Imaging Guidance for Calcified Lesion PCI

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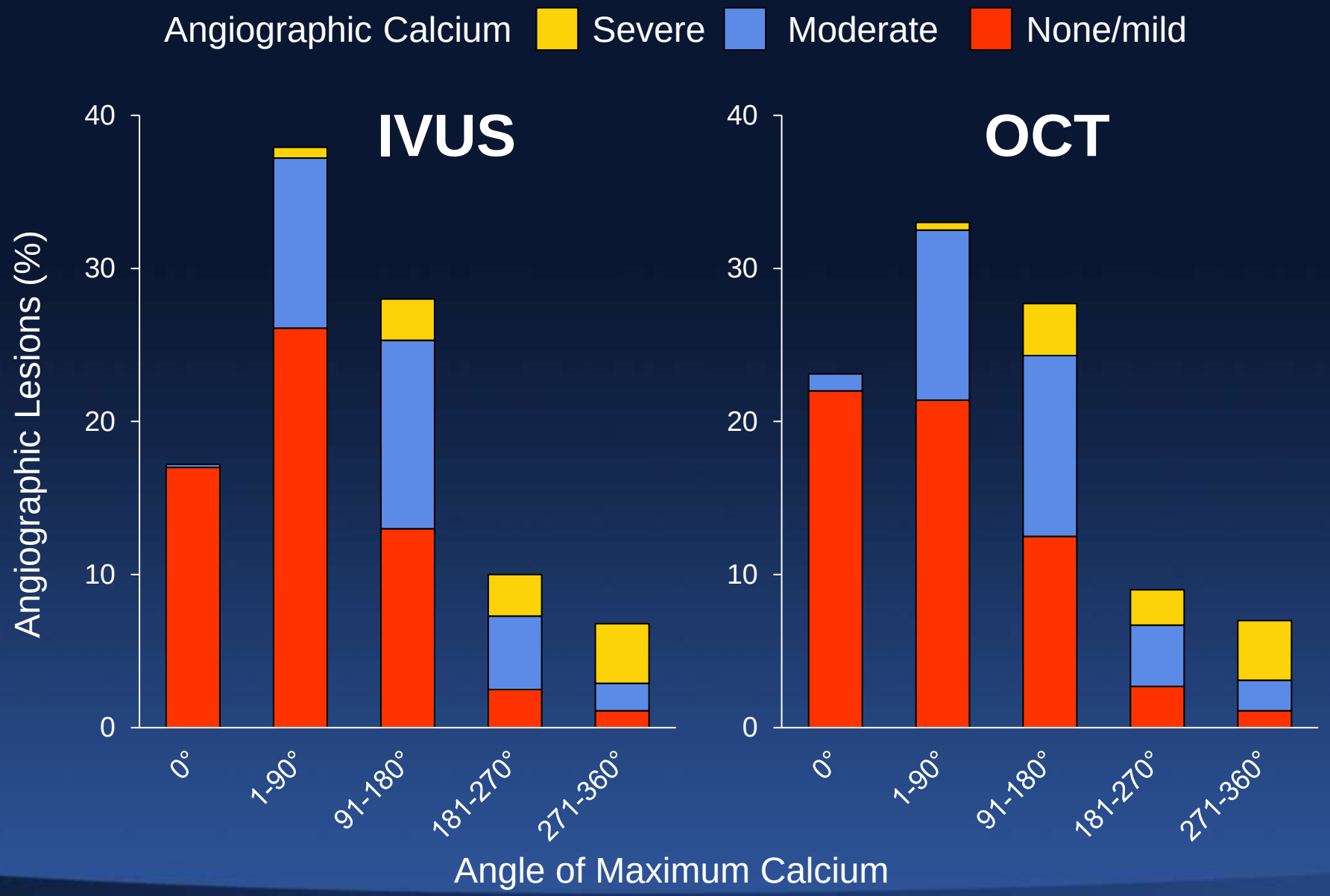
DISCLOSURE

- Research grant and consultant, Boston Scientific, Abbott Vascular

IVUS or OCT and Angiographic Calcium (n=440)

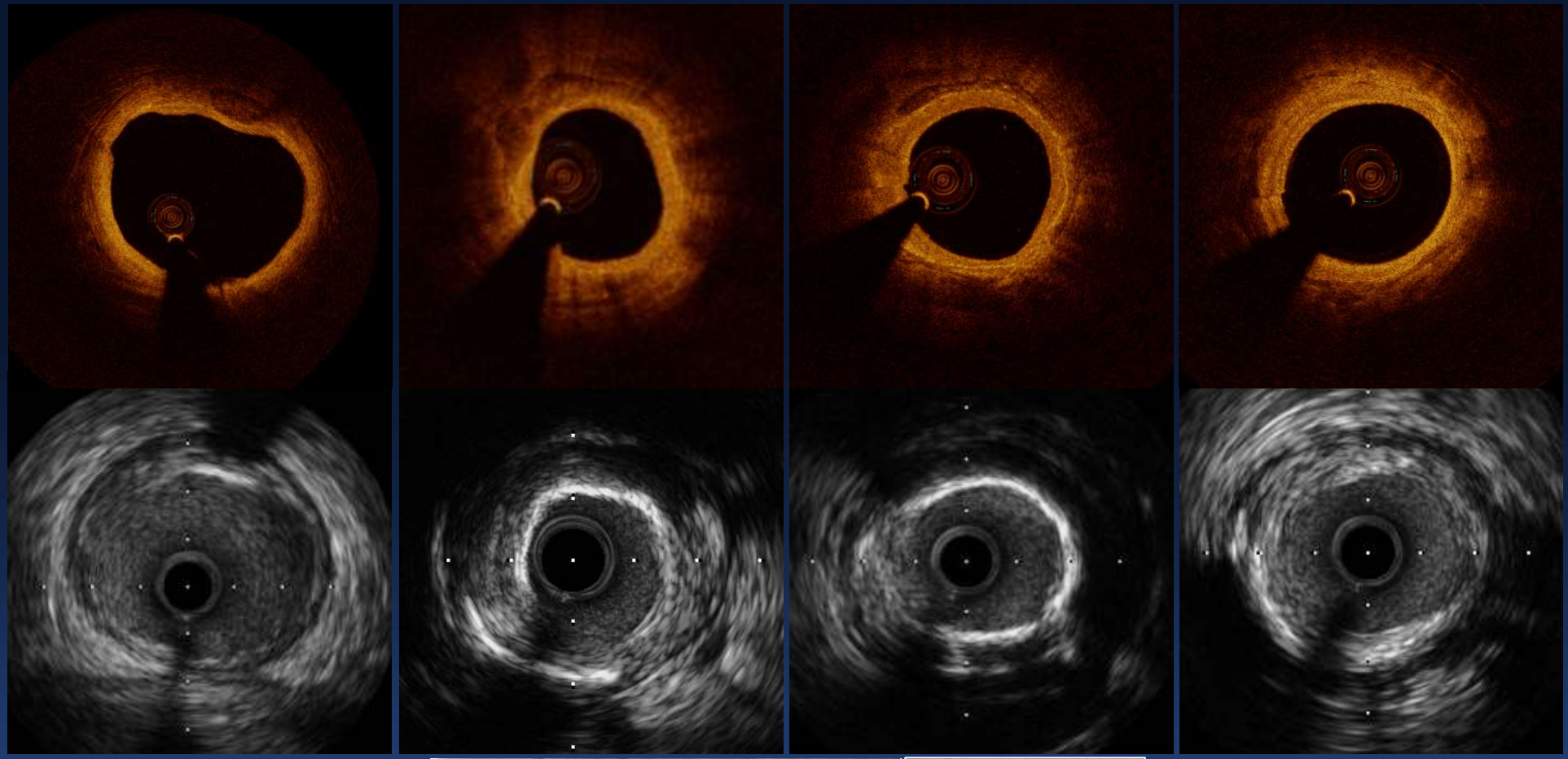


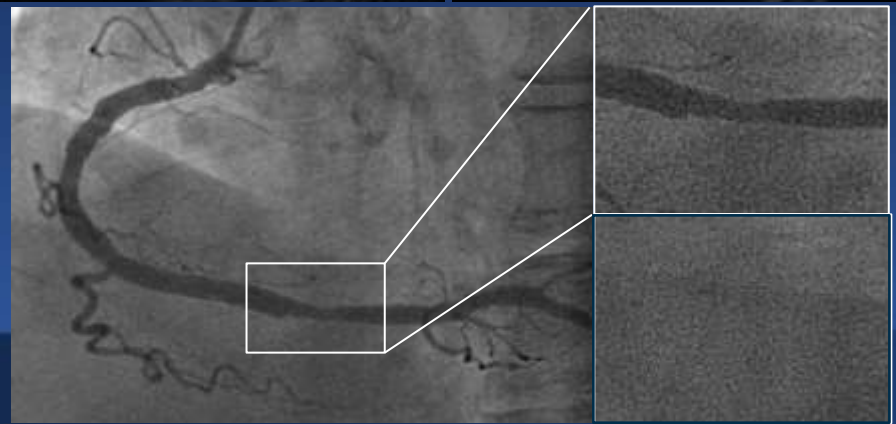
Wang X and Matsumura M, et al. JACC Img 2017;10: 869-79.

