Utilizing Imaging in Your Cath Lab.
Imaging-Based Treatment of Calcified Coronary Artery

Takashi Akasaka, MD, PhD, FAPSC, FESC, FJCS
Department of Cardiovascular Medicine
Wakayama Medical University, Japan

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Wakayama Medical University

Declaration for Conflicts of Interest

Takashi Akasaka, MD, PhD, FAPSC, FESC FJCS

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

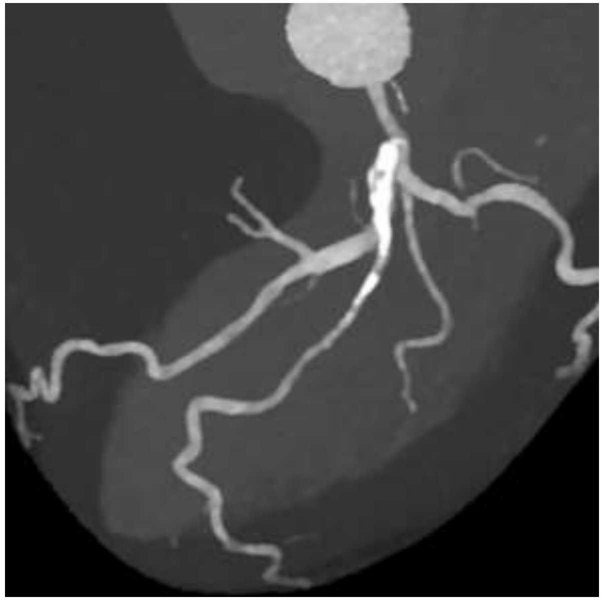
Affiliation/Financial Relationship

- Grant/Research Support : Abbott Vascular Japan
  Nipro Inc.
  St. Jude Medical Japan
  Terumo Inc.

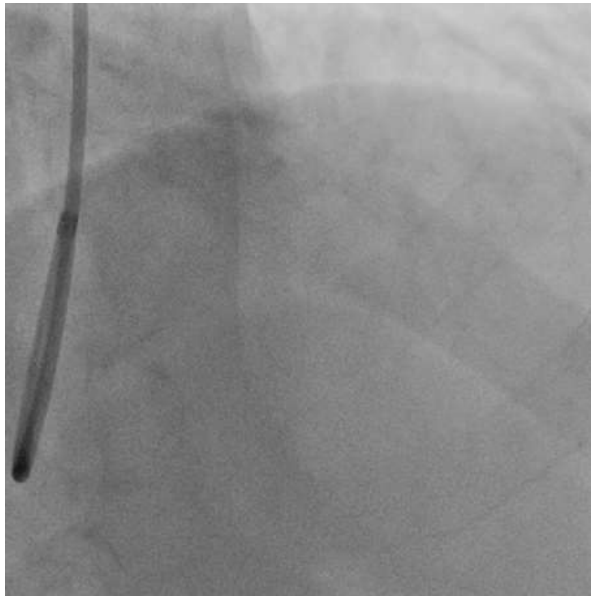
- Consulting Fees/Honoraria : Daiichi-Sankyo Pharmaceutical Inc.
  Nipro Inc.
  St. Jude Medical Japan
  Terumo Inc.

Detection of calcified lesion

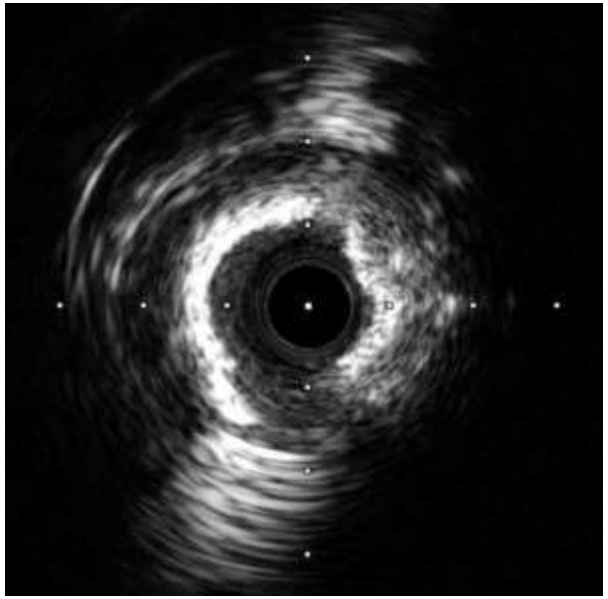
Coronary CTA



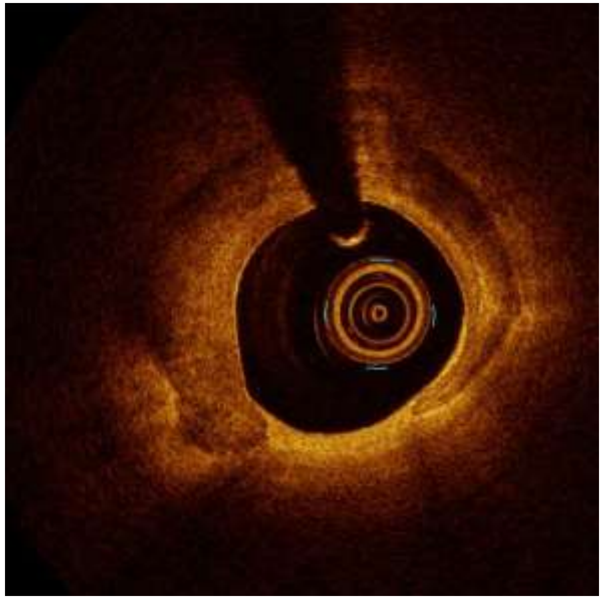
Angiography



IVUS



OCT



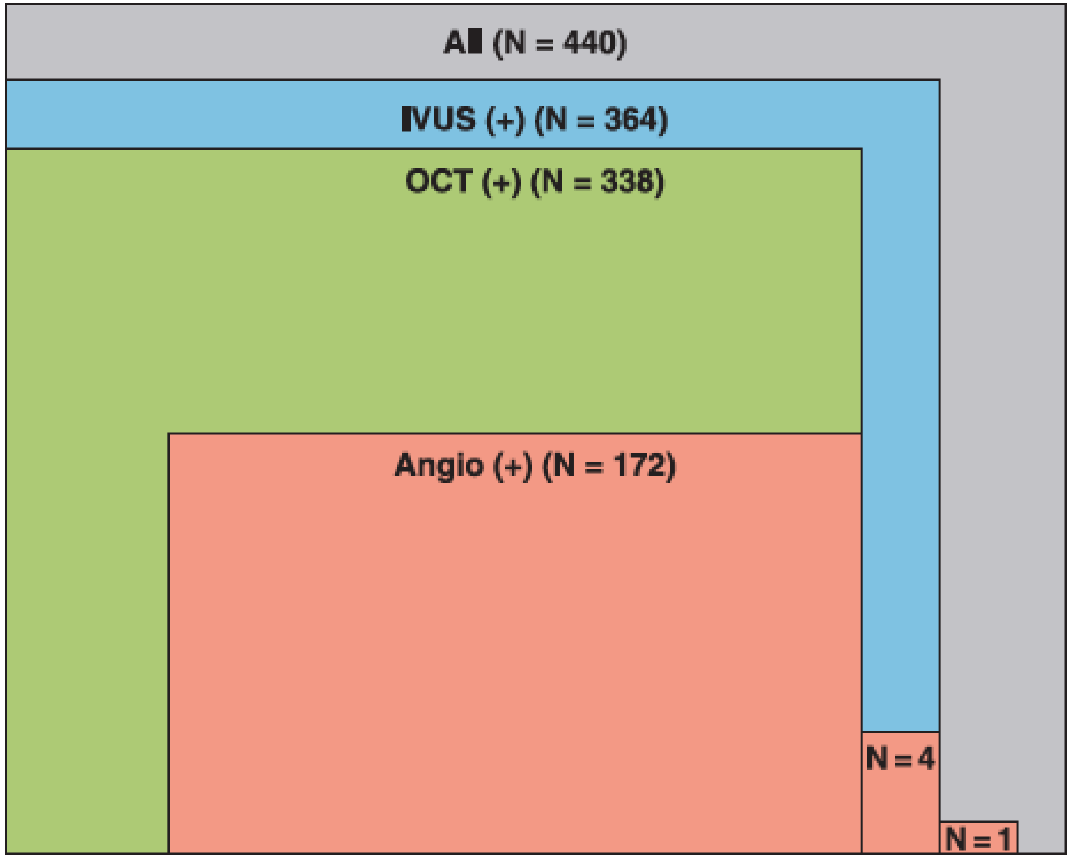
Compared with IVUS, OCT can evaluate the thickness of calcium.

Similarities & differences between OCT & IVUS

Maehara A, et al. J Am Coll Cardiol Img 2017;10:1487-1503

OCT: Very good	OCT: Good	OCT: Feasible		IVUS: Feasible	IVUS: Good	IVUS: Very good
			Pre-PCI			
●	●	●	Severity of calcium	●	●	
		●	Prediction of slow flow	●		
	●	●	Stent sizing by vessel wall	●	●	●
●	●	●	Stent length to cover normal to normal	●	●	●
			Post-PCI			
●	●	●	Stent expansion	●	●	●
●	●	●	Tissue protrusion through strut	●	●	
●	●	●	Stent malapposition	●	●	
	●	●	Stent deformation (frequently at aorto-ostium)	●	●	
●	●	●	Stent edge dissection	●	●	
●	●	●	Residual disease at stent edge	●	●	●
			Follow-up			
●	●	●	Old stent expansion	●	●	●
	●	●	Tissue coverage	●		
●	●	●	Neointimal hyperplasia	●	●	●
	●	●	Stent fracture	●	●	
●	●	●	Stent malapposition	●	●	
		●	Positive remodeling of vessel wall	●	●	●
●	●	●	Neoatherosclerosis	●	●	

Assessment of angiographically visible calcium

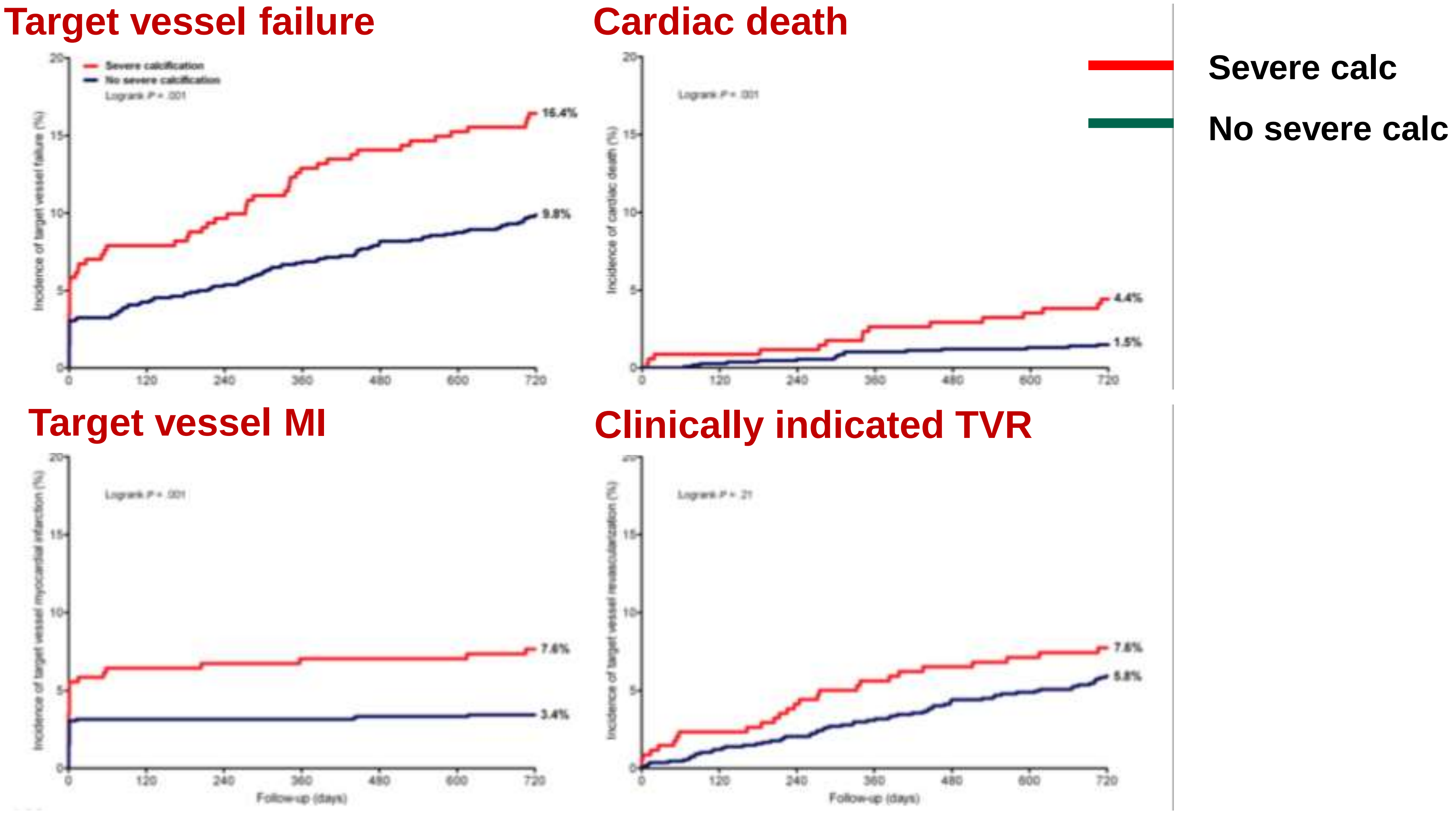


	Angiographically Visible Calcium		
	No (n = 16)	Yes (n = 58)	p Value
Pre-PCI intravascular ultrasound findings			
Maximum calcium angle,°	228 (190,286)	259 (230,322)	0.03
Pre-PCI optical coherence tomography findings			
Presence of any calcium	100 (16)	98.3 (57)	0.99
Maximum calcium angle,°	190 (146,300)	250 (174,320)	0.15
Angle of calcium <0.5 mm thickness,°	160 (69,249)	56 (0,131)	0.002
Angle of calcium ≥0.5 mm thickness,°	61 (10,92)	171 (98,242)	<0.001
Mean calcium angle*,°	44 (33,90)	68 (43,105)	0.047
Maximum calcium thickness, mm	0.71 (0.52,0.89)	0.95 (0.75,1.15)	0.004
Calcium length, mm	11.0 (6.0,18.0)	16.0 (11.0,23.0)	0.01
Post-PCI optical coherence tomography findings			
Minimum stent area, mm^2	8.1 (6.6,9.3)	5.9 (4.6,7.3)	0.001
Reference lumen area†, mm^2	9.4 (7.6,11.4)	6.6 (5.4,8.2)	0.001
Stent expansion, %	80.8 (74.5,107.0)	91.7 (77.6,101.1)	0.88

- **Angiographically visible calcium (thick calcium) seemed to be a marker to predict stent underexpansion.**
- **In 13.2% of IVUS-detected calcium, calcium was either not visible (n=26) or underestimated (>90 smaller) (n=22) by OCT mostly due to superficial OCT plaque attenuation and penetration depth of images.**

