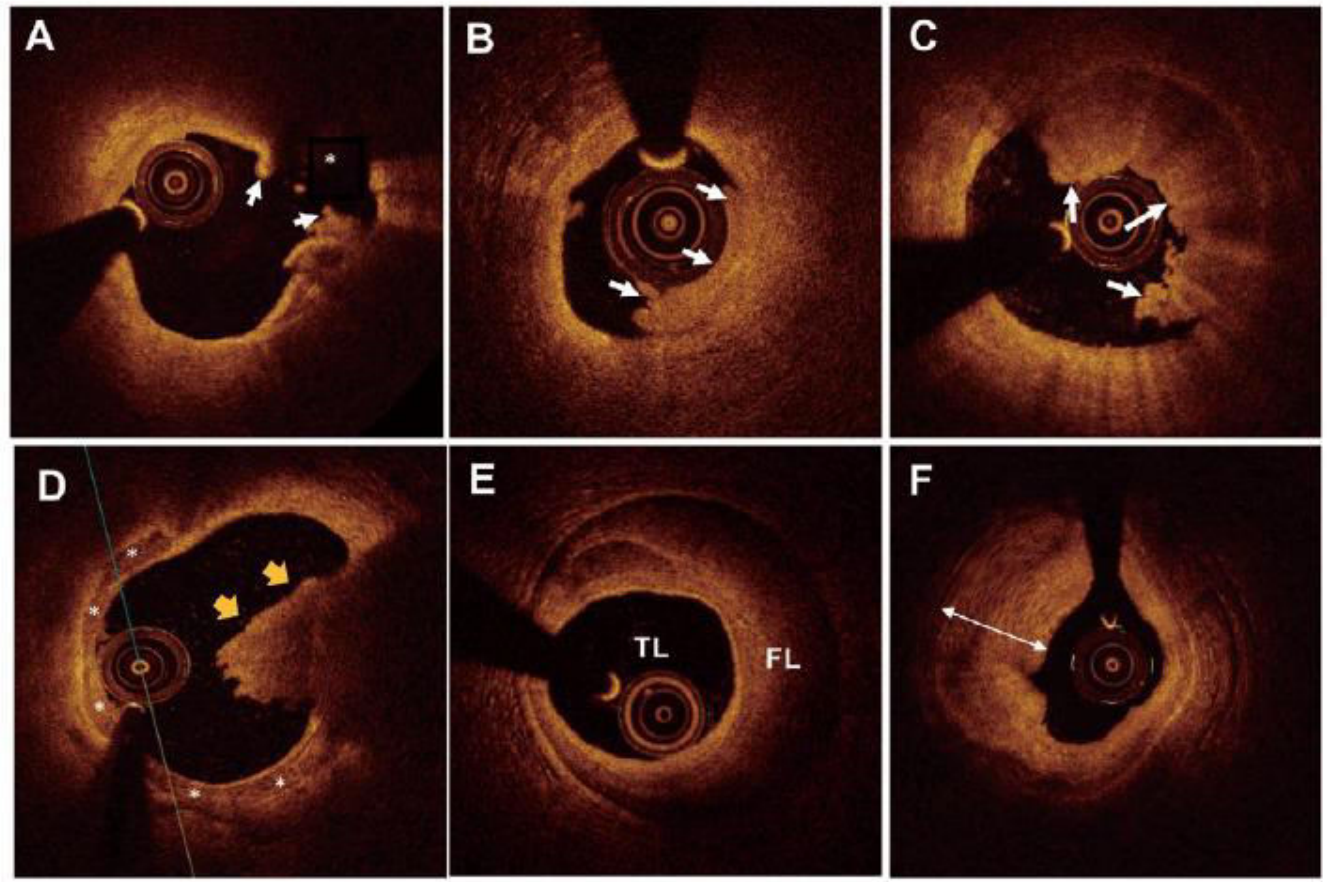


Figure 2. Representative images of culprit lesions by optical coherence tomography (OCT). (**A**) Plaque rupture: disrupted fibrous cap (white arrows) with presence of a cavity (asterisk). (**B**) Definite plaque erosion: mural thrombosis (white arrows) overlying an intact fibrous cap plaque. (**C**) Probable plaque erosion: presence of massive thrombus (white arrows) without superficial lipid pool and calcification immediately proximal or distal to the thrombus. (**D**) Calcified nodule: presence of thrombus (yellow arrows) overlying a superficial and protruding calcification (asterisk). (**E**) Spontaneous coronary artery dissection with hematoma (TL, true lumen; FL, false lumen). (**F**) Coronary spasm characterized by intimal/medial thickening (double arrow).

ILUMIEN IV

ILUMIEN IV (OCT) criteria
Choice of stent size based on external elastic lamina diameter or (if EEL not visible) the mean lumen diameter
Minimum stent area >90% reference lumen area
Minimum lumen area at stent edges >4.5mm^2

BAC