OCT Thin Calcium Not Visible by Angio

Proximal

Distal



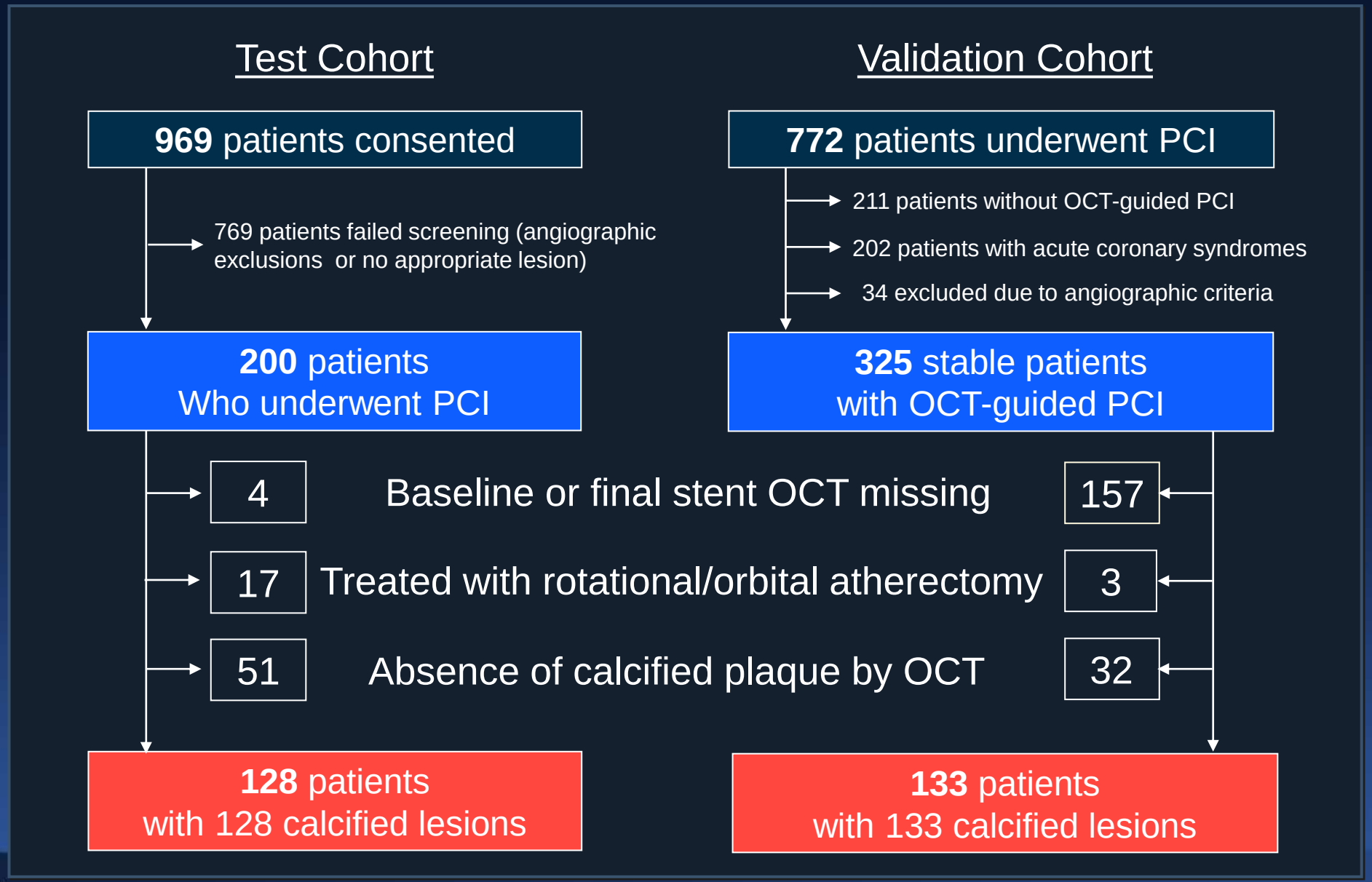


With vs Without Angio Ca Visibility in IVUS Max Ca Angle>180˚

	Angio Non-Visible (n=16)	Angio Visible (n=58)	p
Pre IVUS max Ca angle, ˚	228 (190, 286)	259 (230, 322)	0.03
Pre-OCT			
Presence of Ca	100%	98%	0.99
Max Ca angle, ˚	190 (146, 300)	250 (174, 320)	0.15
<0.5mm thickness, ˚	160 (69, 249)	96 (0, 131)	0.002
≥0.5mm thickness, ˚	61 (10, 92)	171 (98, 242)	<0.001
Mean Ca angle,	44 (33, 90)	68 (43, 146)	0.047
Max Ca thickness, mm	0.71 (0.52, 0.89)	0.95 (0.75, 1.15)	0.004
Ca length, mm	11.0 (6, 18)	16.0 (11, 23)	0.01
Post-OCT			
Minimum stent area, mm^2	8.1 (6.6, 9.3)	5.9 (4.6, 7.3)	0.001
Stent expansion, %	80.8 (75, 107)	91.7 (78, 101)	0.88

Wang X and Matsumura M, et al. JACC Img 2017;10: 869-79.

Study Flow Chart



Fujino A et al. EuroIntervention. 2018;13:e2182-9.

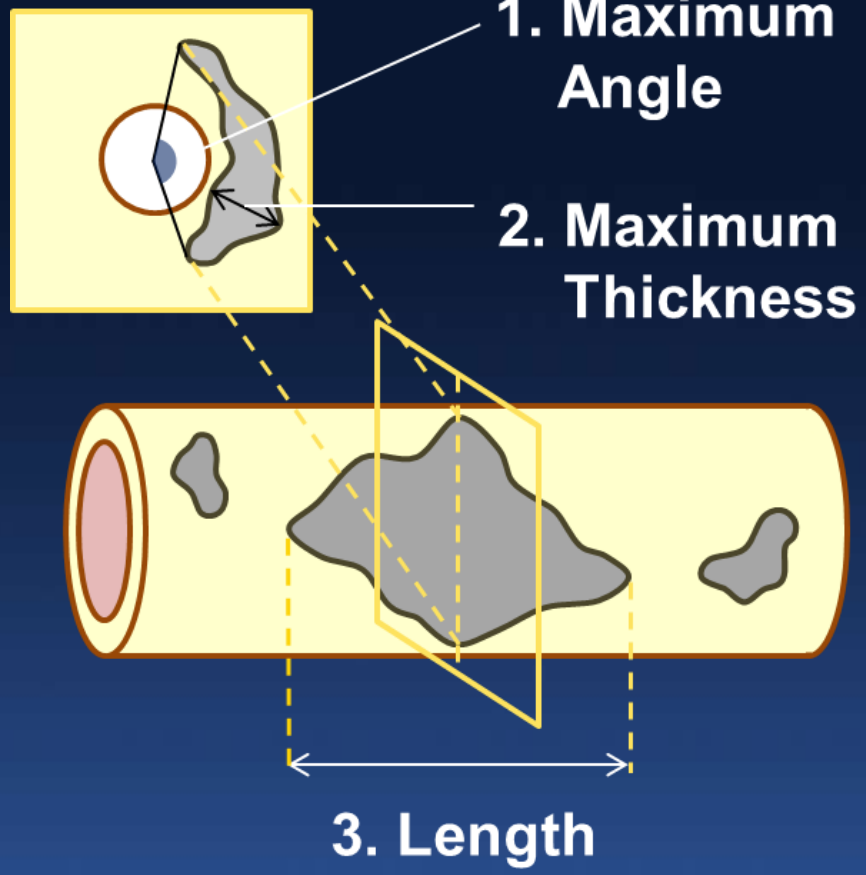
Multivariate Linear Regression Model to Predict Stent Expansion

Covariate	Regression Coefficient	95% Confidence Interval	p Value
Maximum calcium angle (per 180°)	-7.43	-12.6 to -2.21	<0.01
Maximum calcium thickness (per 0.5 mm)	-3.40	-6.35 to -0.45	0.02
Calcium length (per 5 mm)	-3.32	-4.09 to -0.55	0.01

The variables that were included in the model, but found not significant: The number of calcium deposits, Total stent length, Maximum inflation pressure, Balloon-to-artery ratio.

Fujino A et al. EuroIntervention. 2018;13:e2182-9.

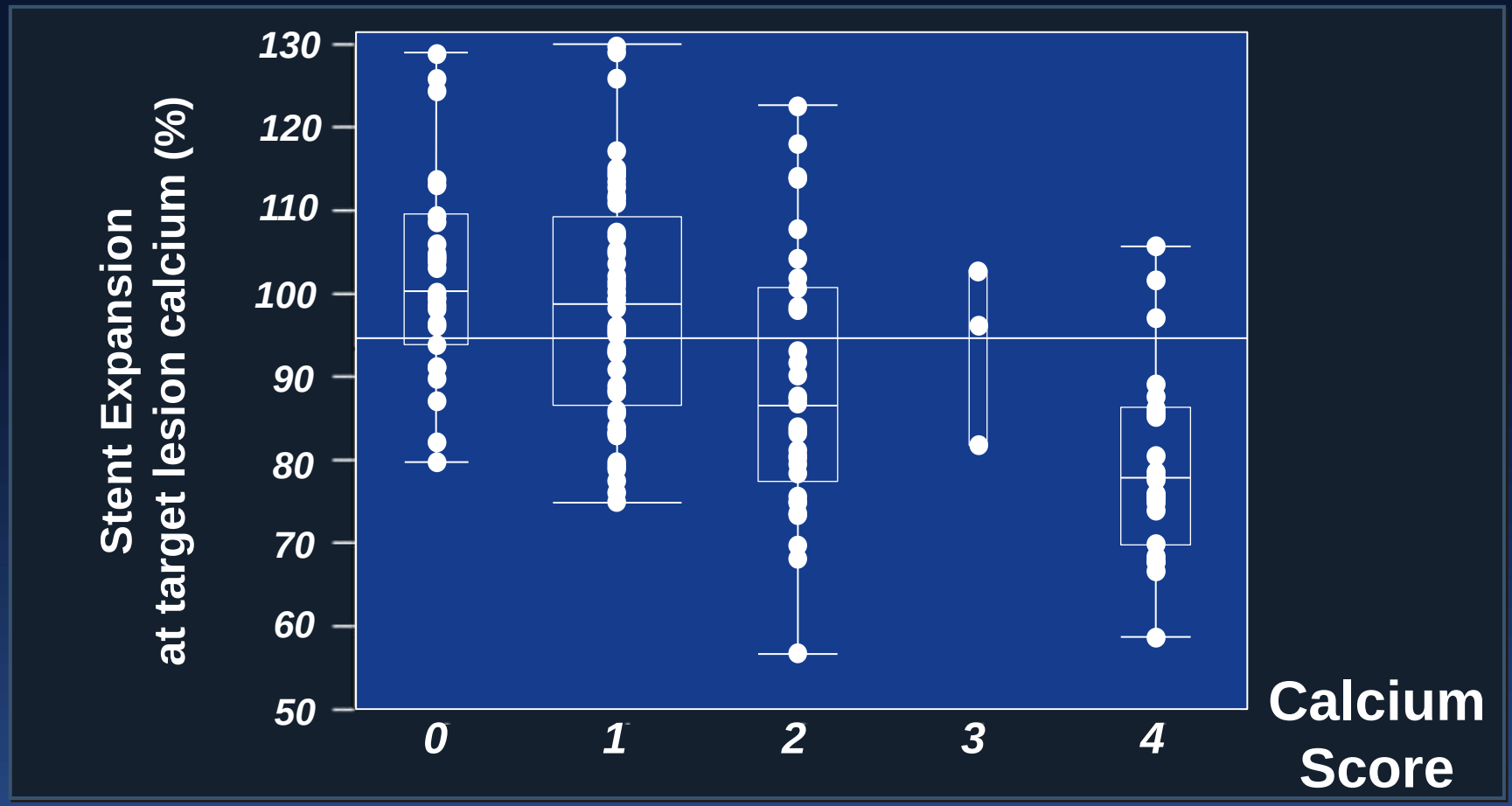
Calcium Scoring System



OCT-based CVI Score	
Angle	≤ 180° ➡ 0 point > 180° ➡ 2 points
Thickness	≤ 0.5 mm ➡ 0 point > 0.5 mm ➡ 1 point
Length	≤ 5.0 mm ➡ 0 point > 5.0 mm ➡ 1 point
Total score: 0 to 4 points	

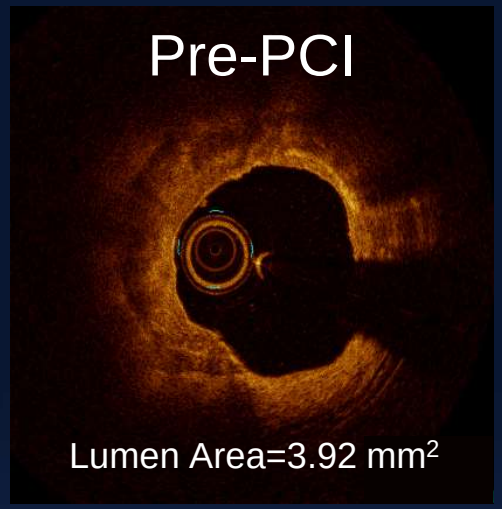
Fujino A et al. EuroIntervention. 2018;13:e2182-9.