JACC Cardiovasc Imaging . 2017;10(8):869-879

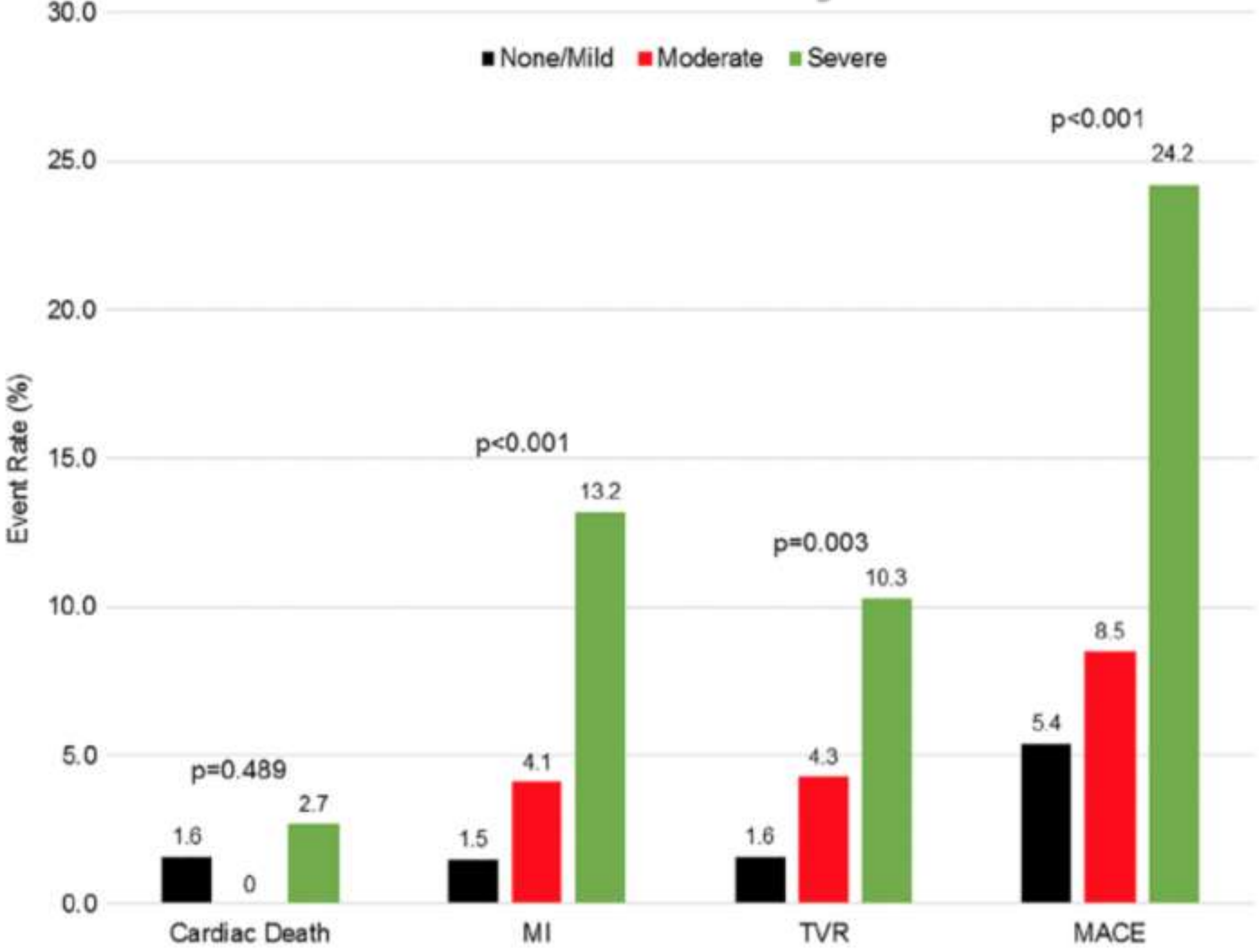
TWENTE and DUTCH PEERS trials



- In patients with stable angina, severe target lesion calcification is associated with an increased risk of adverse cardiovascular events following treatment with 2nd DES.

Am Heart J. 2016;175:121-129

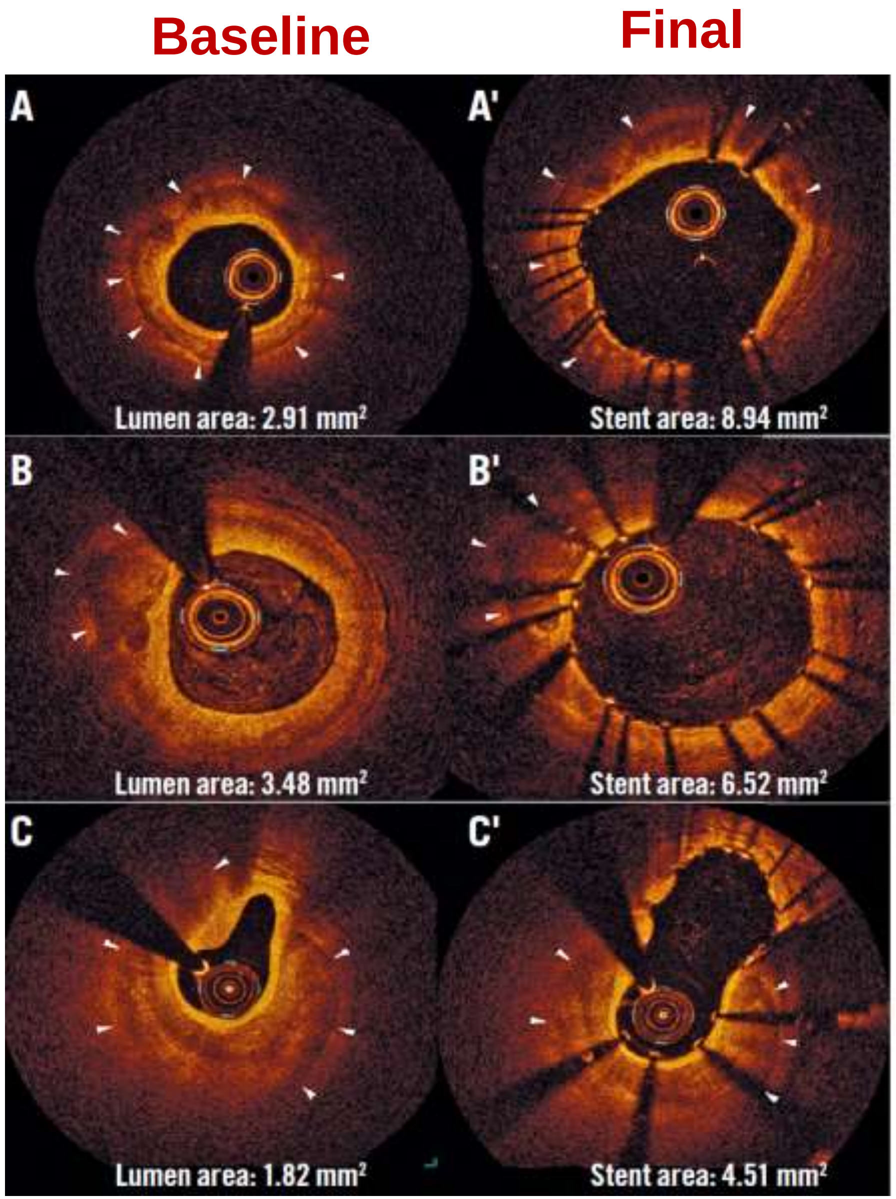
MACE-Trial 1-year results



- **Patients with severe calcification had significantly worse outcomes compared to those without.**

Catheter Cardiovasc Interv. 2019;94(2):187-194

Calcium eccentricity, thickness & length and stent expansion



Angle: 360°
Thickness: 0.48 mm
Length: 3.8 mm
Calcium score: 2 points

Expansion: 99%

Angle: 75°
Thickness: 1.1 mm
Length: 4.3 mm
Calcium score: 1 point

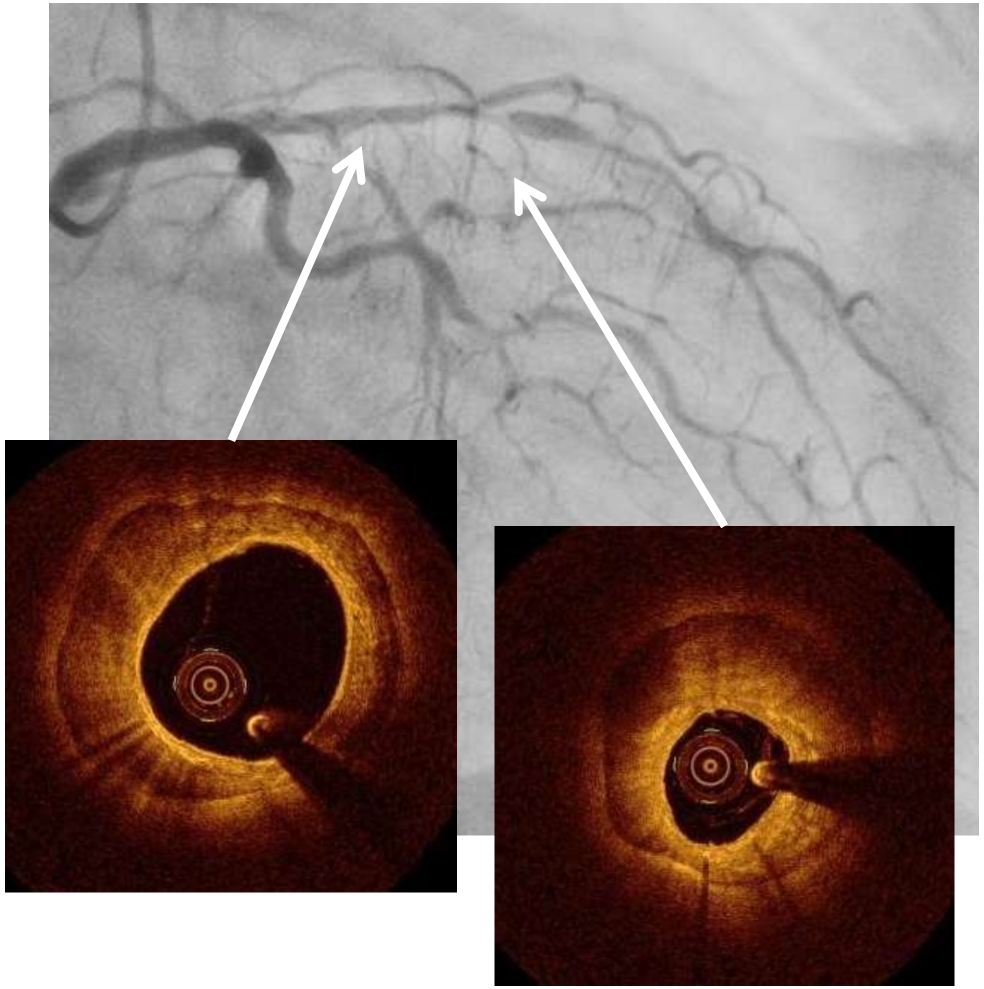
Expansion: 97%

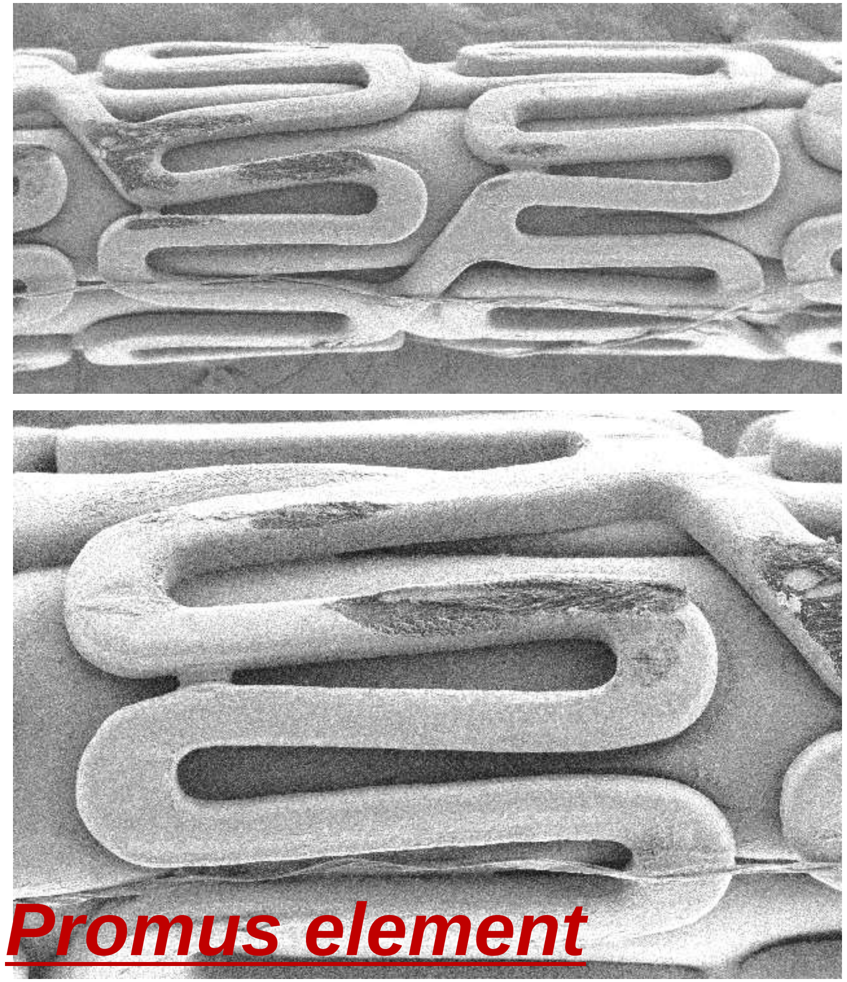
Angle: 312°
Thickness: 1.4 mm
Length: 11.0 mm
Calcium score: 4 points

Expansion: 68%

Fusiono A, et al. EuroInterv 2018;13:e2182-e2189

Polymer damage of DES during PCI in OCT-derived severe calcified lesion without lesion modification





Shimokado, Kubo, Akasaka et al. Int J Cardiov Imag. 2013;29:1909-1913

Case 60's y.o. Female

Clinical Diagnosis: Effort AP

Colon cancer (before operation)

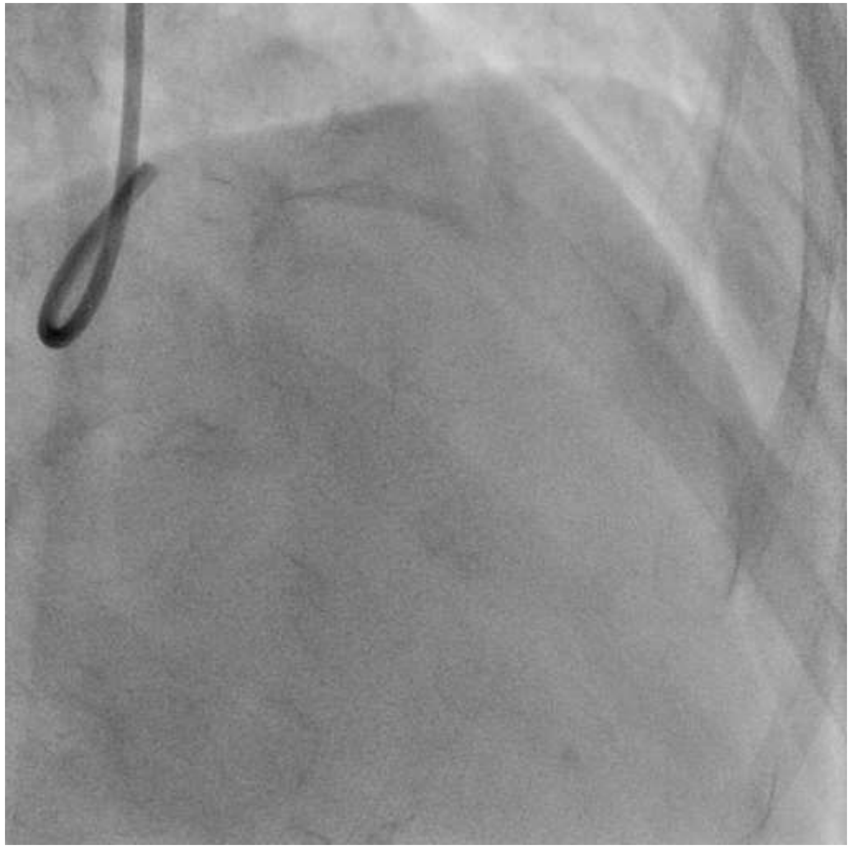
Coronary risk factor: HT, DM

Renal Function: Cr 0.88mg/dl, eGFR 56.3ml/min/1.73m^2

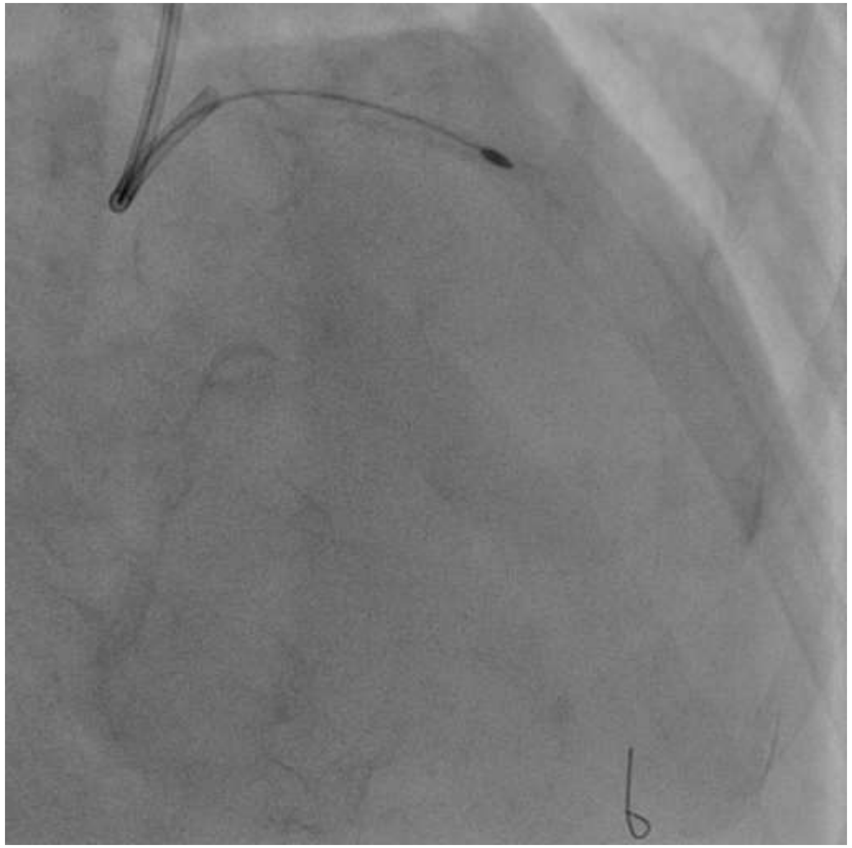
Cardiac Function: EF 63%, asynergy(-)