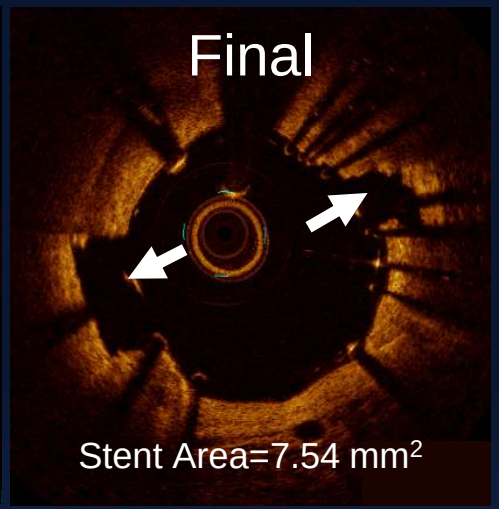
Calcium Score Predicts Stent Expansion



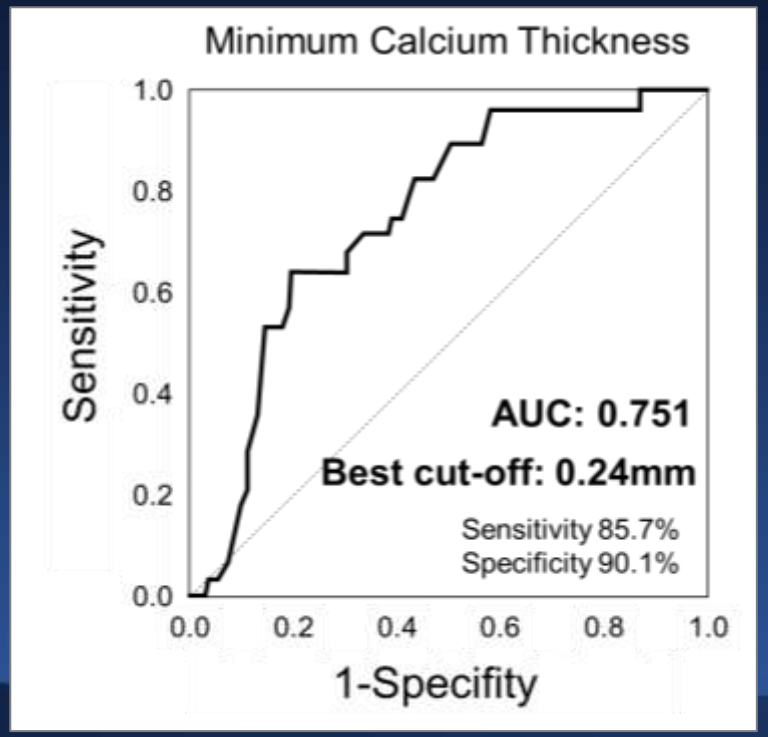
CVI score	0	1	2	3	4	p Value
Expansion at target lesion calcium, %	99	98	86	98	78	<0.01
Expansion at minimum stent area, %	91	85	80	82	69	<0.01

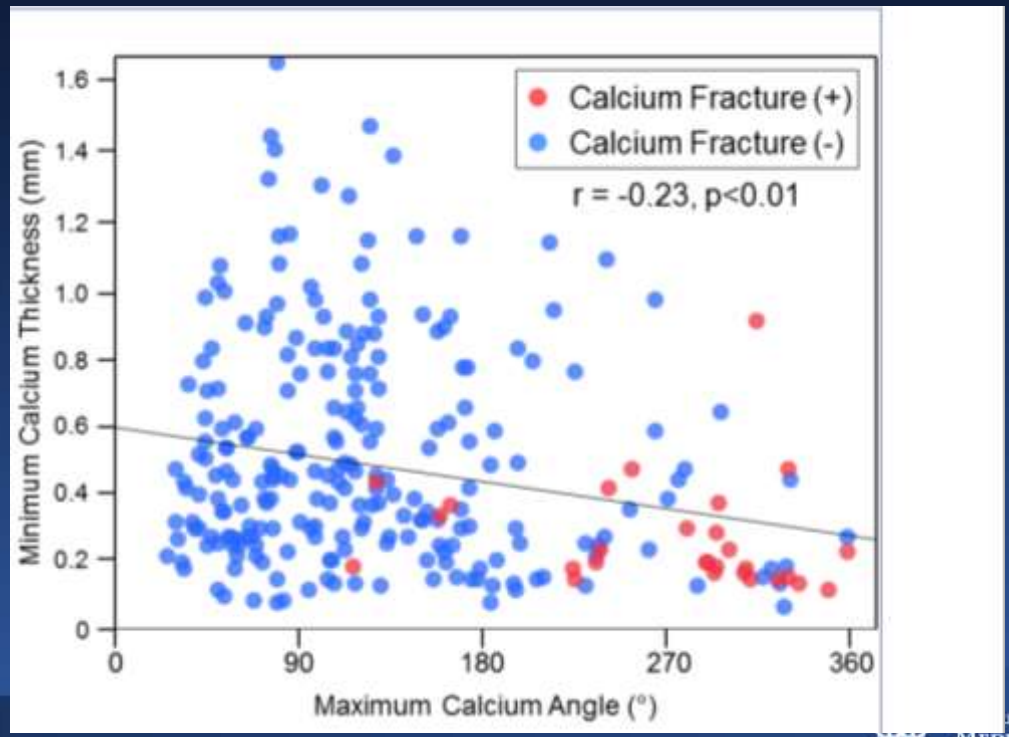
Ca Morphology to Predict Ca Fracture without Atherectomy





Calcium Fracture





Fujino A JACC Interv 2018;11:1015-17.

Angiographic calcium ?

Yes

IVUS: Maximum Calcium >270° ?

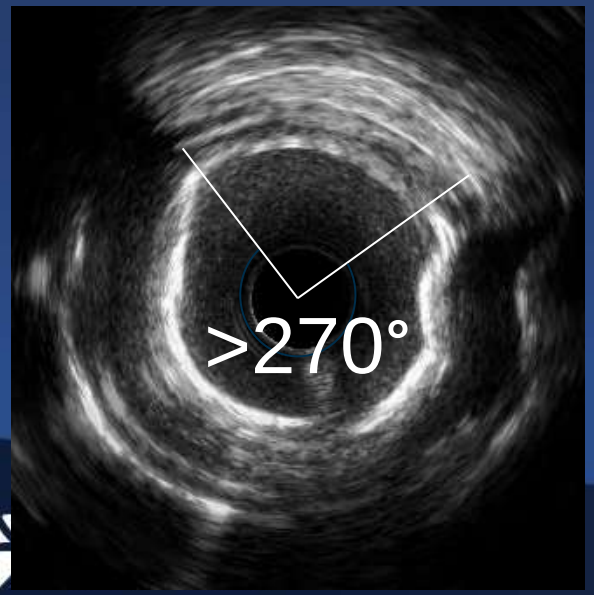
Yes

Calcium Score Calculation: 0~4, if ≥2?

Yes = Point 1, No = Point 0

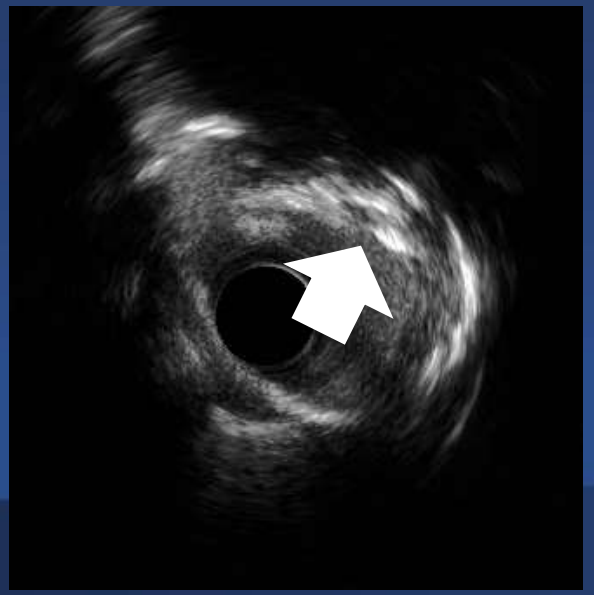
Consider atherectomy

Calcium >270° longer than 5mm?

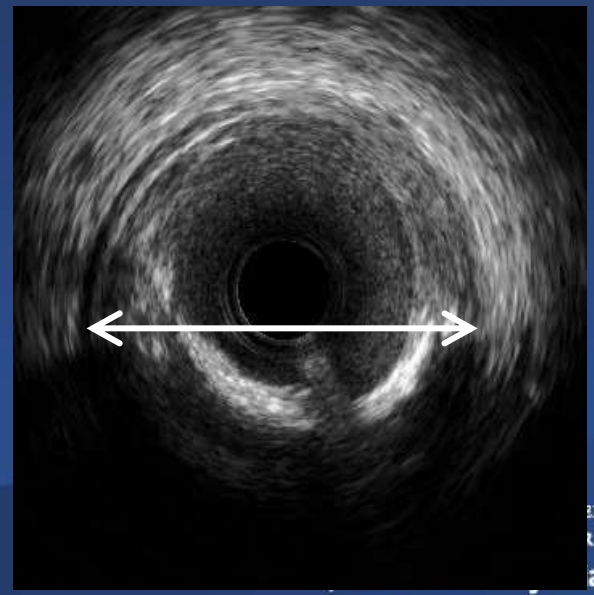


360° of calcium?

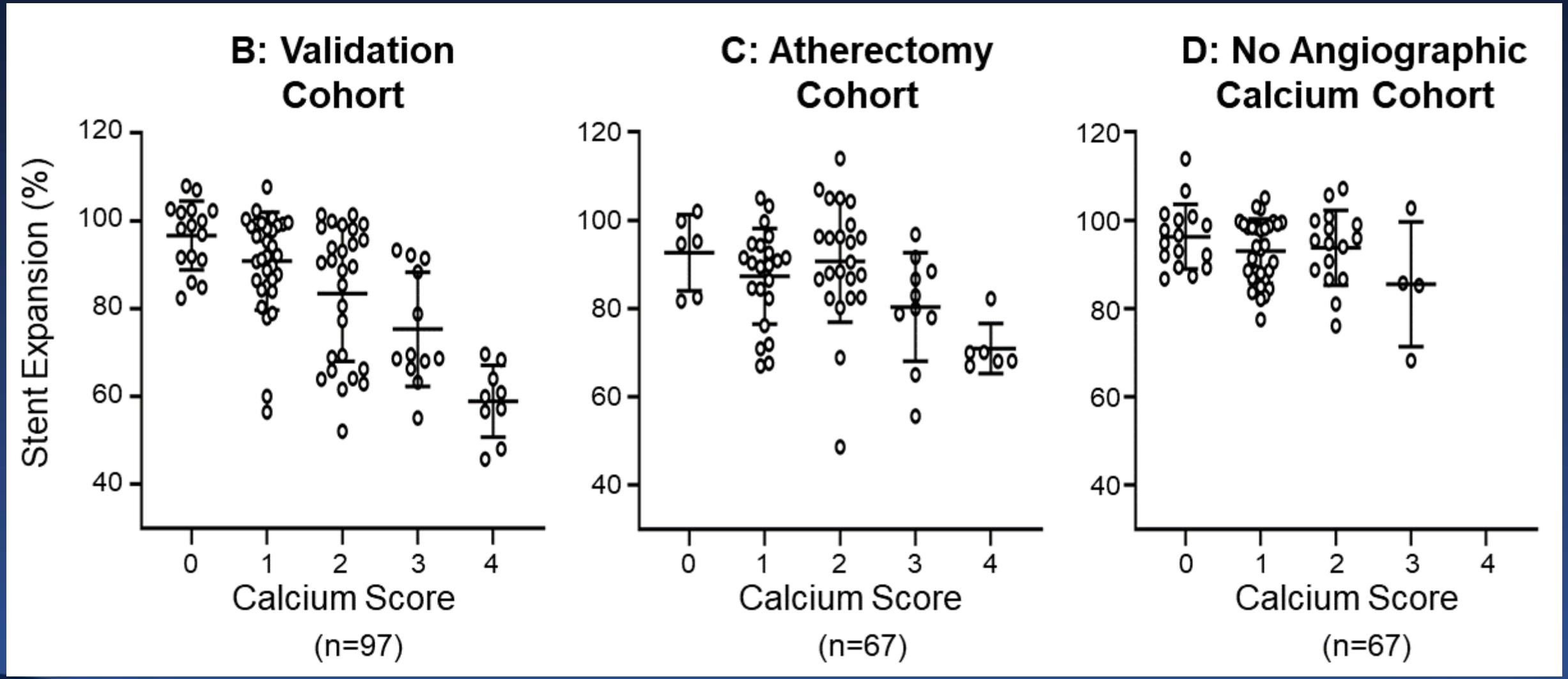
Calcified nodule?