Coronary angiography & rotational atherectomy

Pre PCI

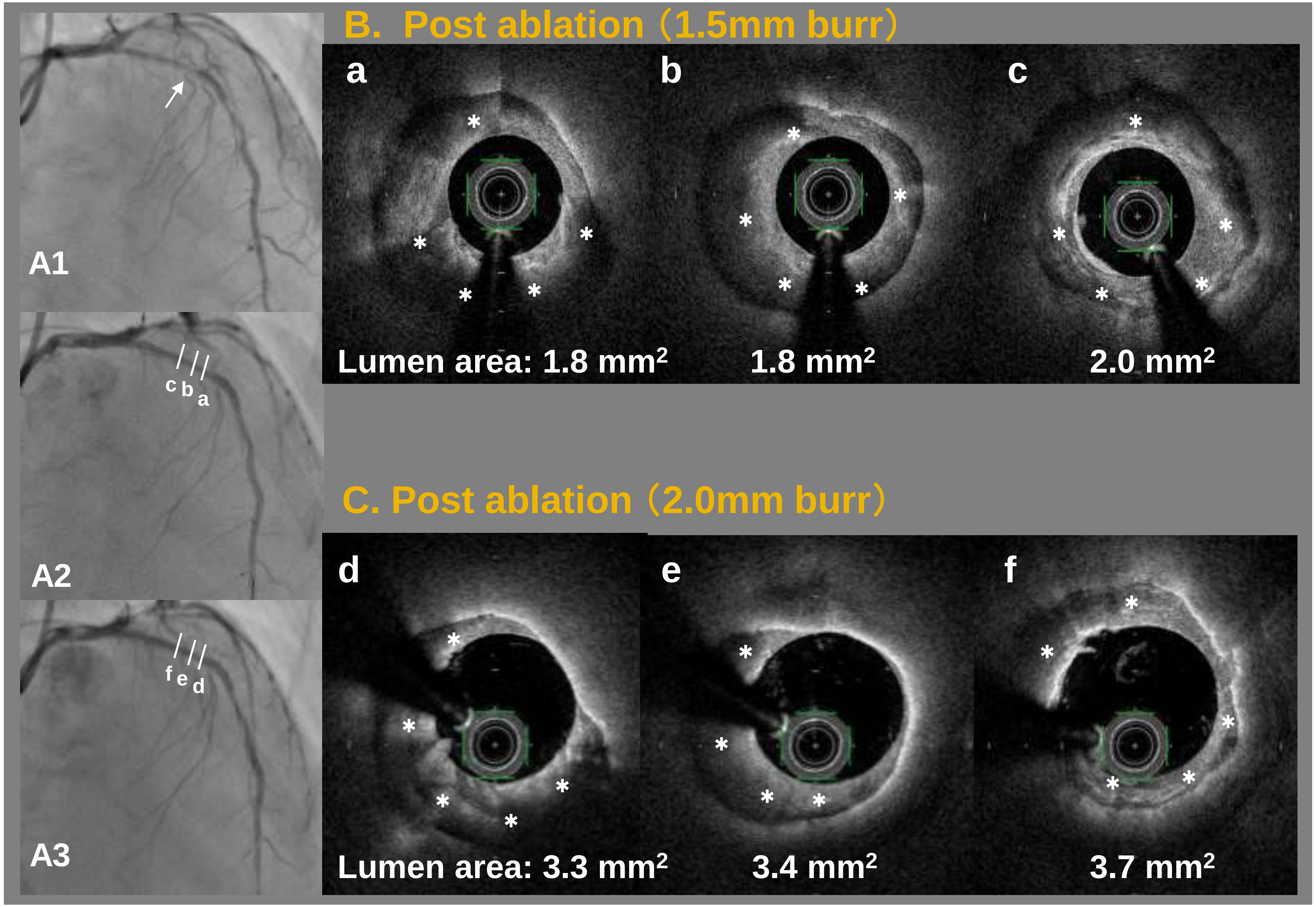


Rota 1.5 mm



Because of heavy calcification, it was difficult to pass any PCI devices & imaging modalities through the MLA site, and rotational atherectomy with 1.5mm burr was selected for lesion modification.

Comparison of OCT findings after rotational atherectomy



Non-stent strategy was selected because of colon cancer operation.

Case: 70’s y.o., Male

Clinical diagnosis

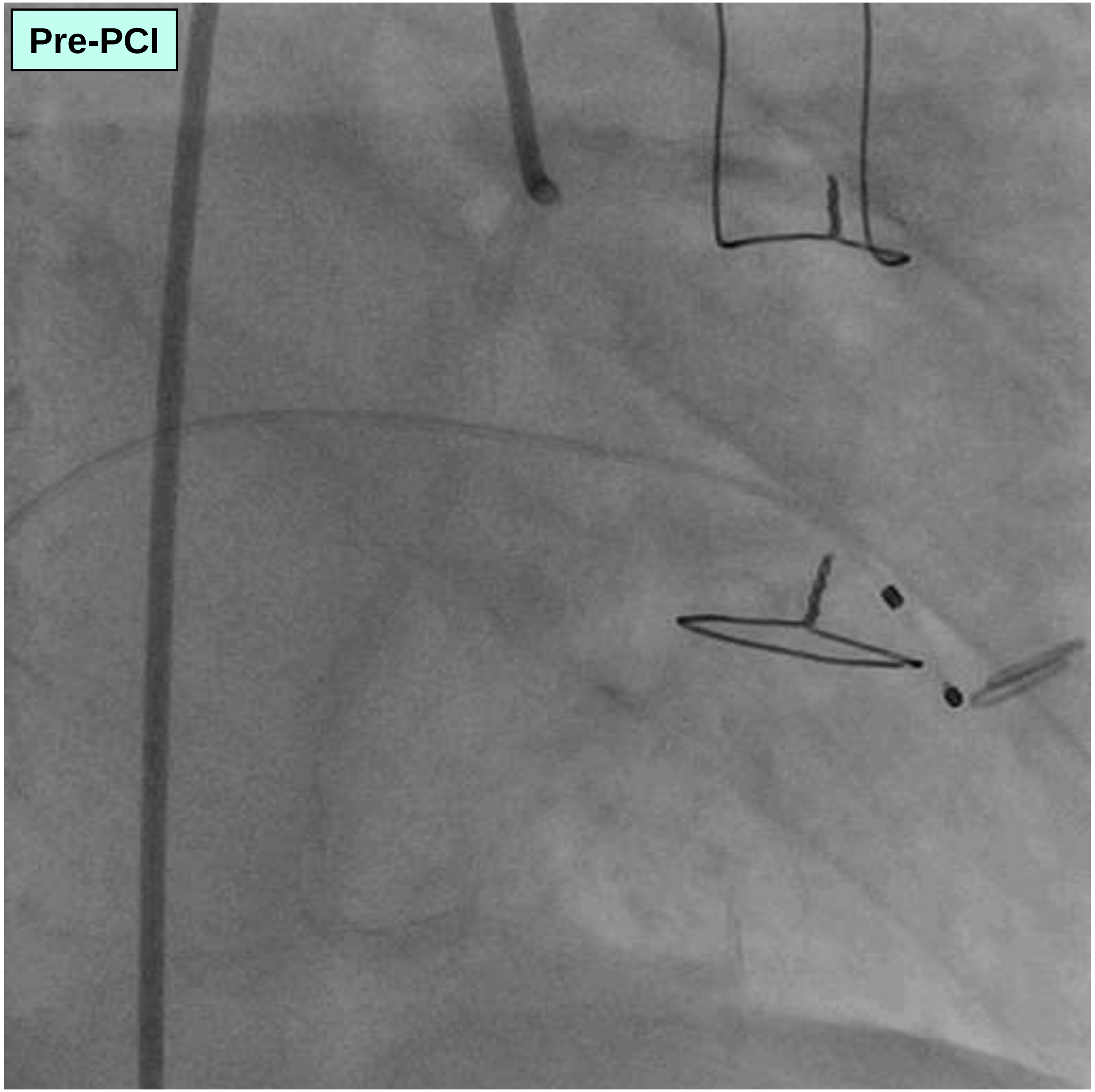
Stable AP, AF

Clinical history

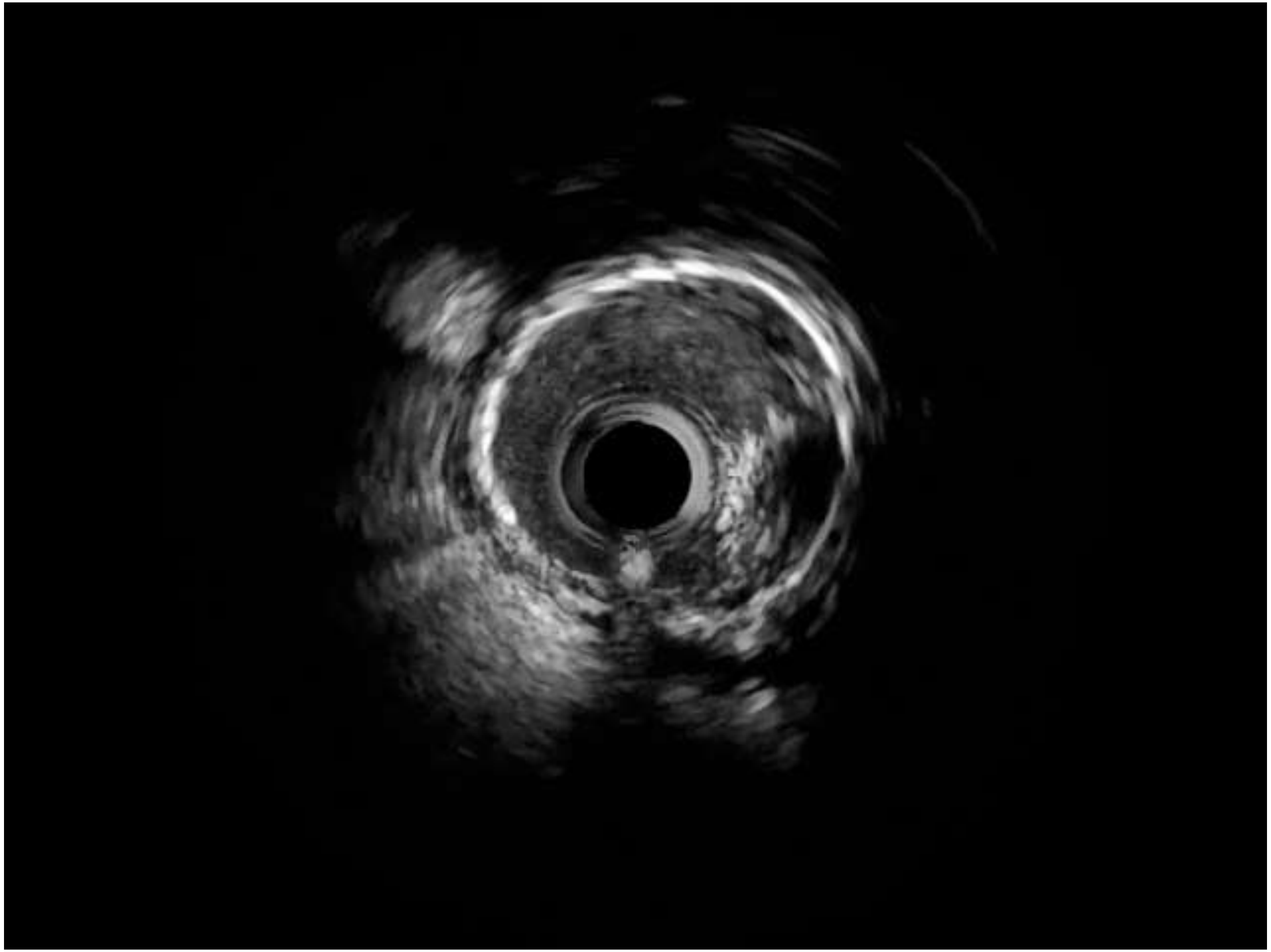
1978. CKD (Glomerular nephritis) ⇒ Hemodialysis
2003. Effort AP, LAD prox. lesion, CABG (LITA to LAD)
2013. Tl Scintigraphy: LV inferior ischemia

Coronary risk factors

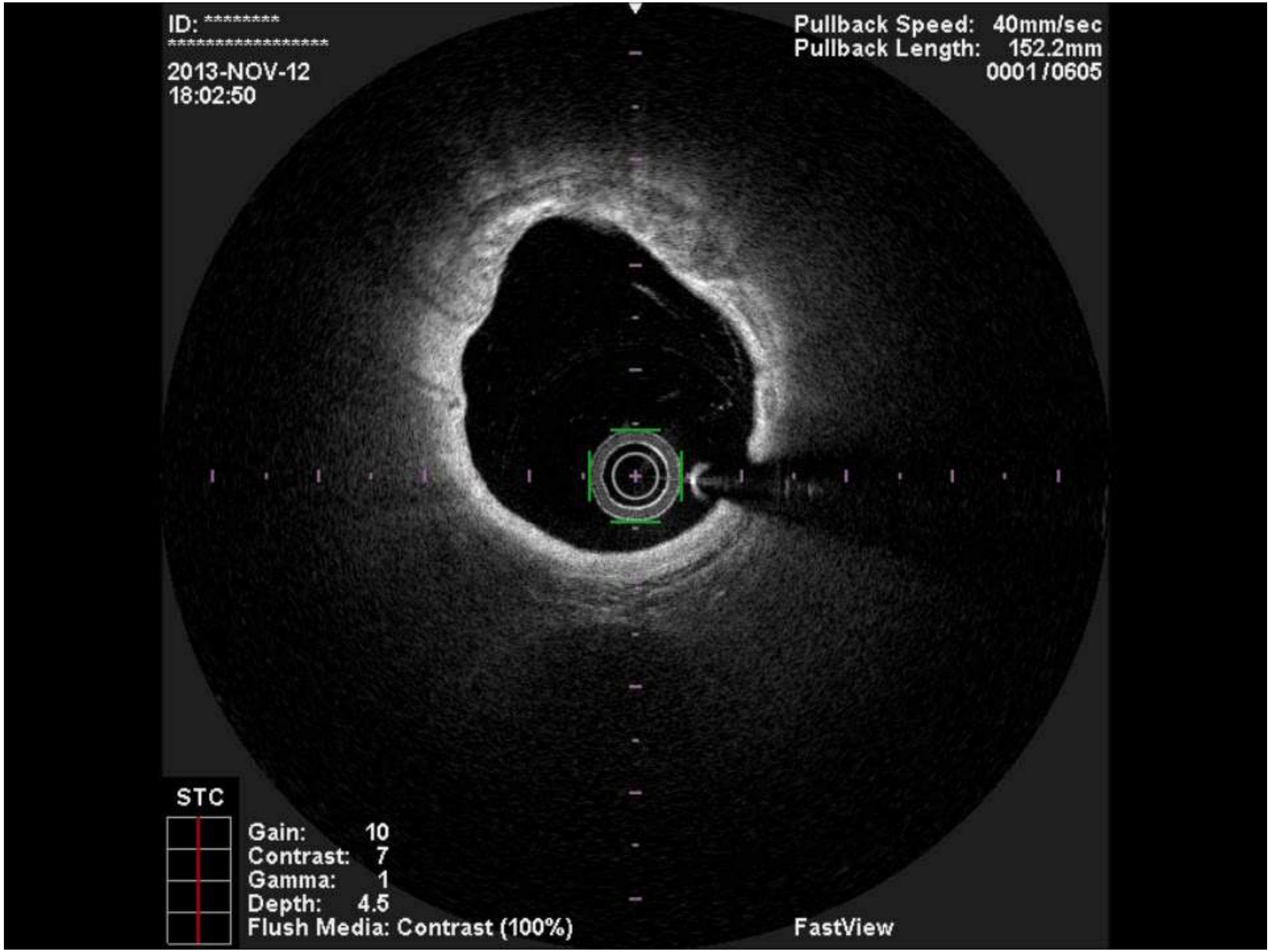
HT (-), DLP (-), DM (-), Obesity (-), Smoker (+)


Pre-PCI

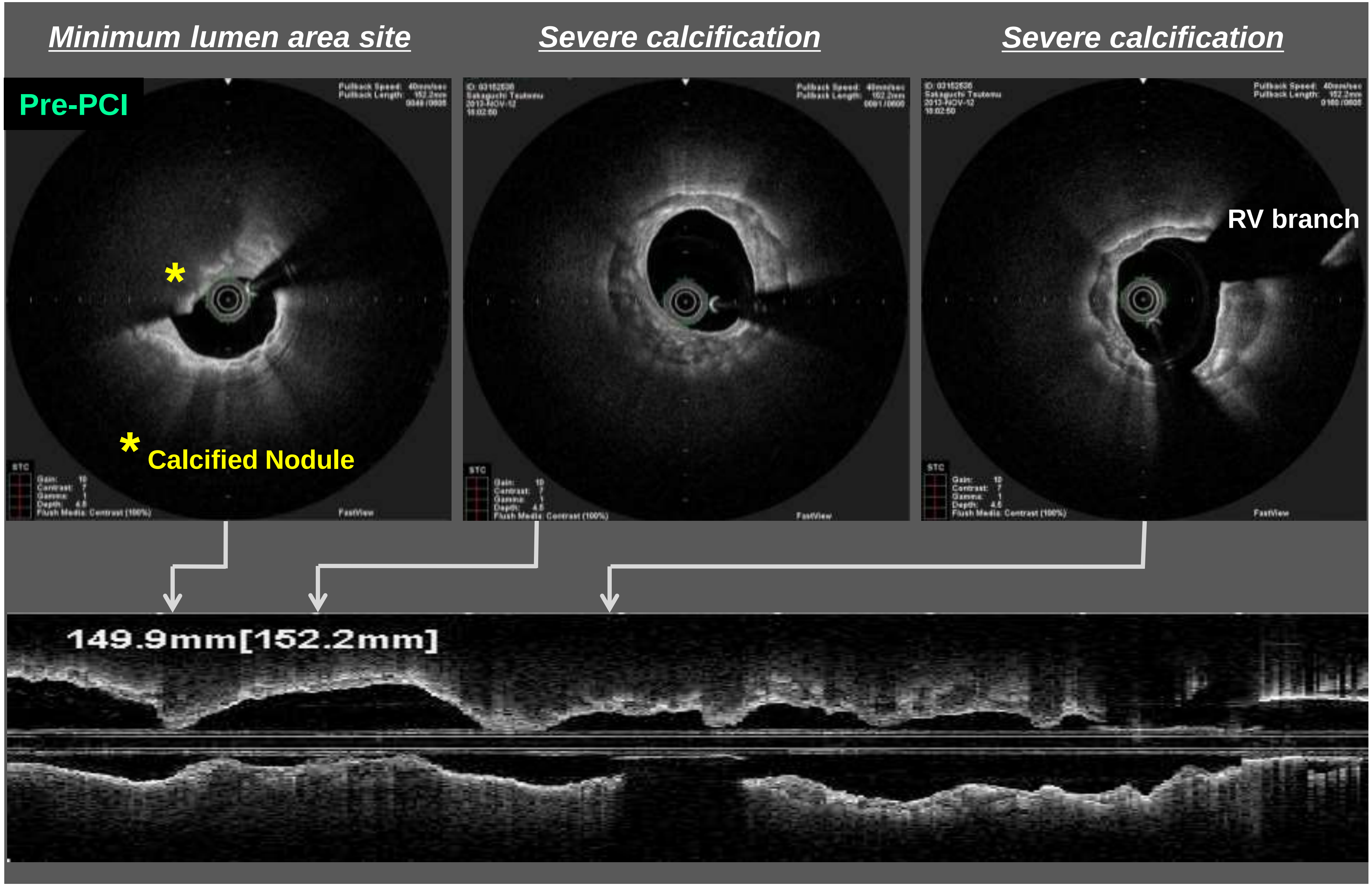
Pre-PCI IVUS



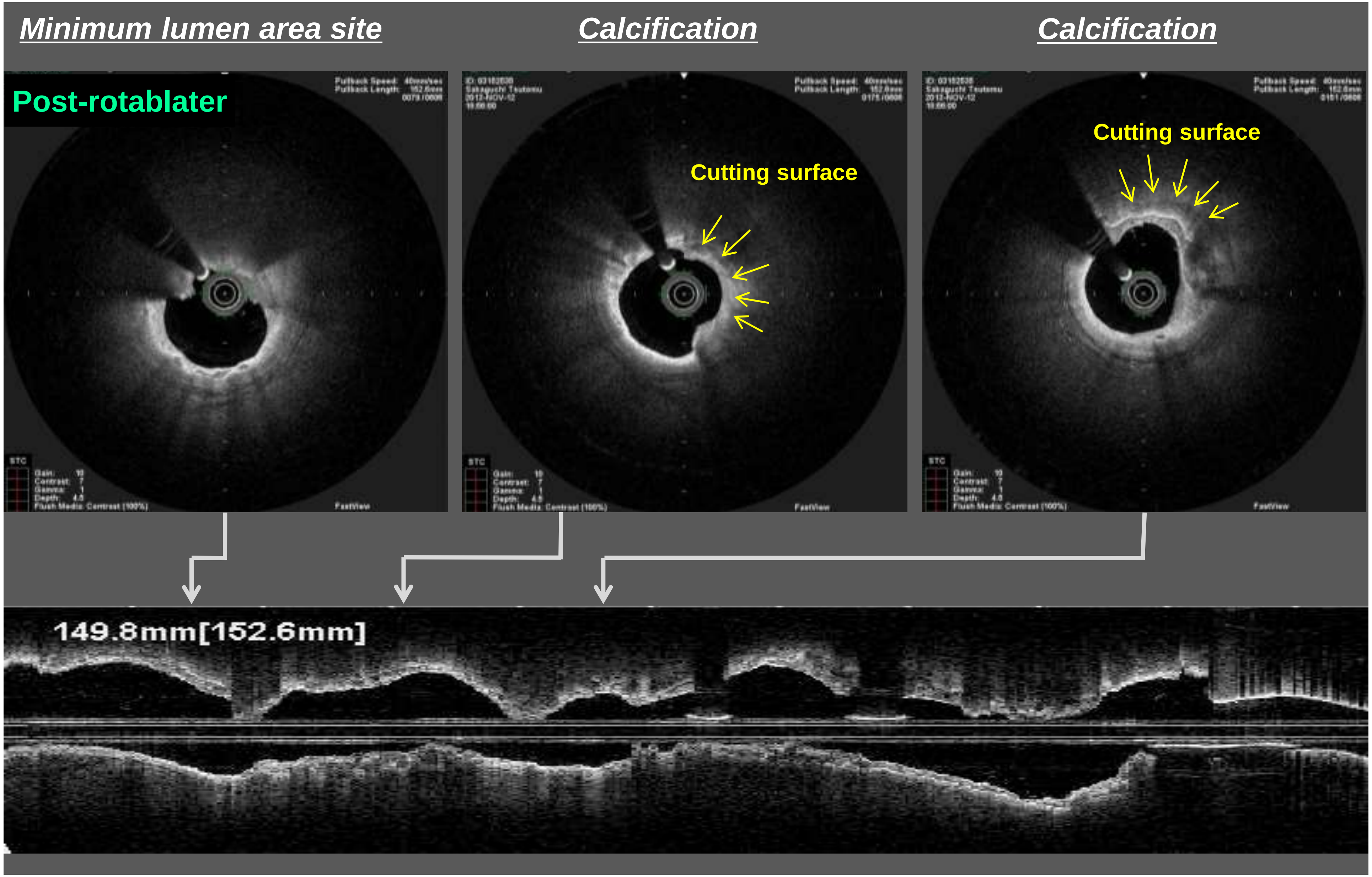
Pre-PCI FD-OCT



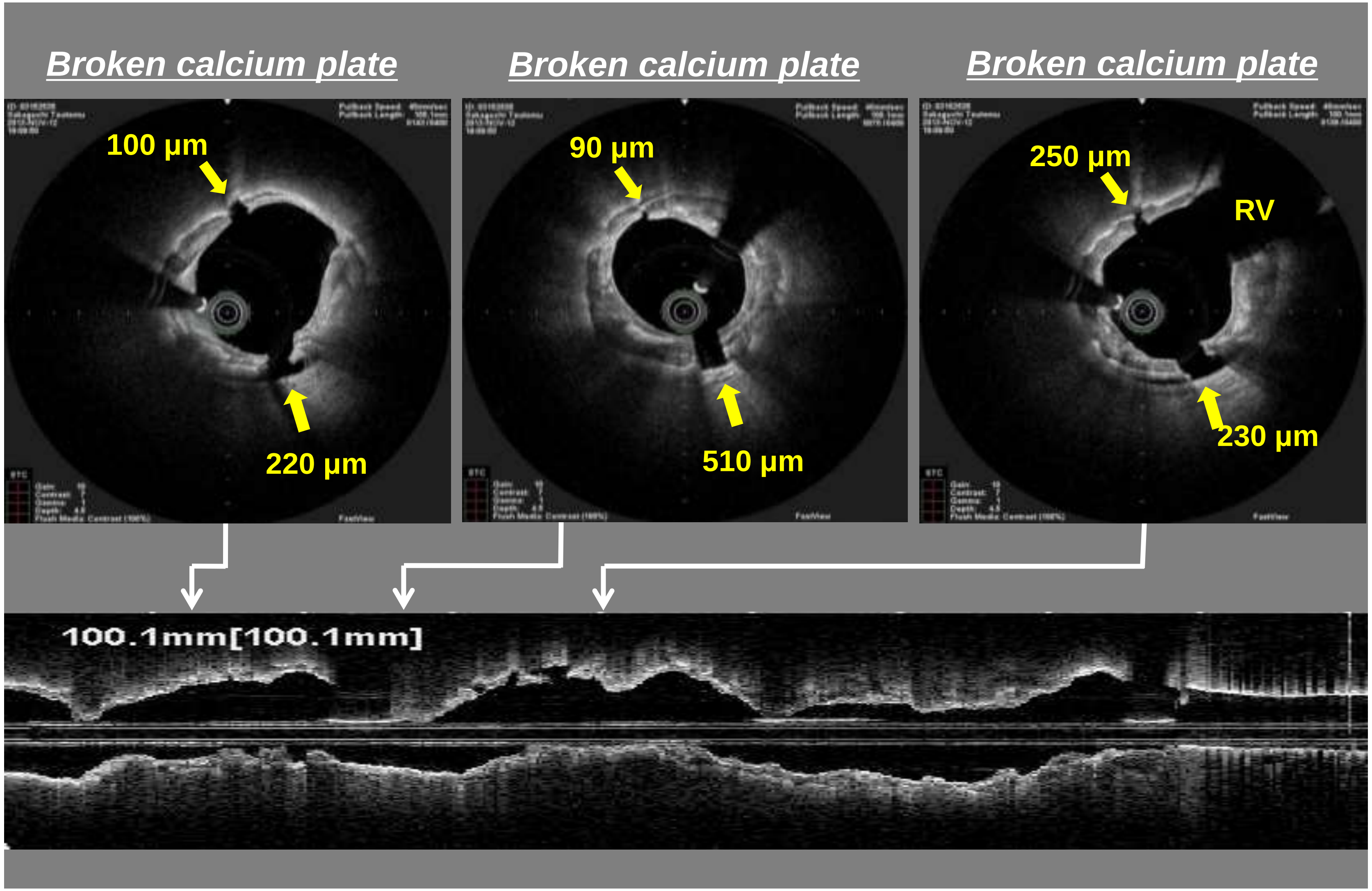
Pre-PCI FD-OCT



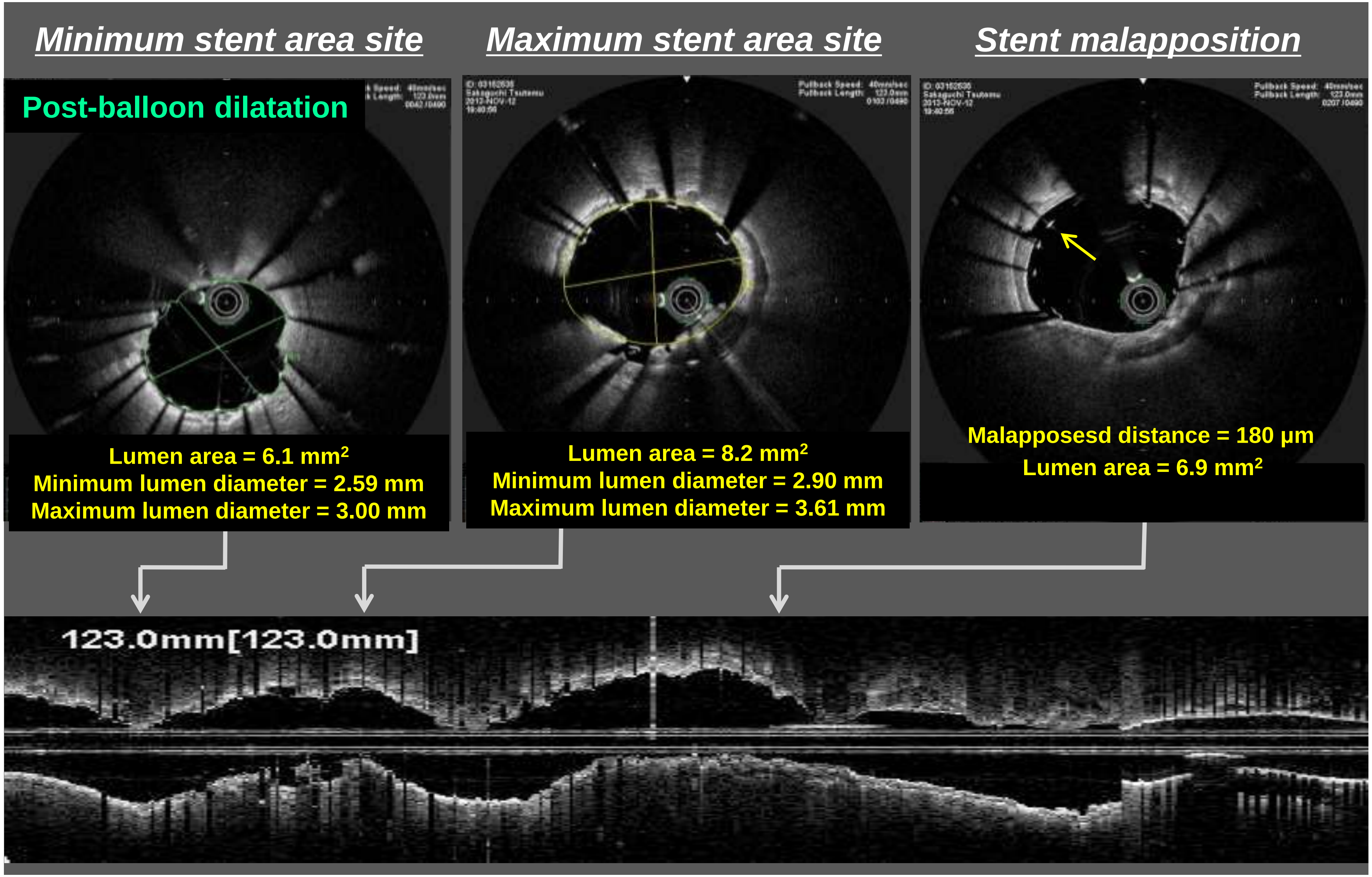
Post-Rotablator FD-OCT



Post-high pressure ballooning



Post-high pressure ballooning after stenting



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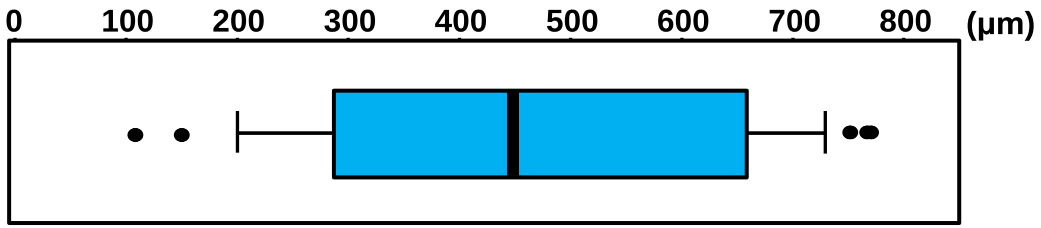
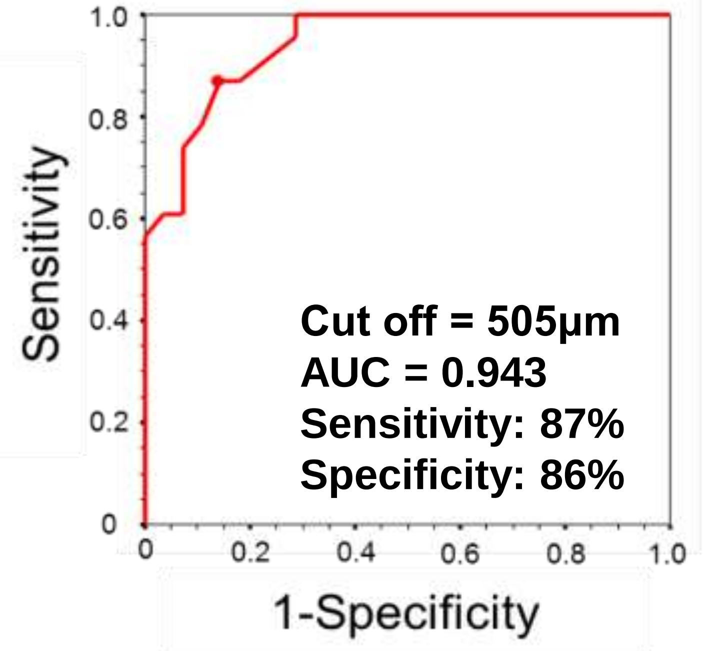
Prediction of calcium plate fracture by ballooning

FD-OCT was performed to assess vascular response immediately after high pressure ballooning in 61 patients with severe calcified coronary lesion.

Thickness distribution of calcium fracture



Median = 450µm; Lower quartile = 300µm; Upper quartile = 660µm; Minimum = 110µm; and Maximum = 770µm.



Conclusion: A calcium plate thickness < 505 µm was the corresponding cut-off value for predicting calcium plate fracture by high pressure ballooning.

Kubo, Akasaka et al. JACC Imag 2015;8:1228-9

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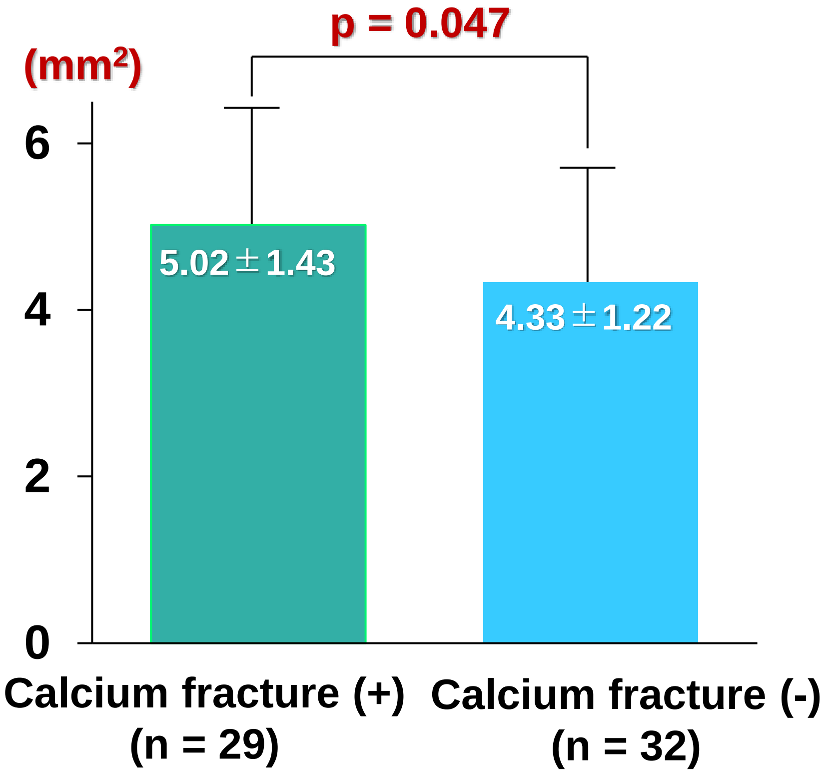
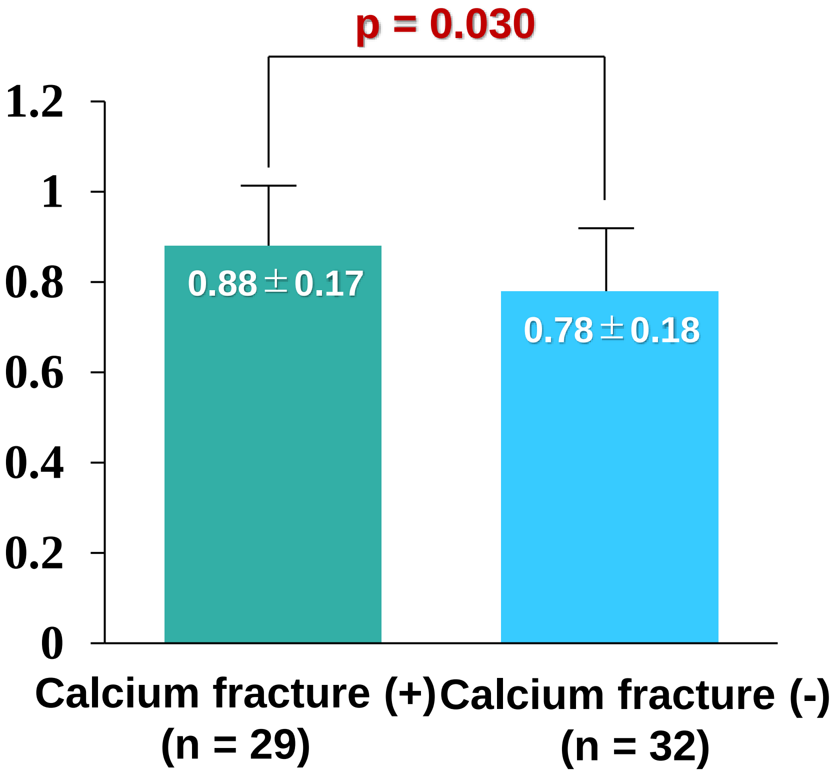
Stent expansion at post-PCI

Minimum stent area