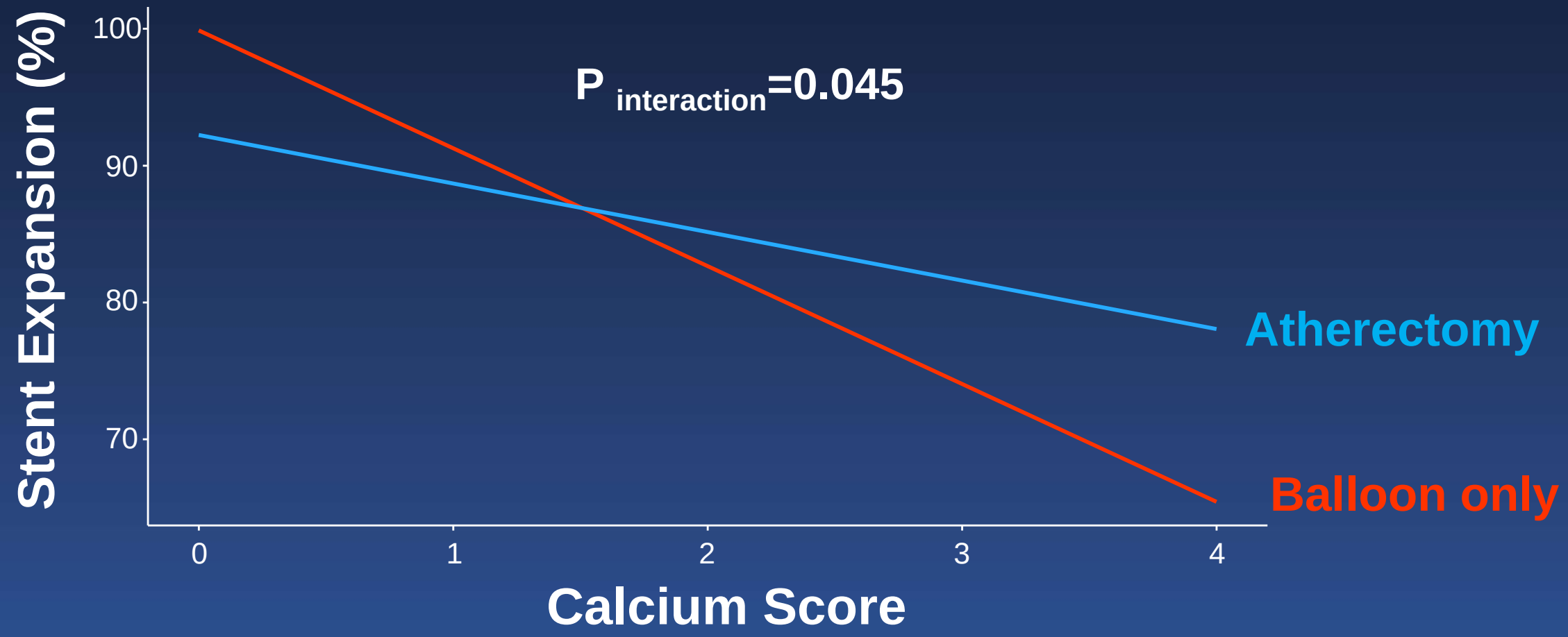
Vessel diameter <3.5mm ?