Stent expansion index

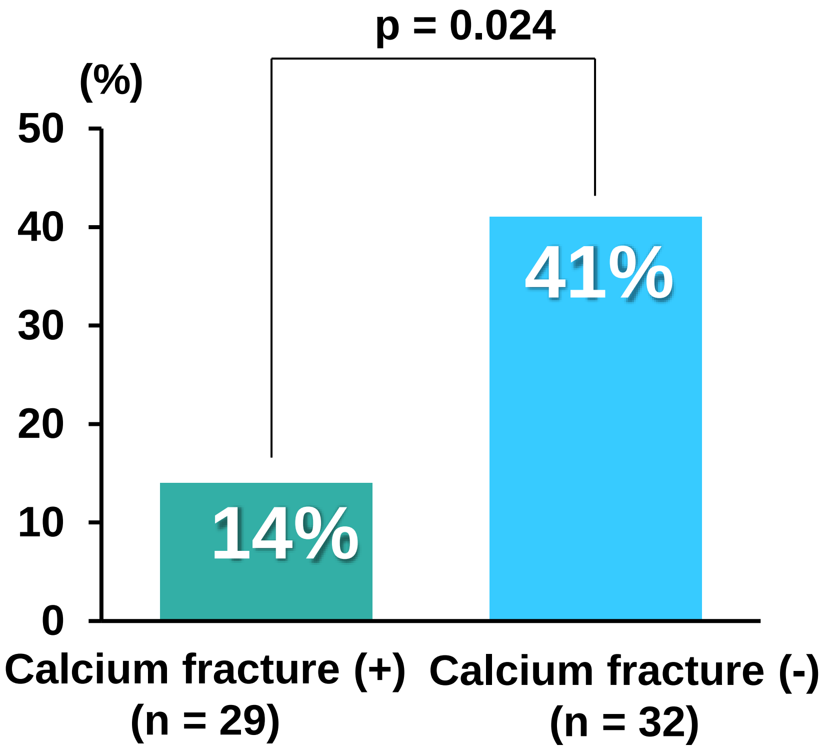


Minimum stent area and stent expansion index were significantly greater in the group with calcium fracture compared with the group without calcium fracture.

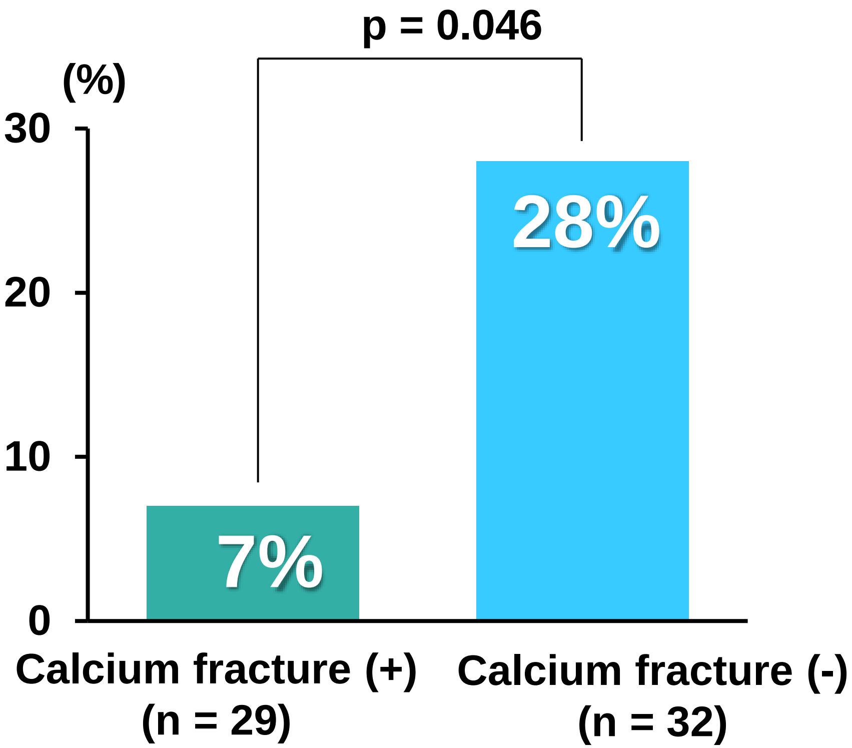
Kubo T, Akasaka T, et al. JACC Imag 2015;8:1228-9

Restenosis and TLR at 10 months follow-up

Binary restenosis



Target lesion revascularization



The frequency of binary restenosis and target lesion revascularization was significantly lower in the group with calcium fracture compared with the group without calcium fracture.

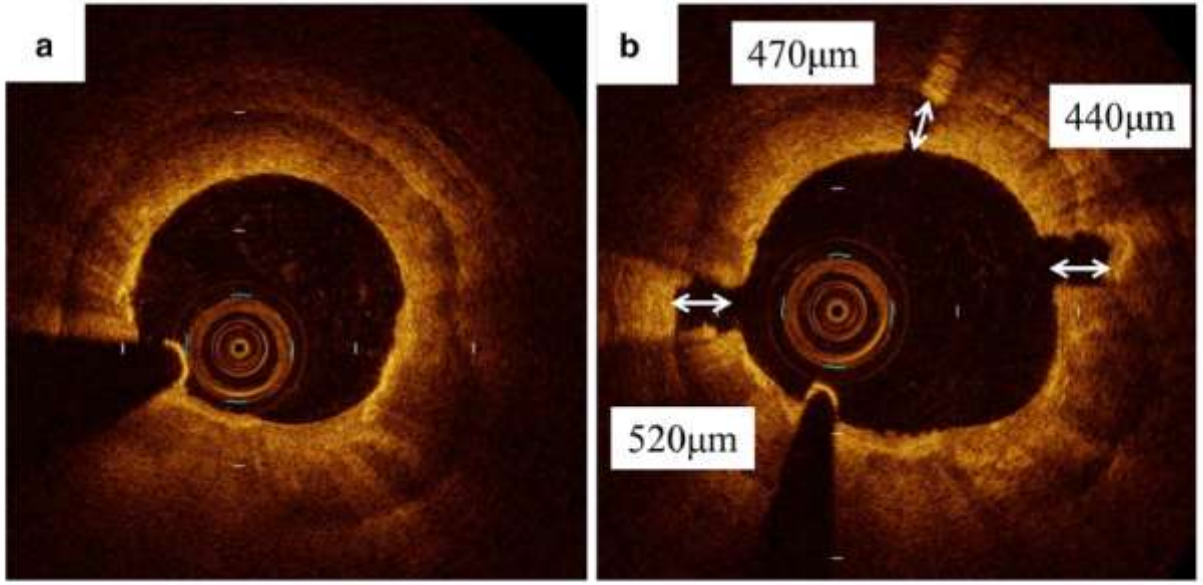
Kubo T, Akasaka T, et al. JACC Imag 2015;8:1228-9

Cardiovascular Intervention and Therapeutics (2019) 34:242–248
https://doi.org/10.1007/s12928-018-0553-6

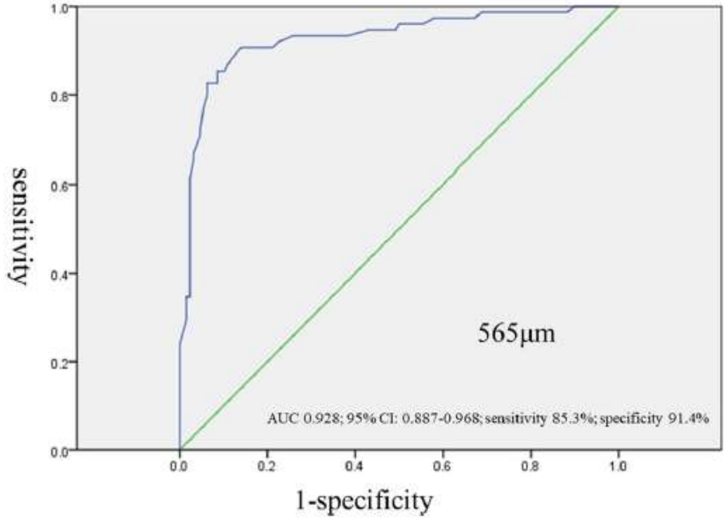
ORIGINAL ARTICLE

Plaque modification of severely calcified coronary lesions by scoring balloon angioplasty using Lacrosse non-slip element: insights from an optical coherence tomography evaluation

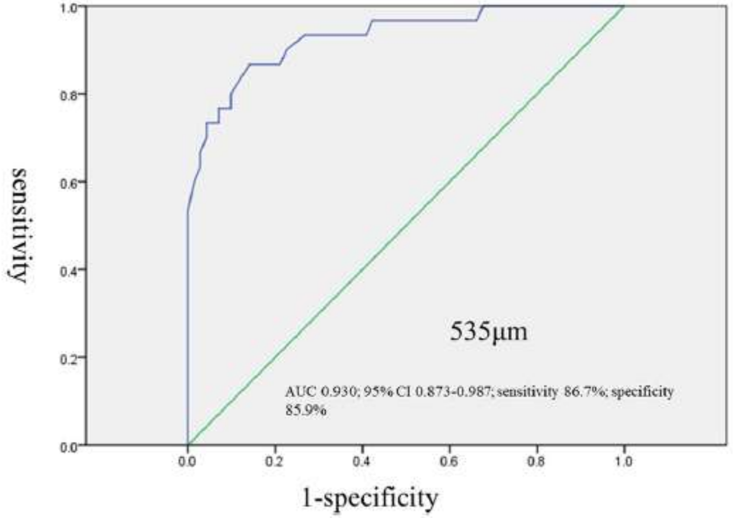
Yu Sugawara[1] · Tomoya Ueda[1] · Tsunenari Soeda[1] · Makoto Watanabe[1] · Hiroyuki Okura[1] · Yoshihiko Saito[1]



All cross sectional OCT images

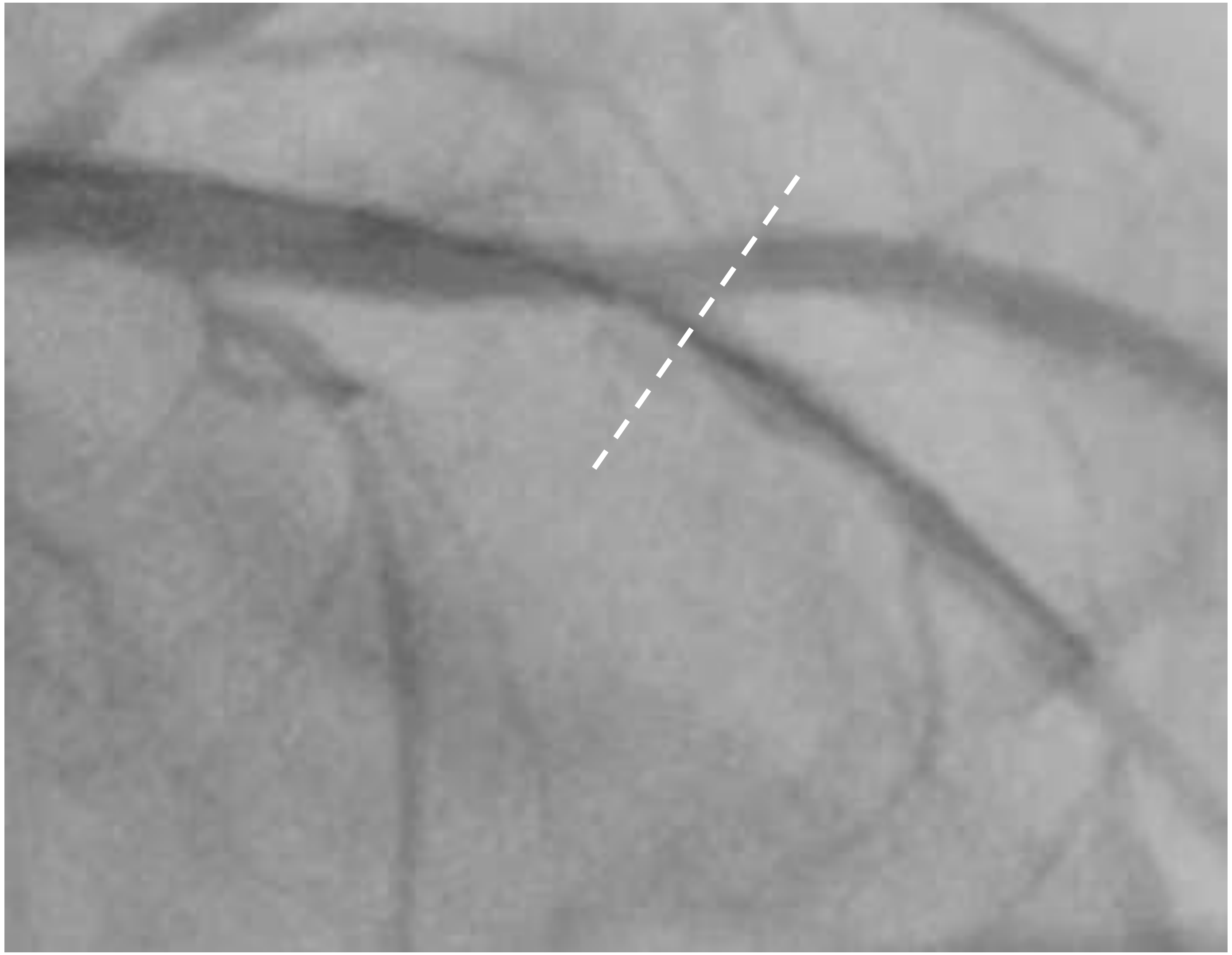


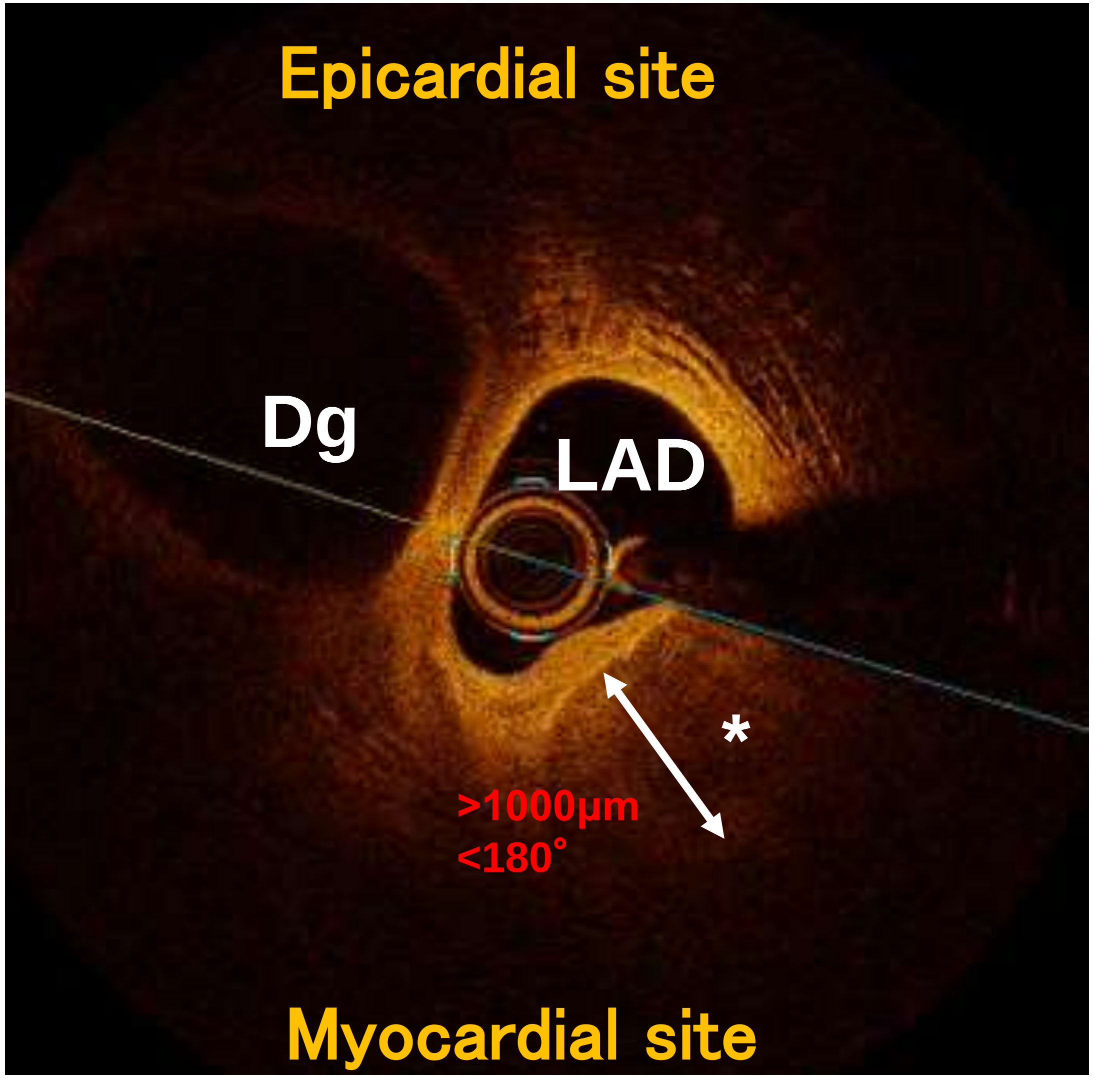
Calcium angle >270°



Eccentric heavily thick calcium

LAD seg.7:50-75%, FFR_{LAD}=0.72, ΔFFR=0.23





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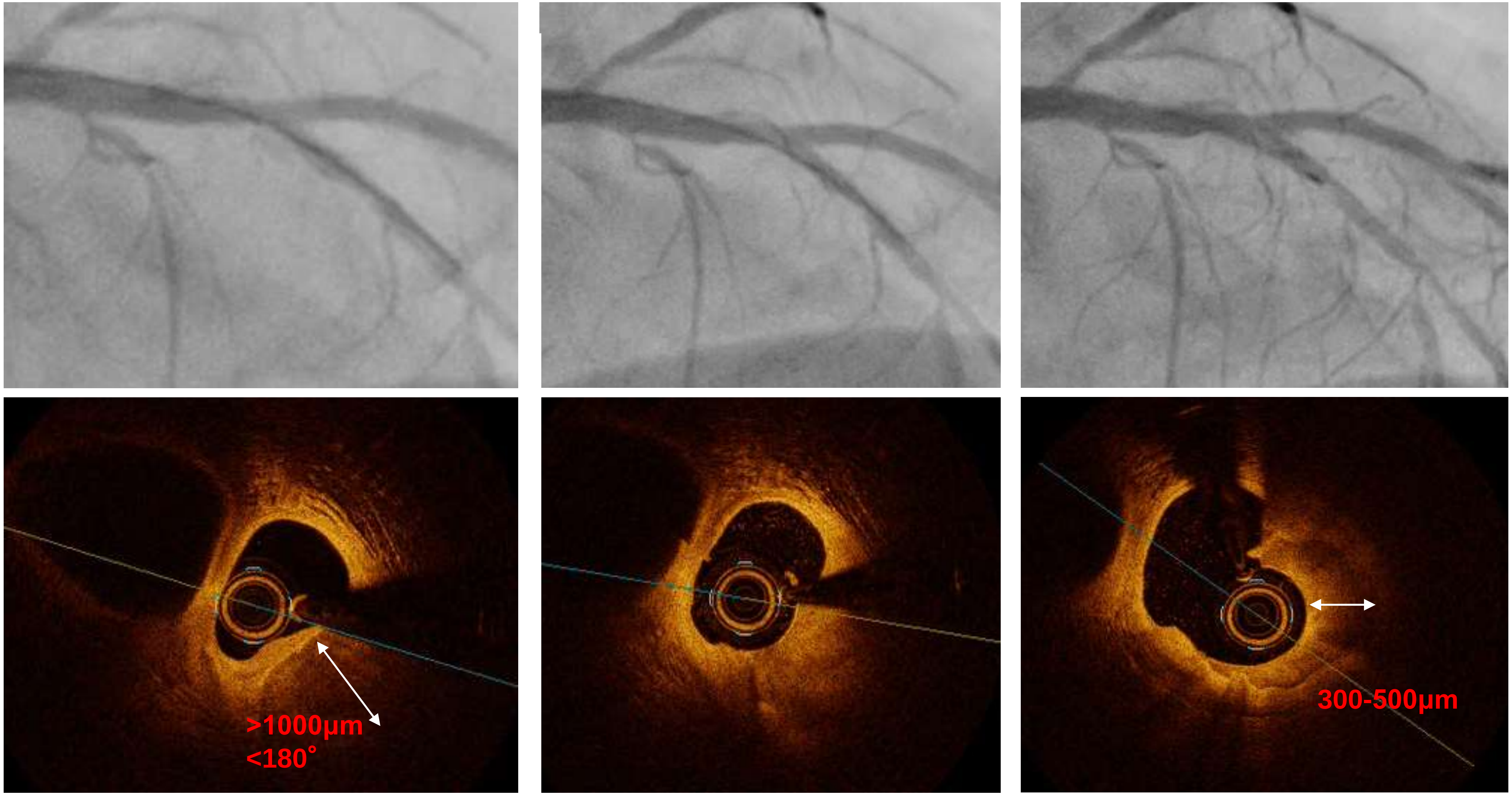
OCT findings of the lesion before and after OAS

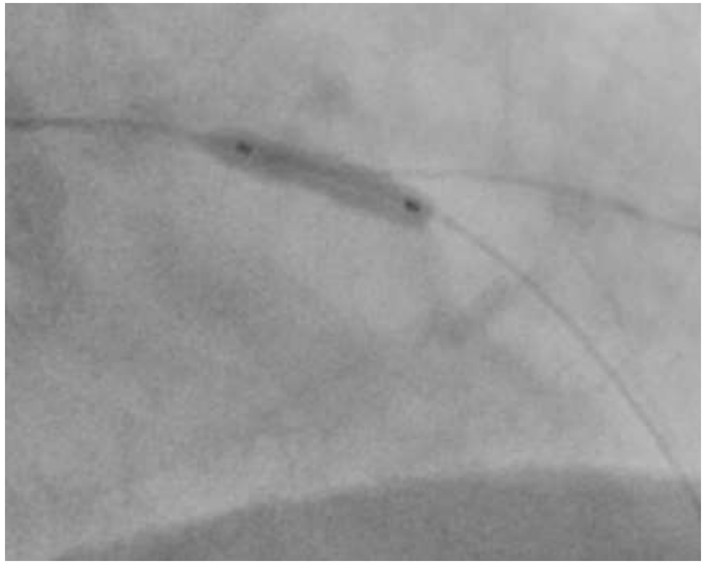
Before OAS | **After low speed OAS** | **After high speed OAS**

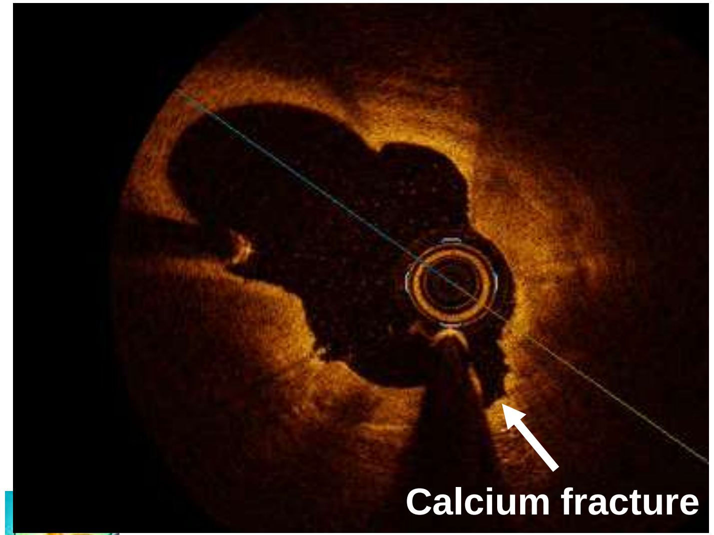


After confirming the effect of OAS with low speed using Viper wire bias, additional OAS with high speed was repeated 4 times as a pull back way.