Stent Expansion Correlates with Calcium Score

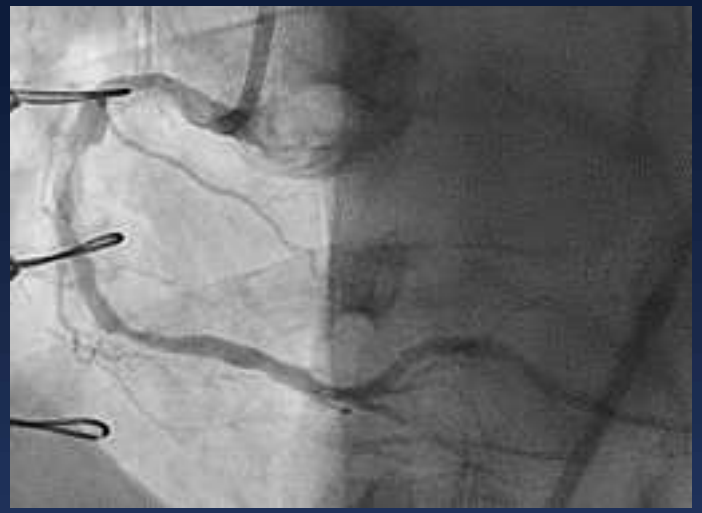


Effect of Atherectomy for Stent Expansion



Zhang et al. TCT2019

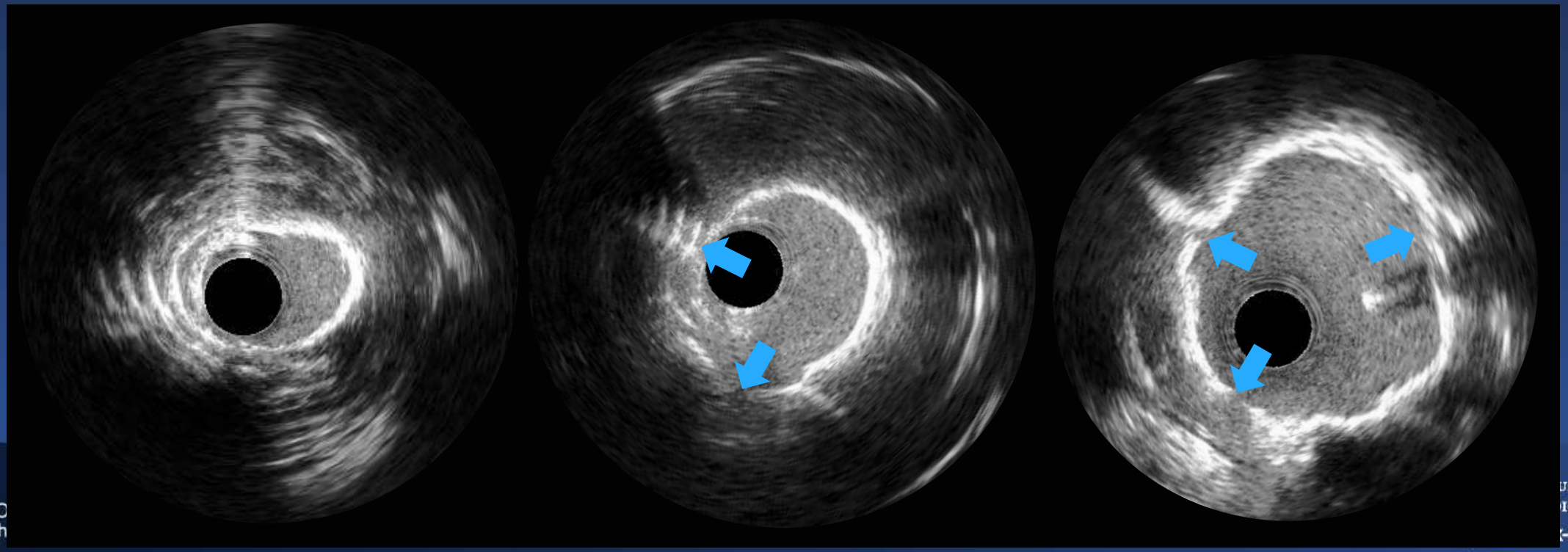
Calcium Score=2
Treated by Rota



Rota Burr 1.25/1.5, NC-B

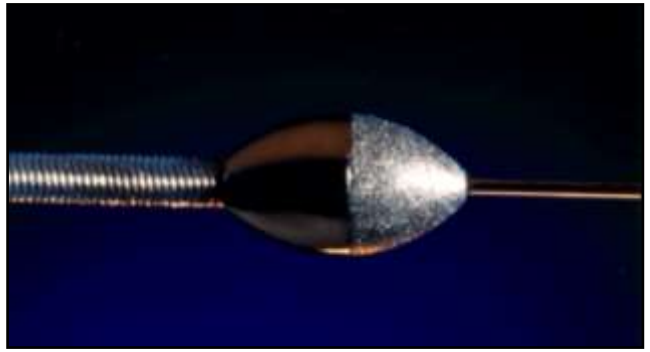
Rota Burr 2.0, NC-B

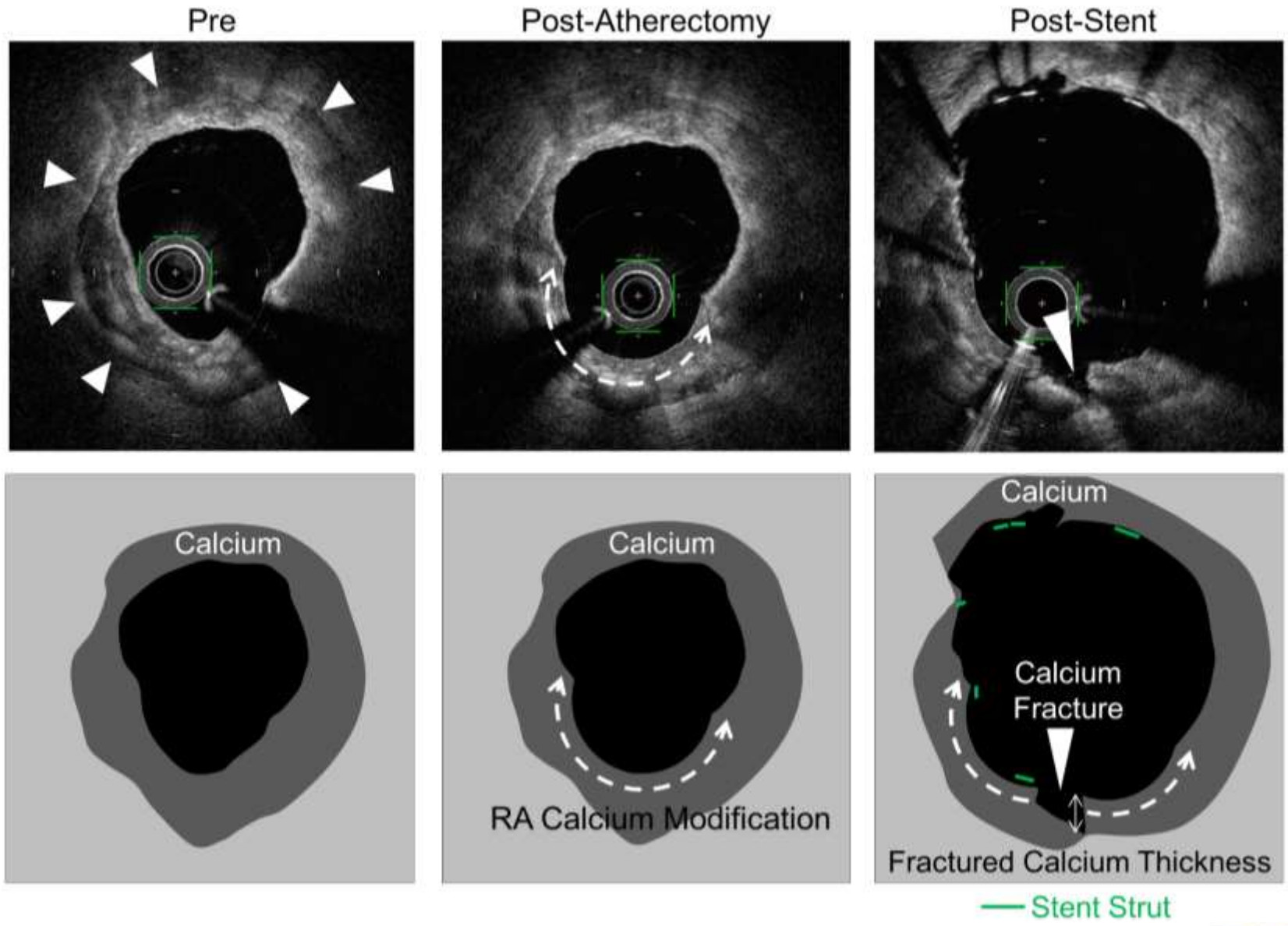
Final



Effect of Ca Modification on Calcified Fracture

Rotational Atherectomy



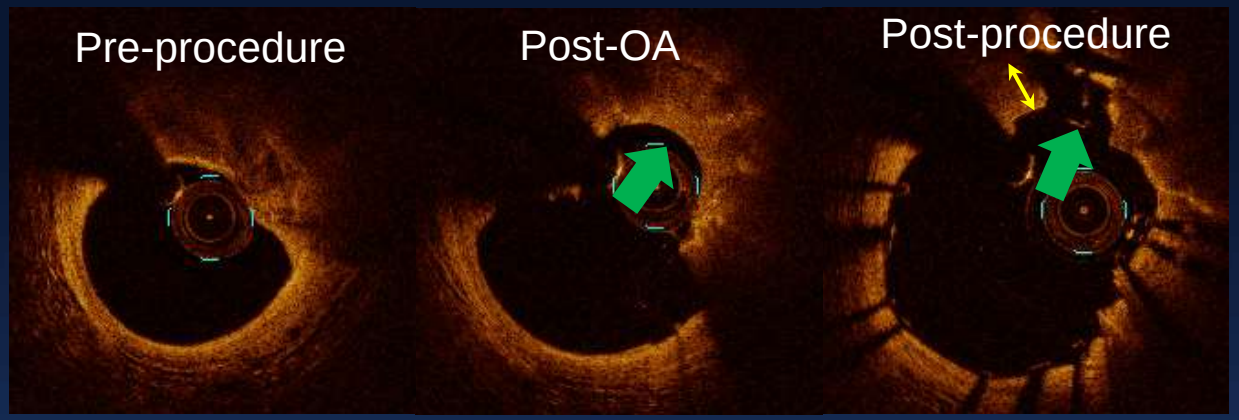


Amemiya K, et al. CCI 2019 doi:10.1002/ccd.28278

Ca Fracture
With and Without Ca Modification by OAS

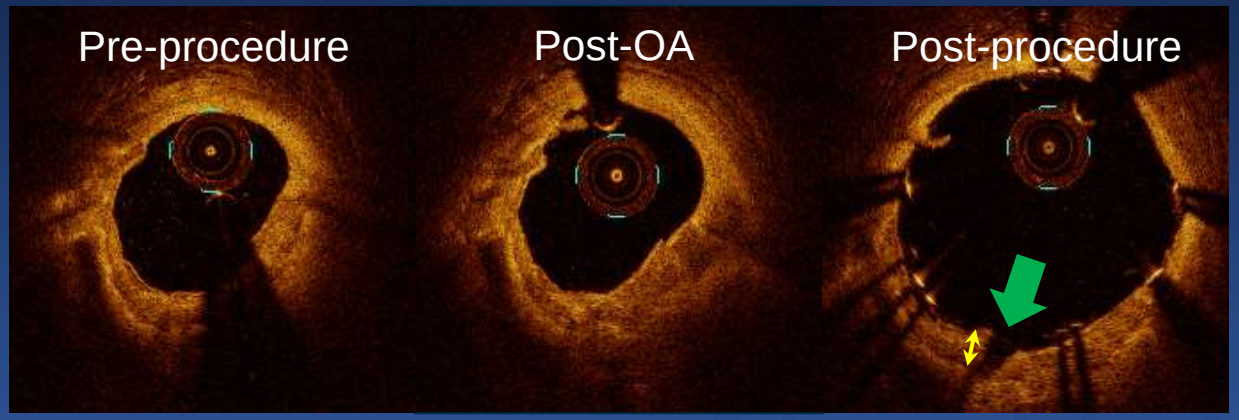
Orbital Atherectomy

Ca modification
(+)



Fractured Ca thickness = 0.62 mm

Ca modification
(-)



Fractured Ca thickness = 0.32 mm

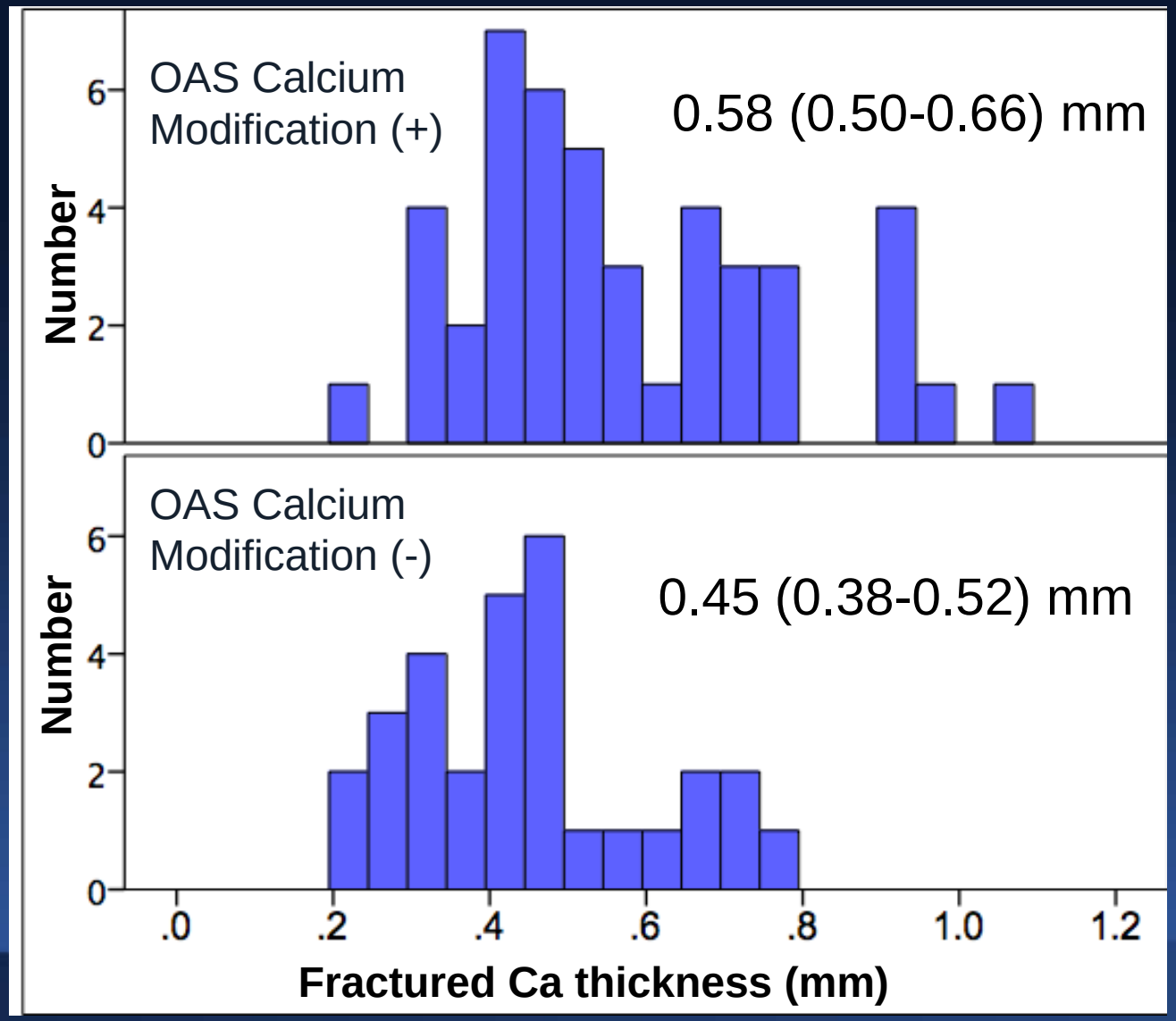
Yamamoto M, et al. CCI 2018 doi:10.1002/ccd.27902

Effect of Calcium Modification on Fracture

Post-stent calcium fracture was correlated with the post-OA/pre-stent calcium modification (r=0.31, p=0.01).

Comparison between OAS Ca Modification (+) vs (-)

GEE adjusted p-value=0.003



Yamamoto M JACC Interv 2017; 10:2584-6.

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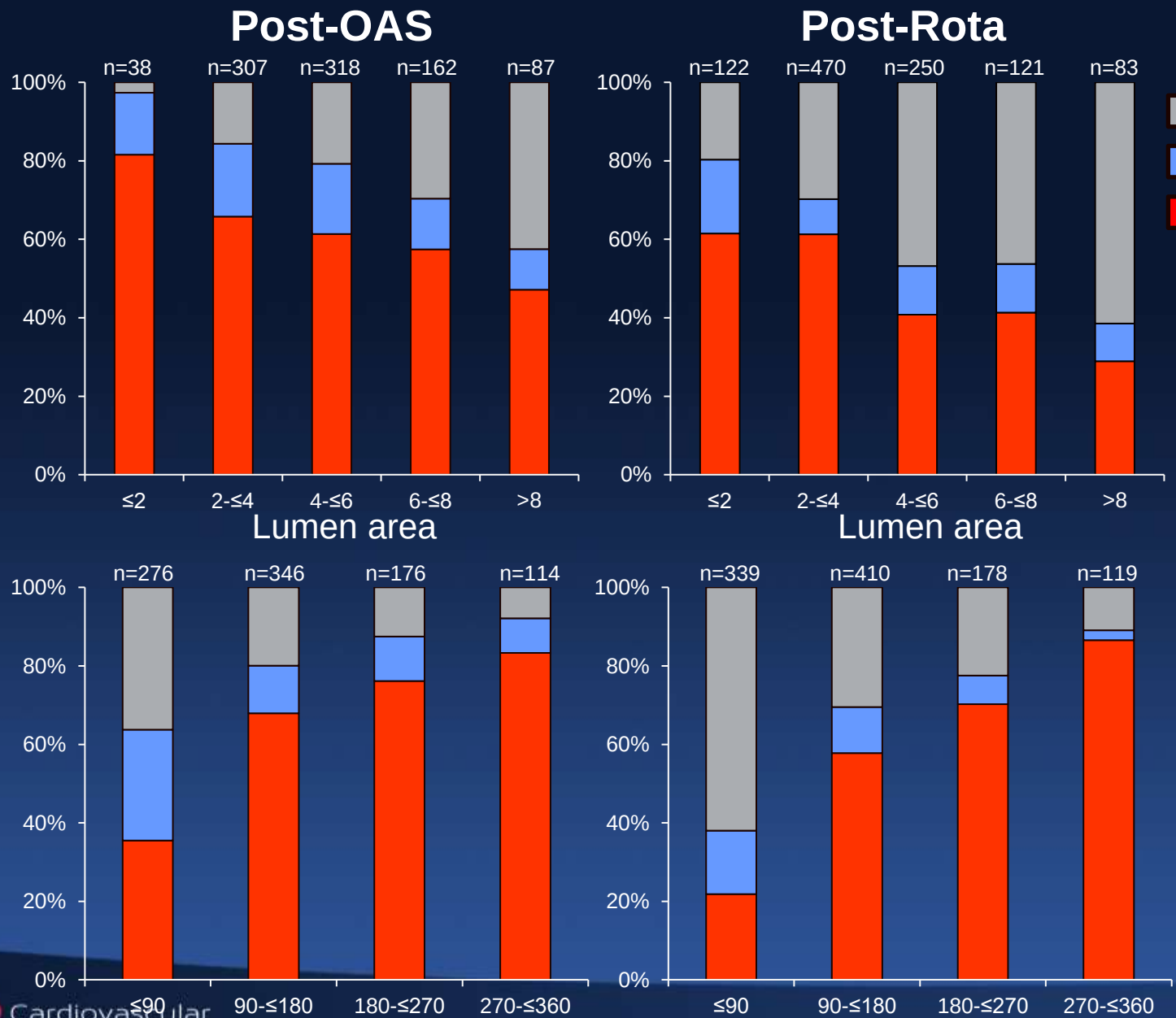
Difference between Rota and OAS