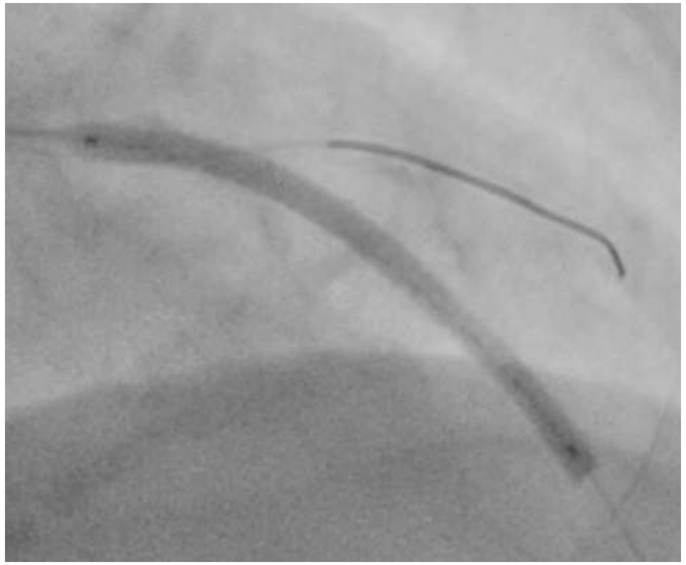
POBA & Stenting

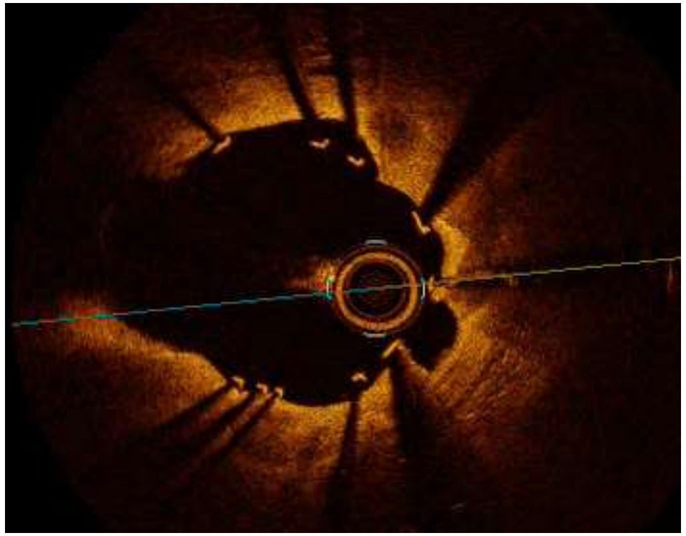
POBA
Wolverine 2.75*10mm





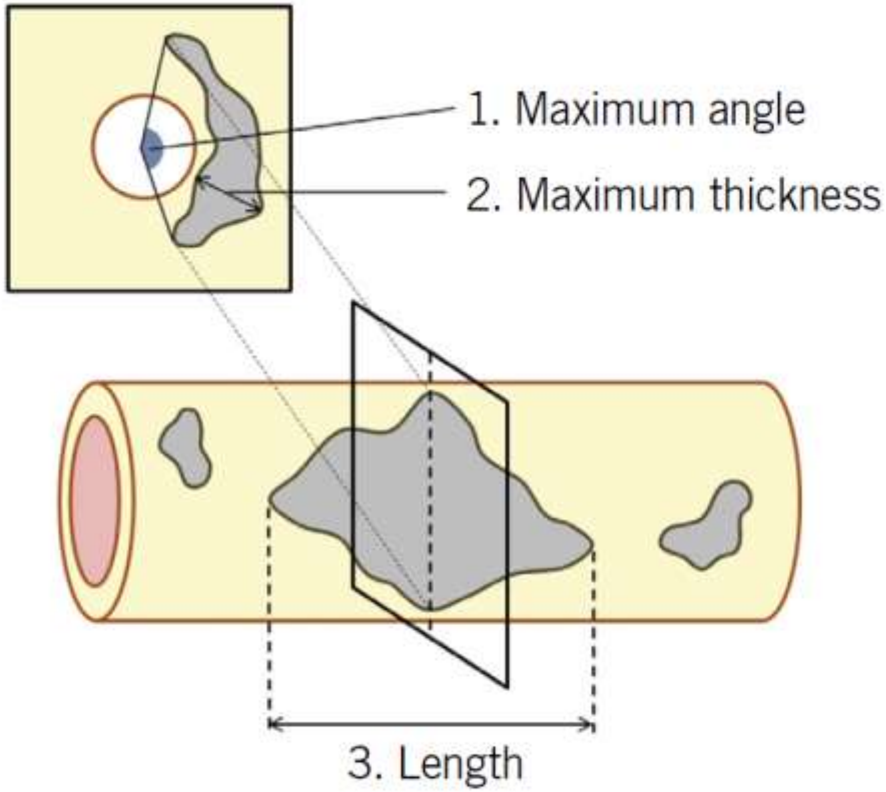
DES
3.0*38mm





Final Angiography
After stenting

OCT based calcium scoring system

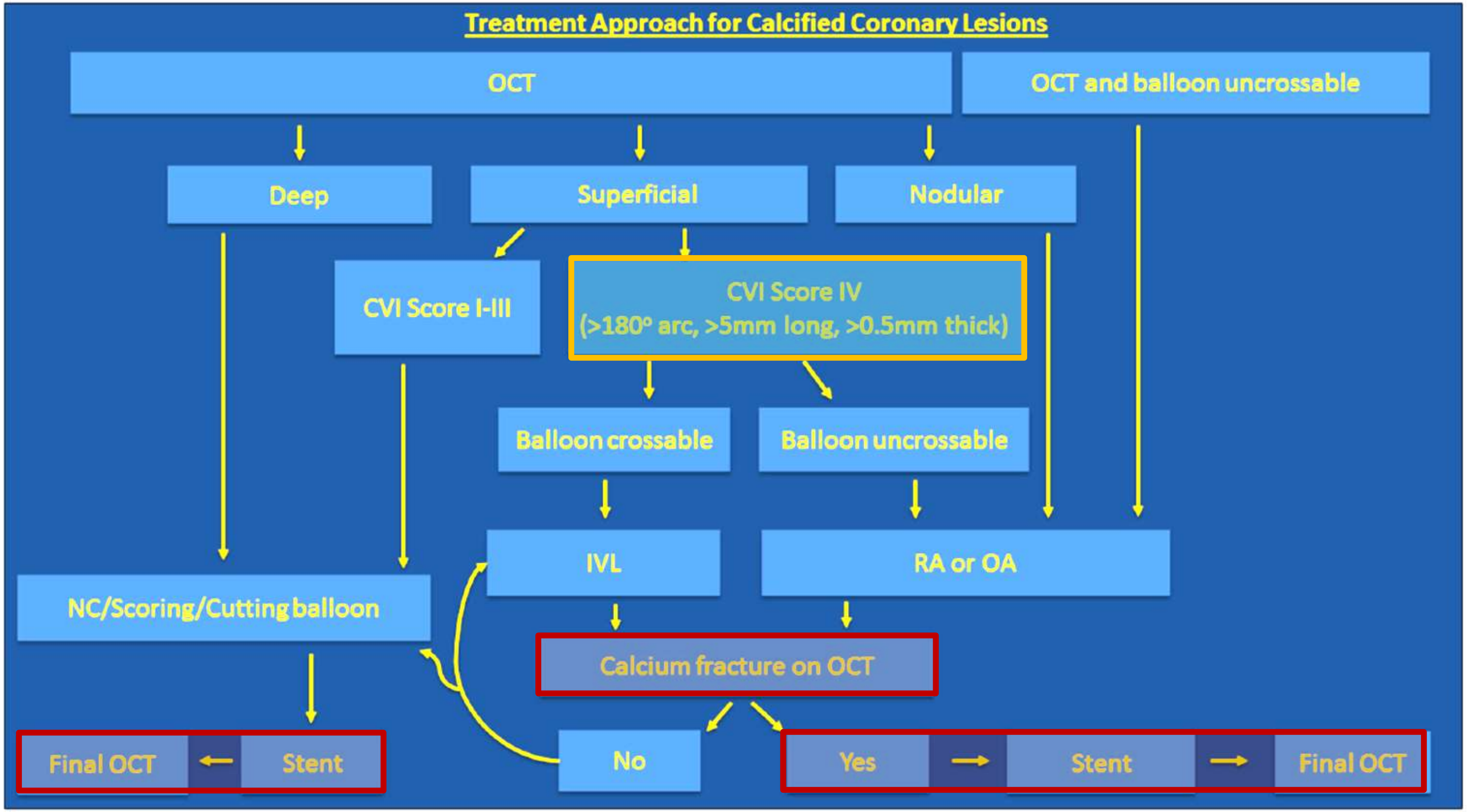


OCT-based calcium score	
1. Maximum calcium angle (°)	≤180° ➡ 0 point >180° ➡ 2 points
2. Maximum calcium thickness (mm)	≤0.5 mm ➡ 0 point >0.5 mm ➡ 1 point
3. Calcium length (mm)	≤5.0 mm ➡ 0 point >5.0 mm ➡ 1 point
Total score	**0 to 4 points**

Fusiono A, et al. EuroInterv 2018;13:e2182-e2189

OCT-guided PCI for severe calcified lesions

Shlofmitz E, et al. Curr Cardiovasc Imaging Rep 2019;12;32

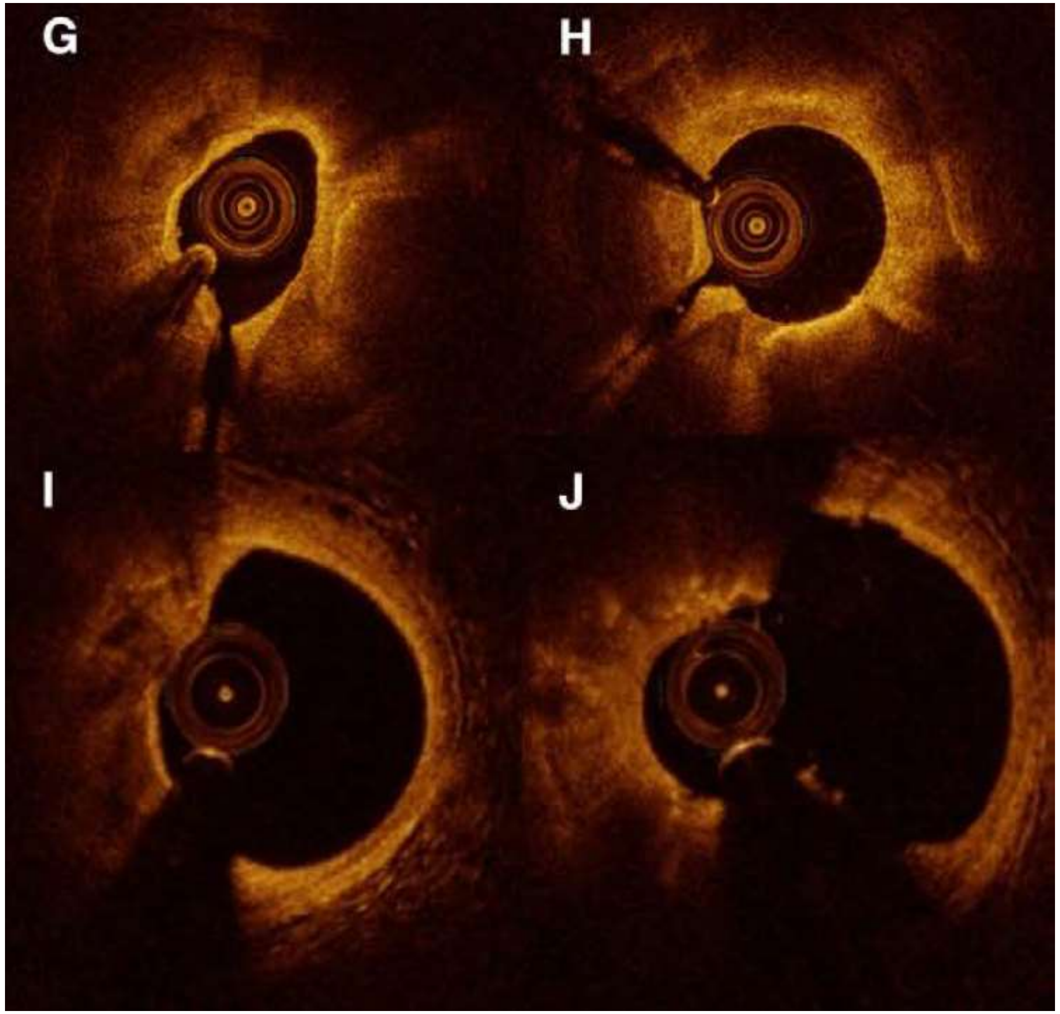


Comparison Between Rotational & Orbital Atherectomy

Pre PCI | Post PCI

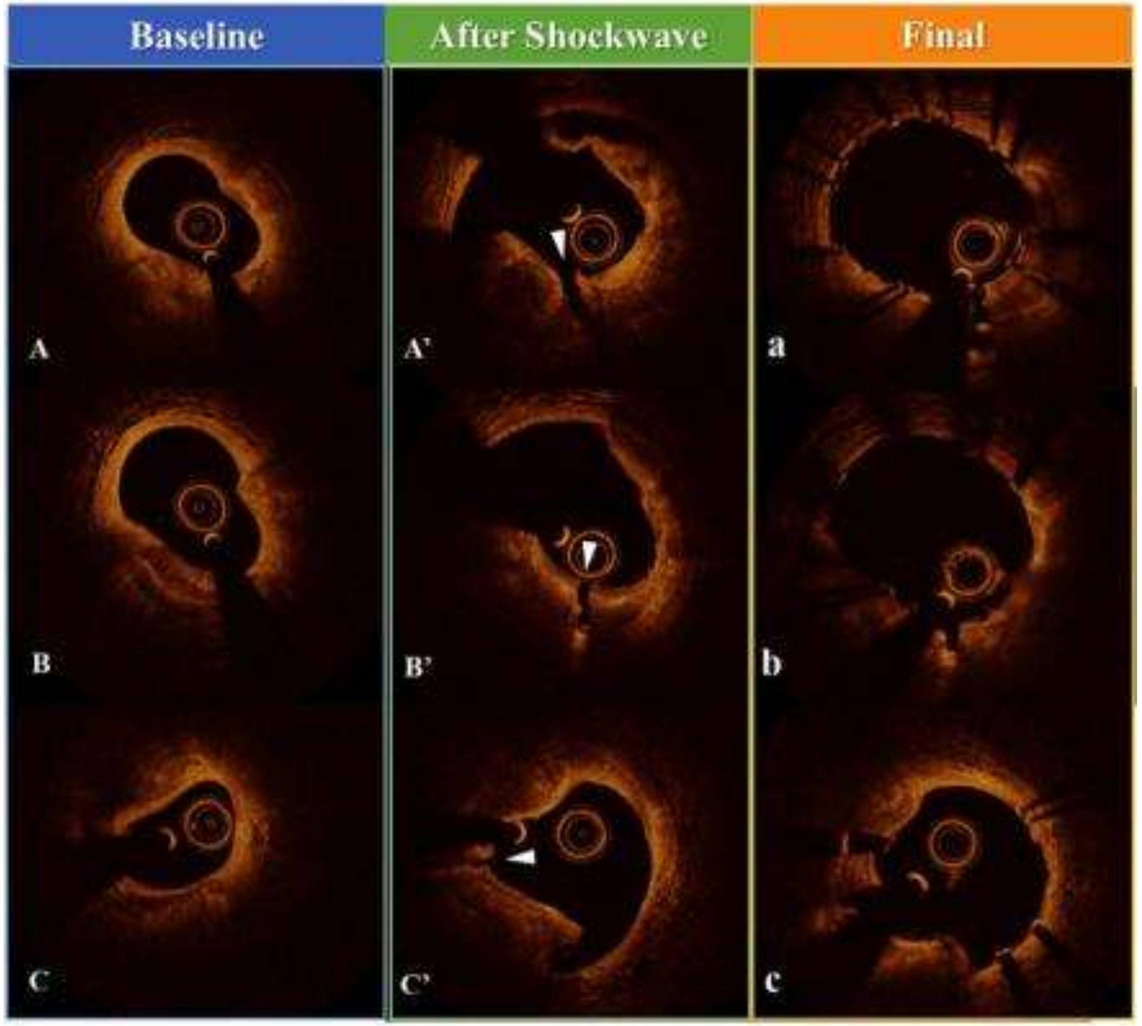
Rotational atherectomy

Orbital atherectomy



Mehanna E, et al. Circ Cardiovasc Interv 2018;11:e006813,
DOI:10.1161/CIRCINTERVENTIONS.118.006813.

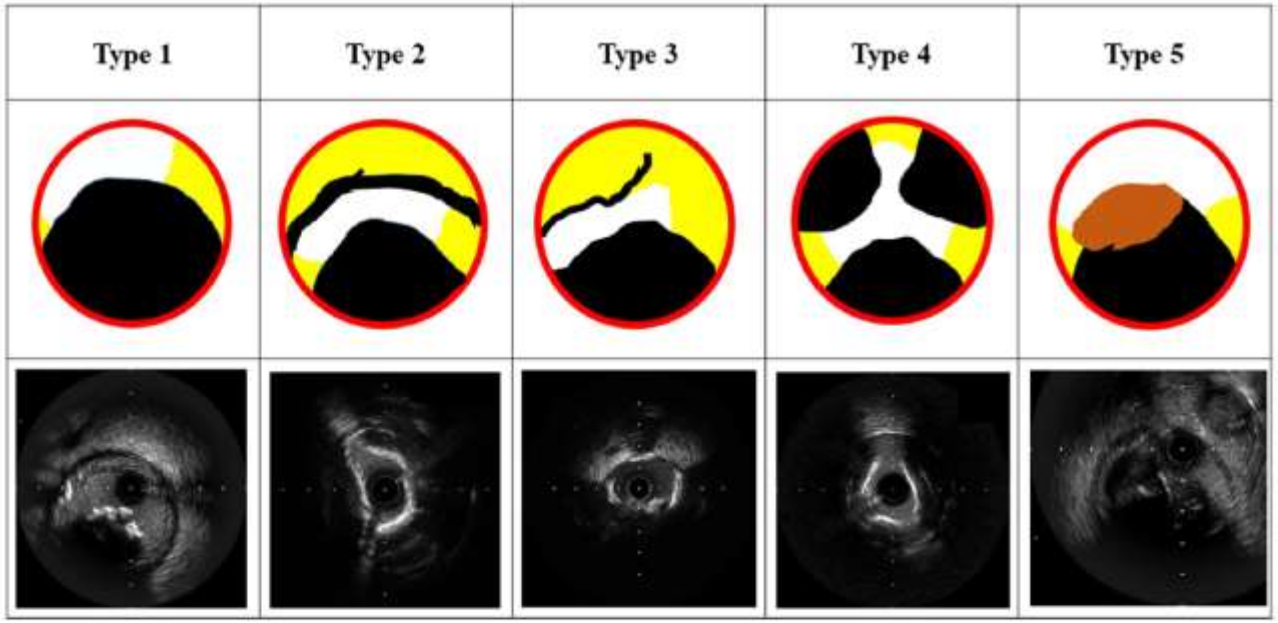
Shockwave Intravascular Lithotripsy

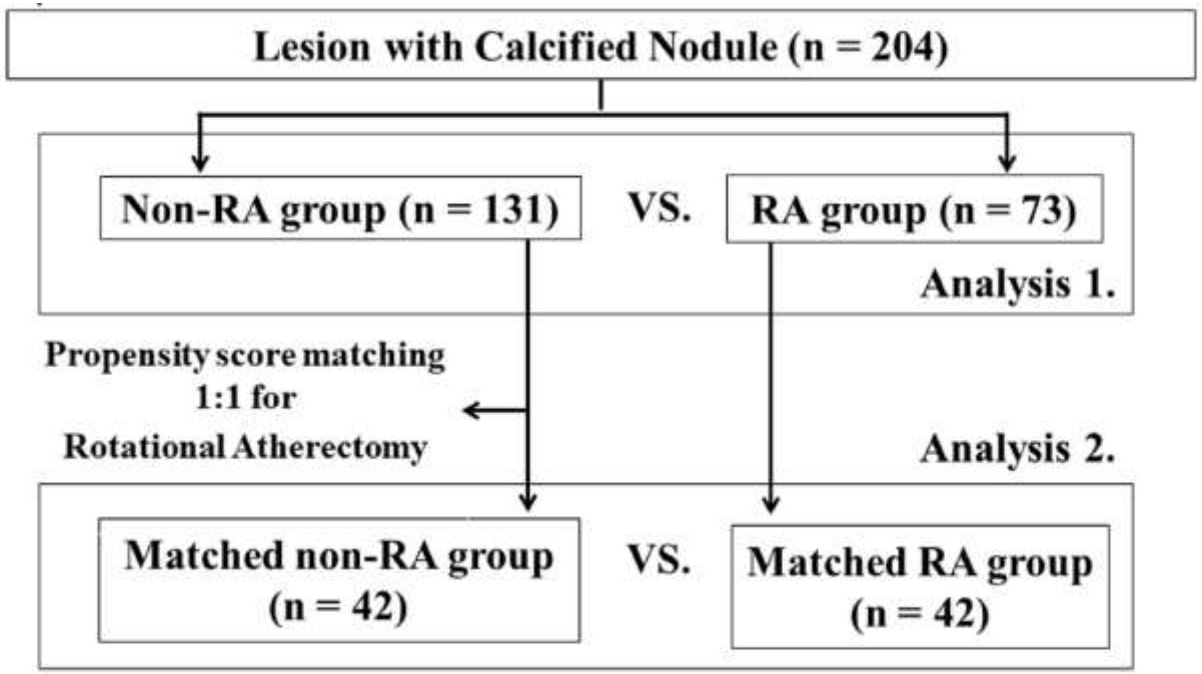


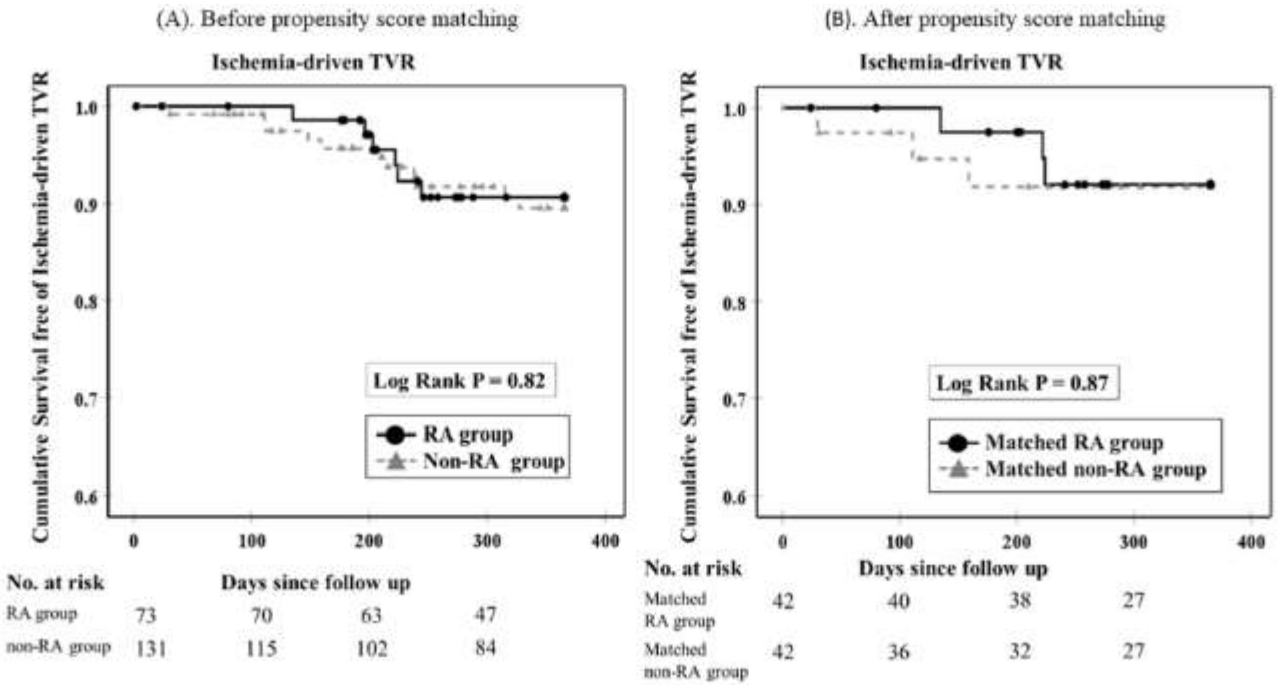
Comparison of clinical outcomes of intravascular ultrasound-calcified nodule between percutaneous coronary intervention with versus without rotational atherectomy in a propensity-score matched analysis

Yusuke Watanabe, Kenichi Sakakura*, Yousuke Taniguchi, Kei Yamamoto, Masaru Seguchi, Takunori Tsukui, Hiroyuki Jinnouchi, Hiroshi Wada, Shin-ichi Momomura, Hideo Fujita

Division of Cardiovascular Medicine, Saitama Medical Center, Jichi Medical University, Shimotsuke, Japan



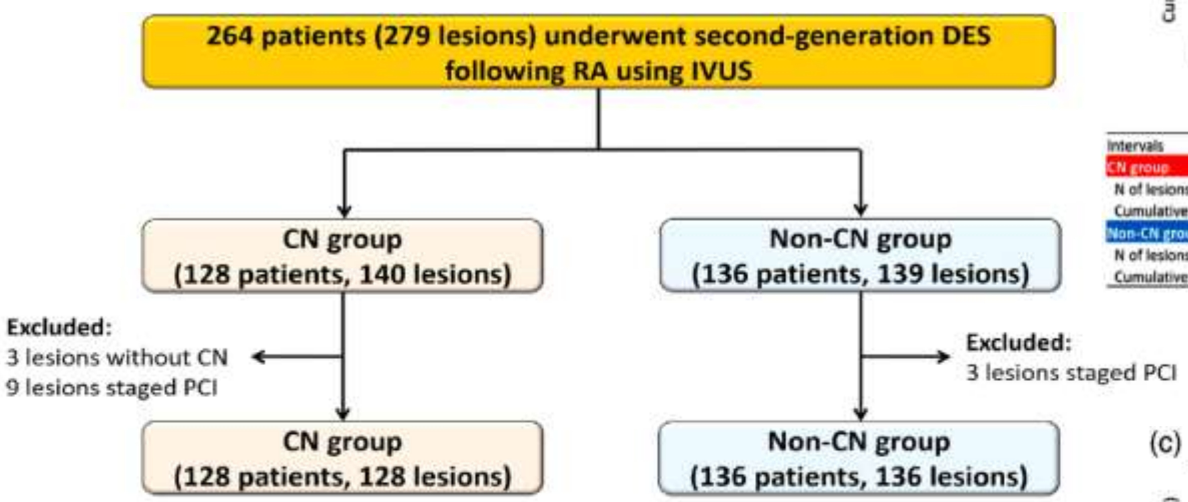


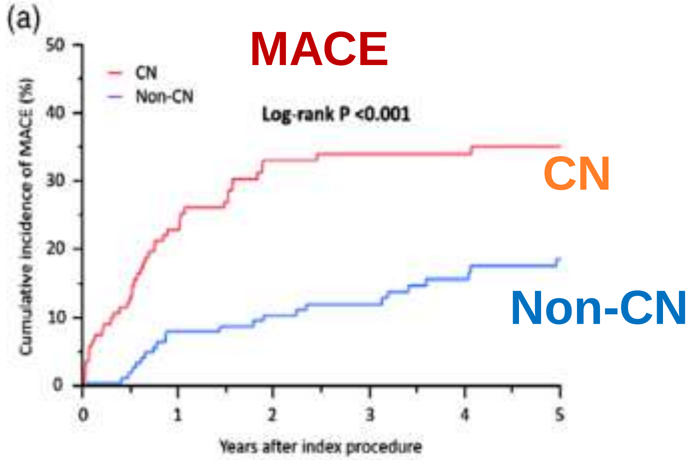


Watanabe Y, et al. *PLoS ONE 2020;15:e0241836*

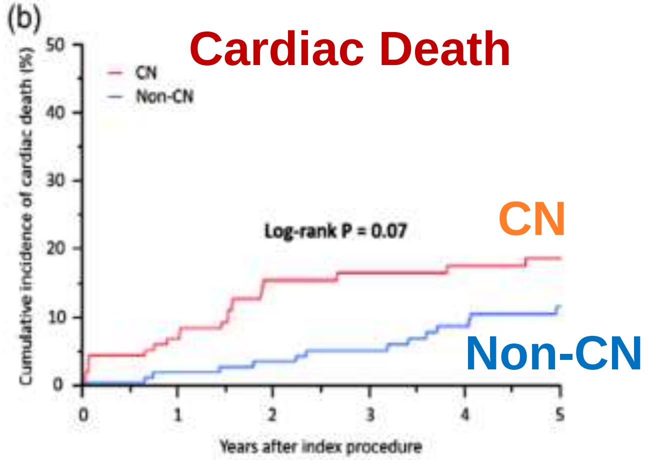
Clinical impact of calcified nodule in patients with heavily calcified lesions requiring rotational atherectomy

Toru Morofuji MD[1] | Shoichi Kuramitsu MD, PhD[1] | Tomohiro Shinozaki PhD[2]
Hiroyuki Jinnouchi MD[1] | Shinjo Sonoda MD, PhD[3] | Takenori Domei MD[1] |
Makoto Hyodo MD[1] | Shinichi Shirai MD[1] | Kenji Ando MD[1]

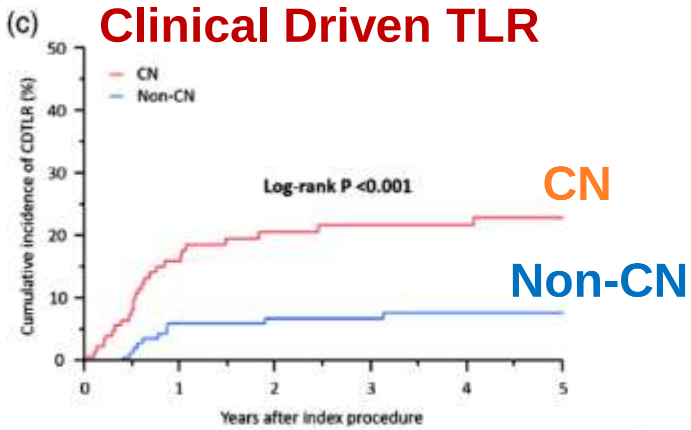




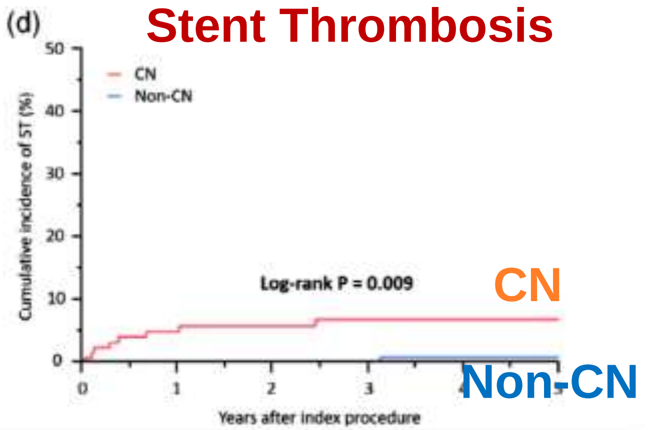
Intervals	0	30 days	1 Year	2 Years	3 Years	4 Years	5 Years
CN group							
N of lesions at risk	128	119	94	73	65	63	56
Cumulative incidence	0.0%	6.3%	24.7%	33.3%	34.3%	34.3%	35.4%
Non-CN group							
N of lesions at risk	136	135	121	111	102	91	81
Cumulative incidence	0.0%	0.74%	8.3%	10.7%	12.3%	15.9%	18.8%



Intervals	0	30 days	1 Year	2 Years	3 Years	4 Years	5 Years
CN group							
N of lesions at risk	128	120	114	94	84	78	70
Cumulative incidence	0.0%	4.7%	8.0%	15.7%	16.7%	17.7%	18.9%
Non-CN group							
N of lesions at risk	136	136	129	120	110	100	90
Cumulative incidence	0.0%	0.0%	2.3%	3.8%	5.5%	9.1%	11.9%



Intervals	0	30 days	1 Year	2 Years	3 Years	4 Years	5 Years
CN group							
N of lesions at risk	128	119	94	74	66	64	57
Cumulative incidence	0.0%	0.79%	17.0%	20.8%	21.9%	21.9%	23.2%
Non-CN group							
N of lesions at risk	136	136	121	111	101	91	81
Cumulative incidence	0.0%	0.0%	6.1%	7.0%	7.0%	7.9%	7.9%



Intervals	0	30 days	1 Year	2 Years	3 Years	4 Years	5 Years
CN group							
N of lesions at risk	128	119	108	89	80	74	66
Cumulative incidence	0.0%	0.79%	5.0%	5.9%	7.0%	7.0%	7.0%
Non-CN group							
N of lesions at risk	136	136	129	120	110	99	89
Cumulative incidence	0.0%	0.0%	0.0%	0.0%	0.0%	0.93%	0.93%

Morofuji T, et al. *Catheter Cardiovasc Interv. 2021;97:10-19*

Take home message

In cases with heavily calcified lesion,

- Rotational atherectomy with small bar size would be recommended if any imaging devices could not be pathed through the tight lesion.
- OCT may allow us to demonstrate clearly the position, distribution and thickness of calcium, although IVUS might be more sensitive to detect calcium than OCT.
- Lesion modification and site and degree of ablation can be clearly observed after rotational and/or orbital atherectomy, by intracoronary imaging.
- Step by step change in burr size and rotation speed would be recommended for ablating calcium safely using wire bias.
- Calcium plate fracture can be made by high pressure ballooning with noncompliant, scoring or cutting balloon if the thickness of it become less than 500μm.
- Enough stent expansion and less instent restenosis could be expected if calcium plate fracture can be obtained after high pressure ballooning following step by step calcium ablation by atherectomy.