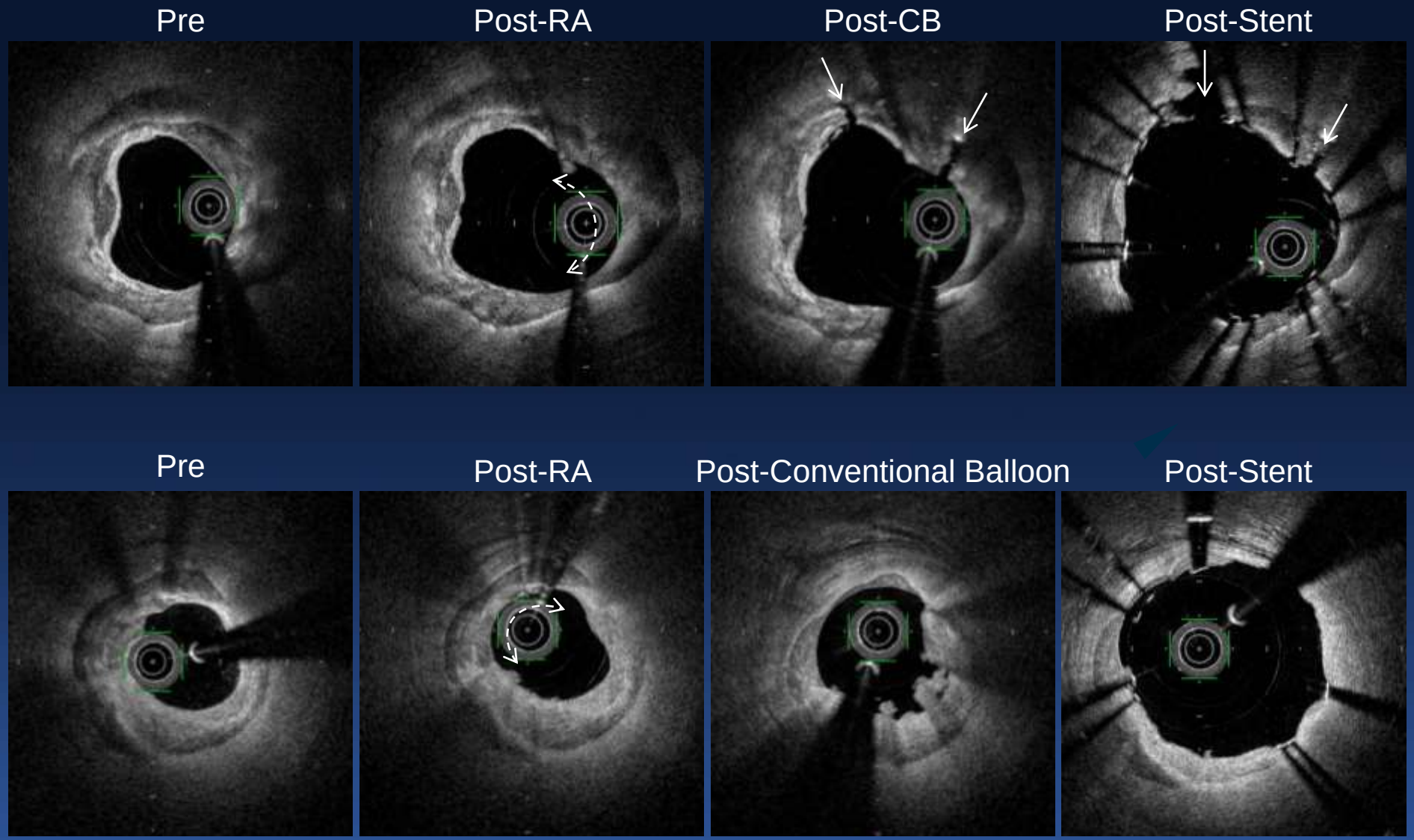


	OAS	Rota	P
Slice # with any Ca	912	1042	
LA>4mm^2, %	64%	52%	0.09
LA≤4mm^2, %	71%	67%	0.81

- Wire bias: OAS=Rota
- Differential cutting: OAS<Rota
- Large lumen: OAS>Rota
- Small calcium: OAS>Rota

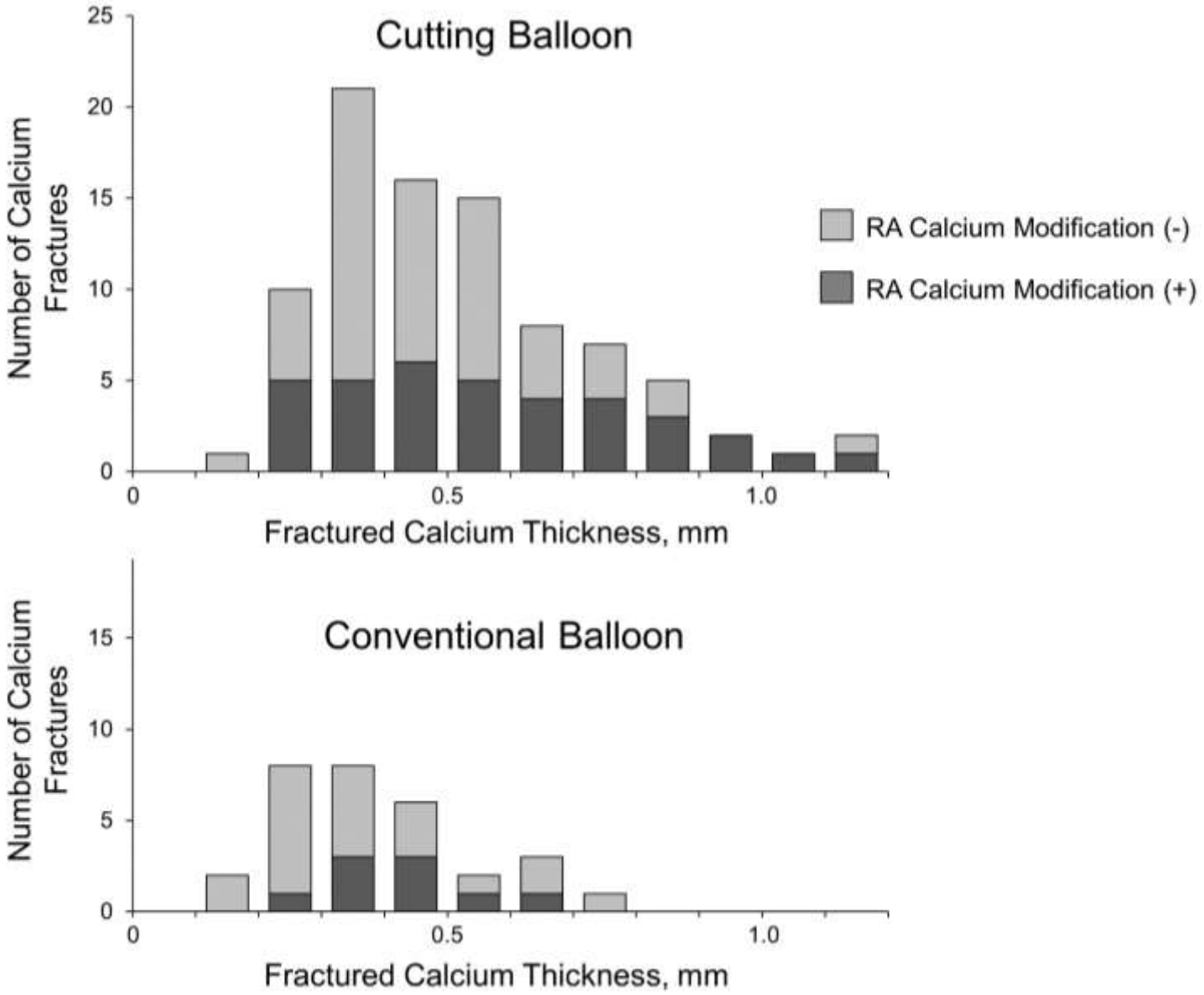
Yamamoto M JACC Interv 2017; 10:2584-6.

Rota and Cutting Balloon



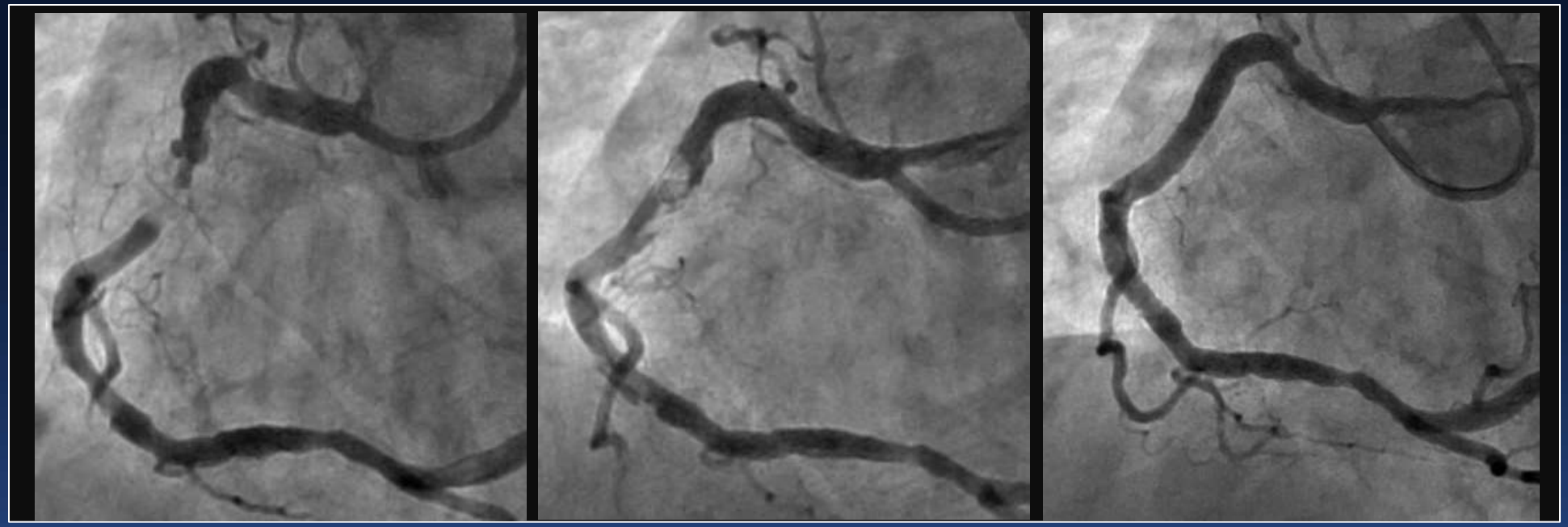
Amemiya K, et al. CCI 2019 doi:10.1002/ccd.28278

Effect of CB following Rota



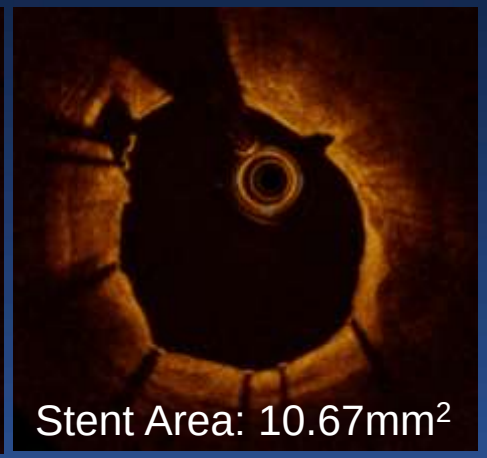
Amemiya K, et al. CCI 2019 doi:10.1002/ccd.28278

Shockwave - Lithotripsy -

Baseline	Post Lithoplasty	Final
		
3.6mm RVD 87.6% stenosis 37.5mm length	4.0mm Lithoplasty	4.0% stenosis Acute gain 3.1 Stent length 40.5mm

Ziad A, et al. JACC Img 2017;10:897-906.

Shockwave - Lithotripsy -

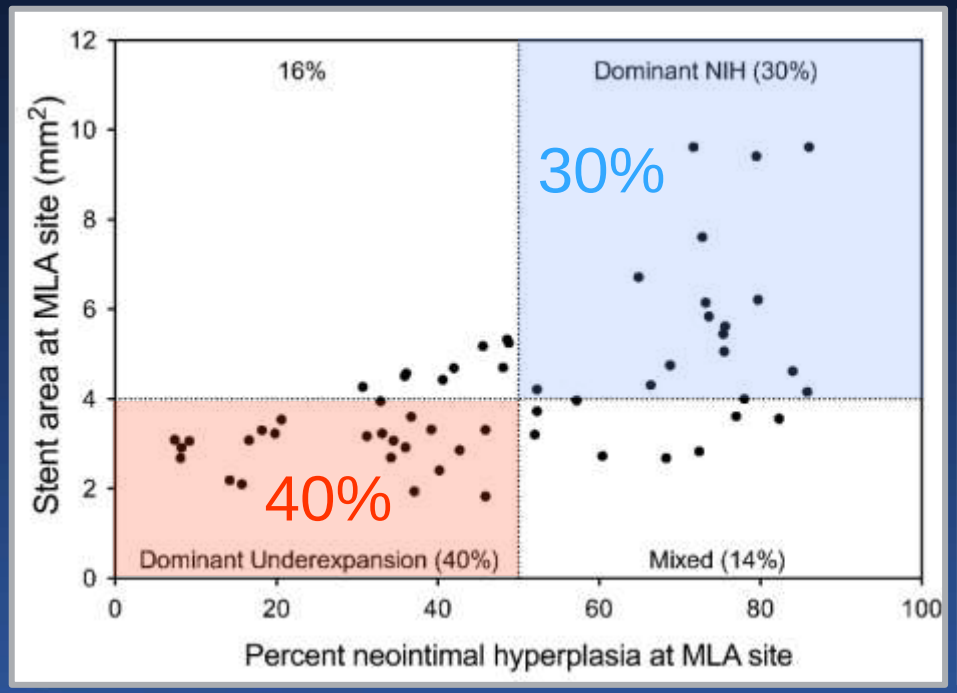
Pre	Post-Lisotripsy	Post-Stent
 Lumen Area: 4.12mm^2	 Lumen Area: 6.40mm^2	 Stent Area: 8.16mm^2
 Lumen Area: 6.27mm^2	 Lumen Area: 7.61mm^2	 Stent Area: 10.67mm^2

Ziad A, et al. JACC Img 2017;10:897-906.

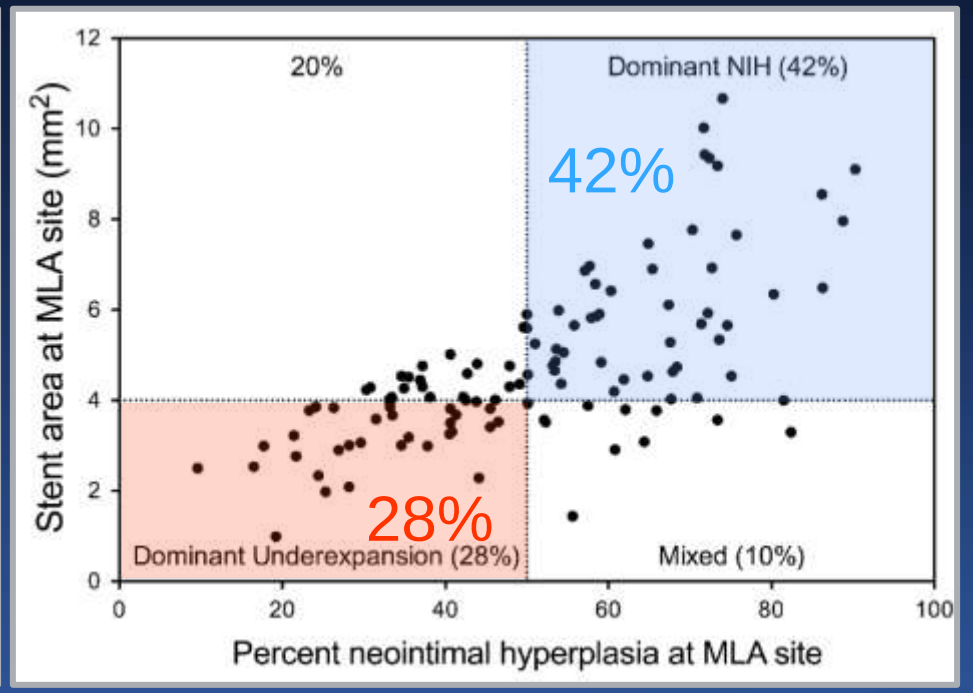
Different Mechanism between ISR ≤1 Year vs >1 Year in 2nd GEN DES by OCT

Dominant stent under-expansion: Minimum stent area<4mm^2
Dominant NIH: % Neointimal hyperplasia (NIH)>50%

Duration from implantation ≤ 1year (n=57)

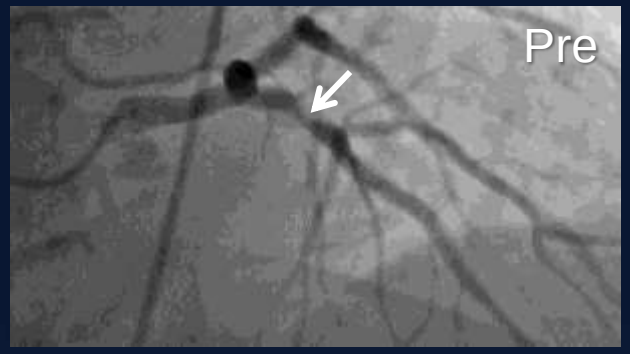


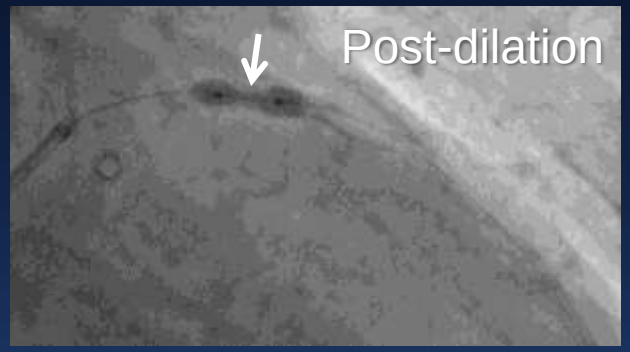
Duration from implantation > 1year (n=114)

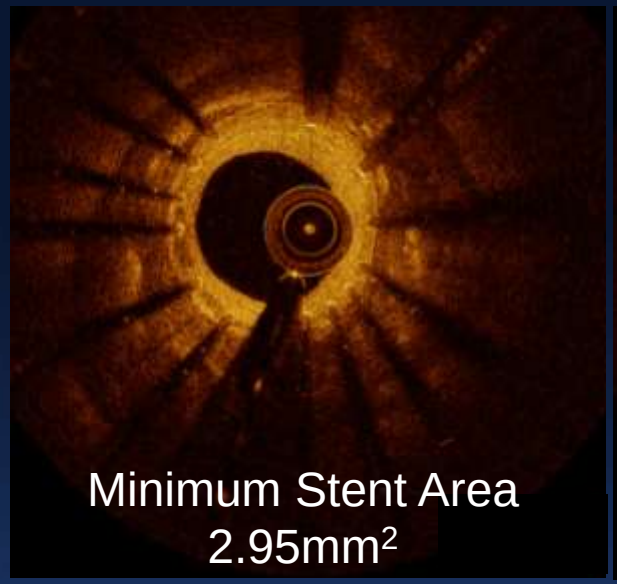


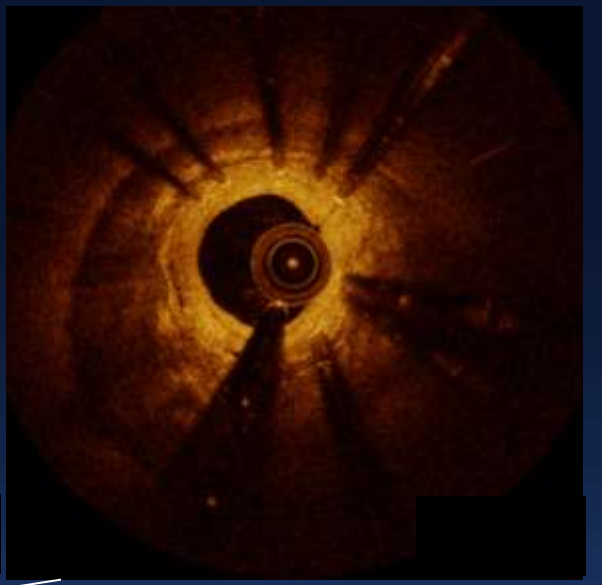
Song L et al. EuroIntervention 2017 13: 294-302.

79 yo, Recurrent ISR



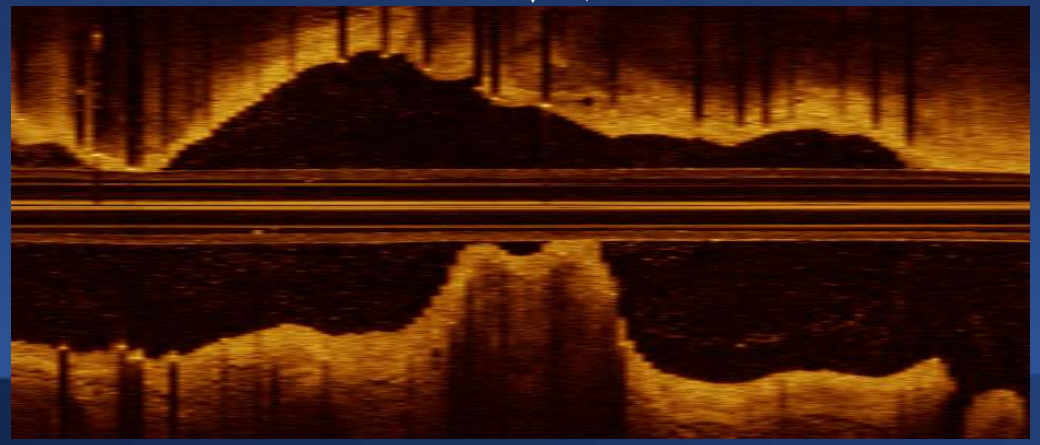




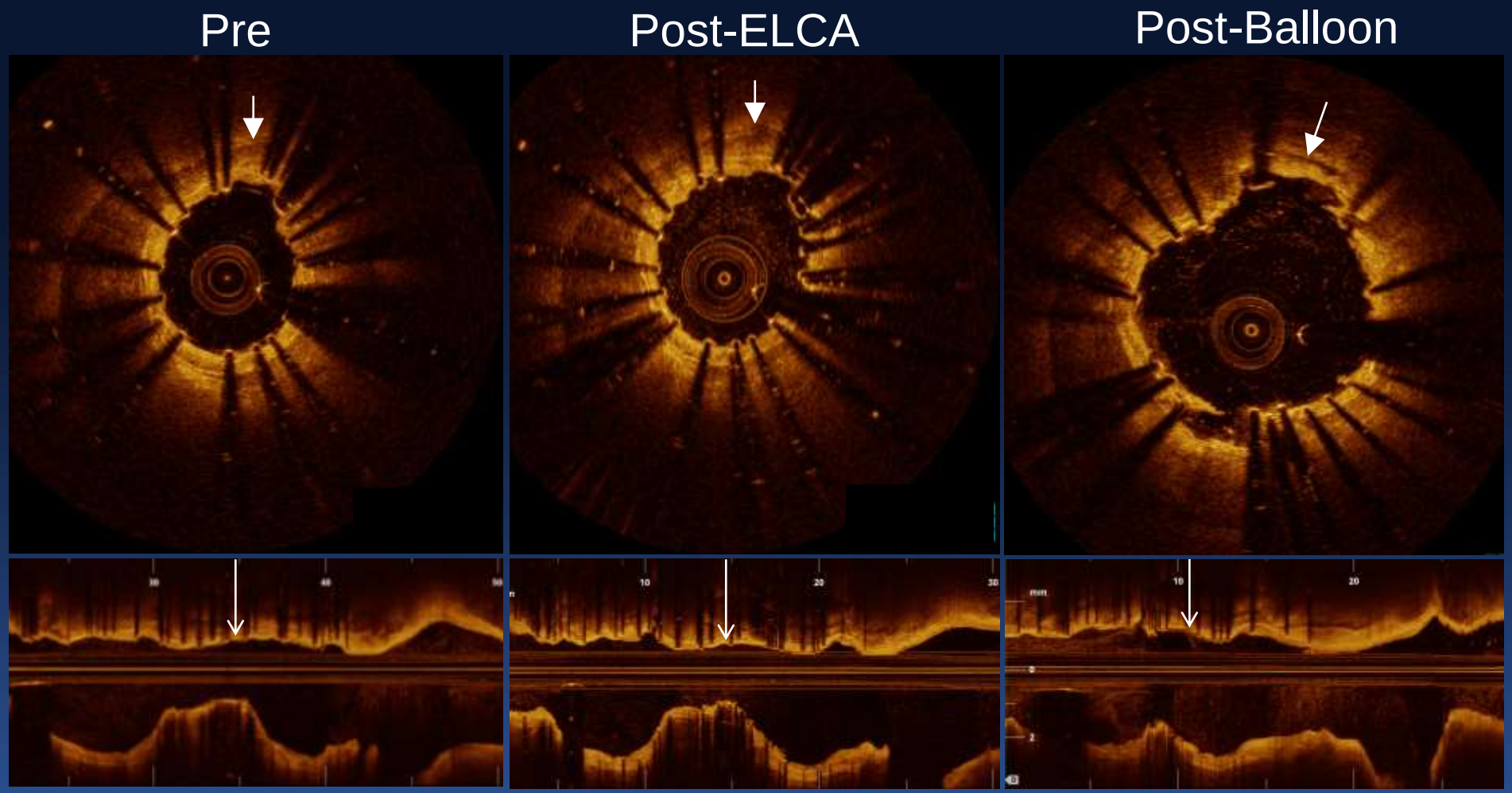


Distal

Proximal



Successful Treatment by ELCA



Yin D et al. JACC Interv, 2015; 8: e137-9.

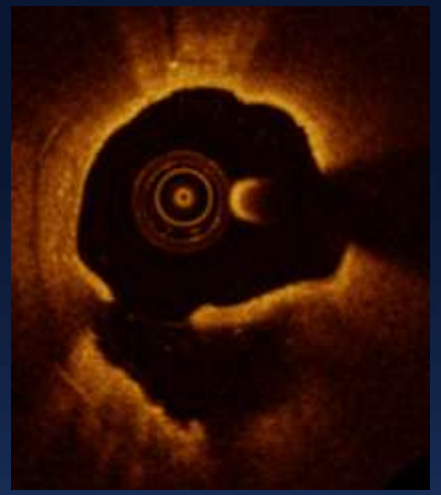
With vs without ELCA to Treat ISR with Peri-Stent Severe Calcium

	ELCA (n=23)	POBA (n=58)	P
Max peri-stent Ca arc, °	289 (231,360)	258 (210,307)	0.09
Pre Min Lumen Area, mm^2	2.0 (1.3, 2.6)	1.8 (1.4, 2.1)	0.01
Pre Min Stent Area, mm^2	3.2 (2.3, 4.6)	3.5 (3.1, 4.2)	0.41
Final Min Lumen Area, mm^2	4.8 (3.3, 5.6)	3.5 (2.8, 4.1)	0.01
Final Min Stent Area, mm^2	6.2 (4.8, 7.1)	4.7 (3.8, 5.4)	0.01
Final Ca Fracture	61%	12%	0.01

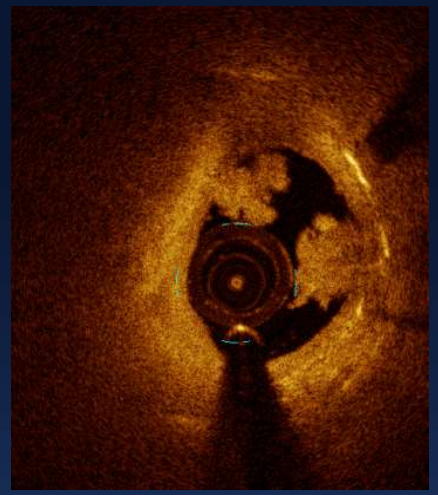
Lee C, et al. *Eurointervention* doi 10.4244/EIJ-D-18-00139.

Late Stent Failure OCT Imaging

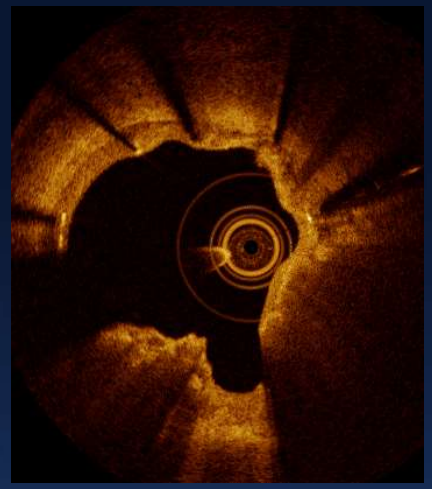
Neointimal rupture



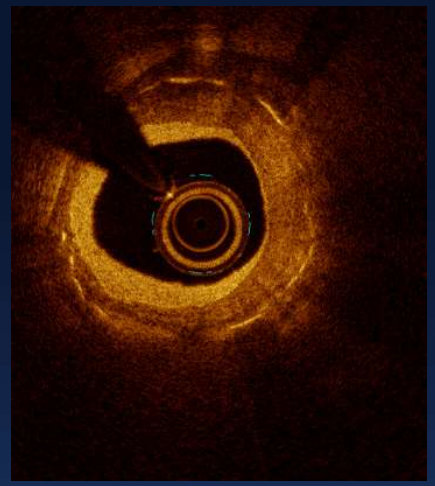
Thrombus w/o rupture



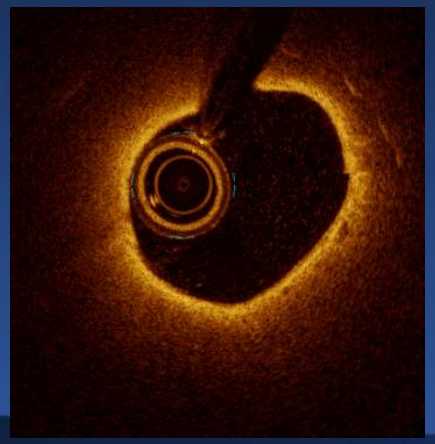
Neointimal calcified nodule



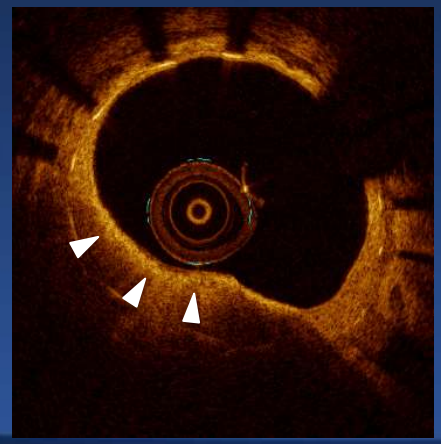
Neointimal calcified plate



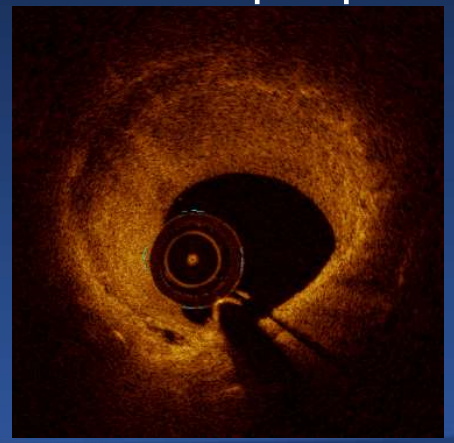
Lipidic plaque



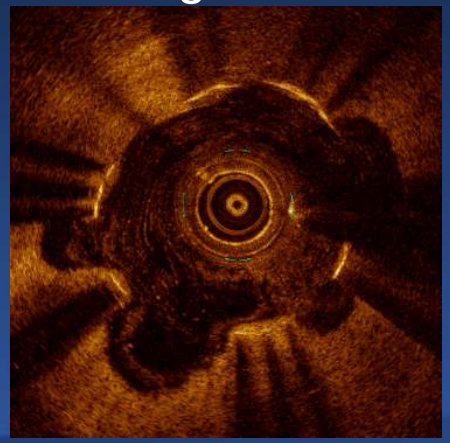
Macrophage



Healed plaque



Evagination



Song L et al. Int J Cardiovasc Img 2017 33: 1115-24.

Cardiovascular Research Foundation

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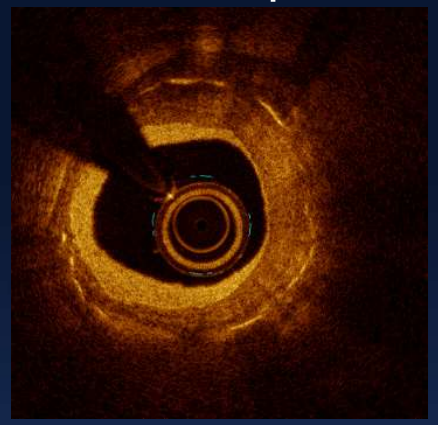
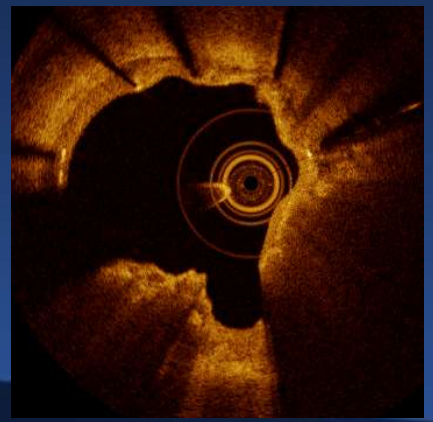
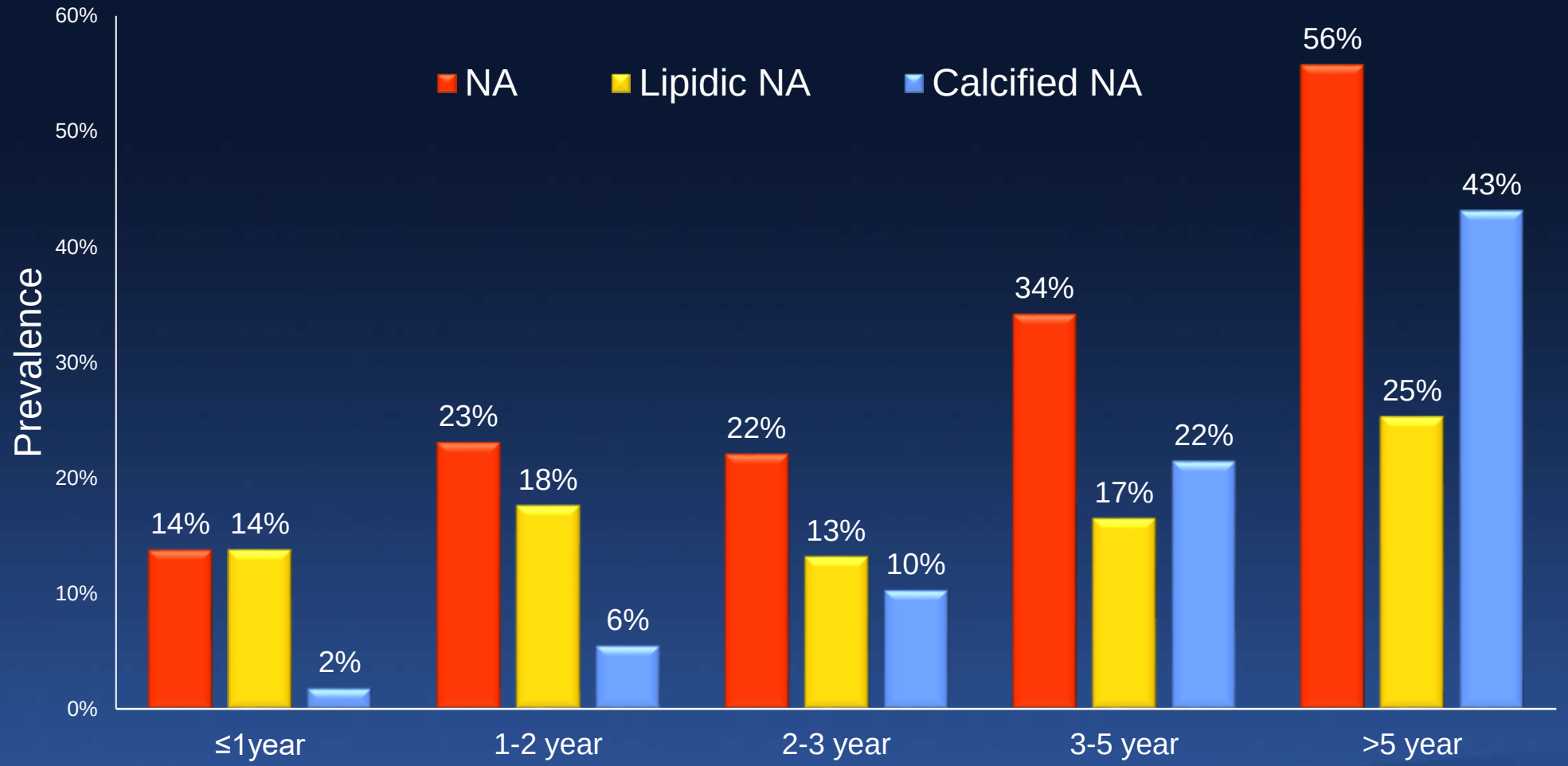
Prevalence of Neoatherosclerosis (NA) in 2nd GEN DES

Neointimal calcified plate



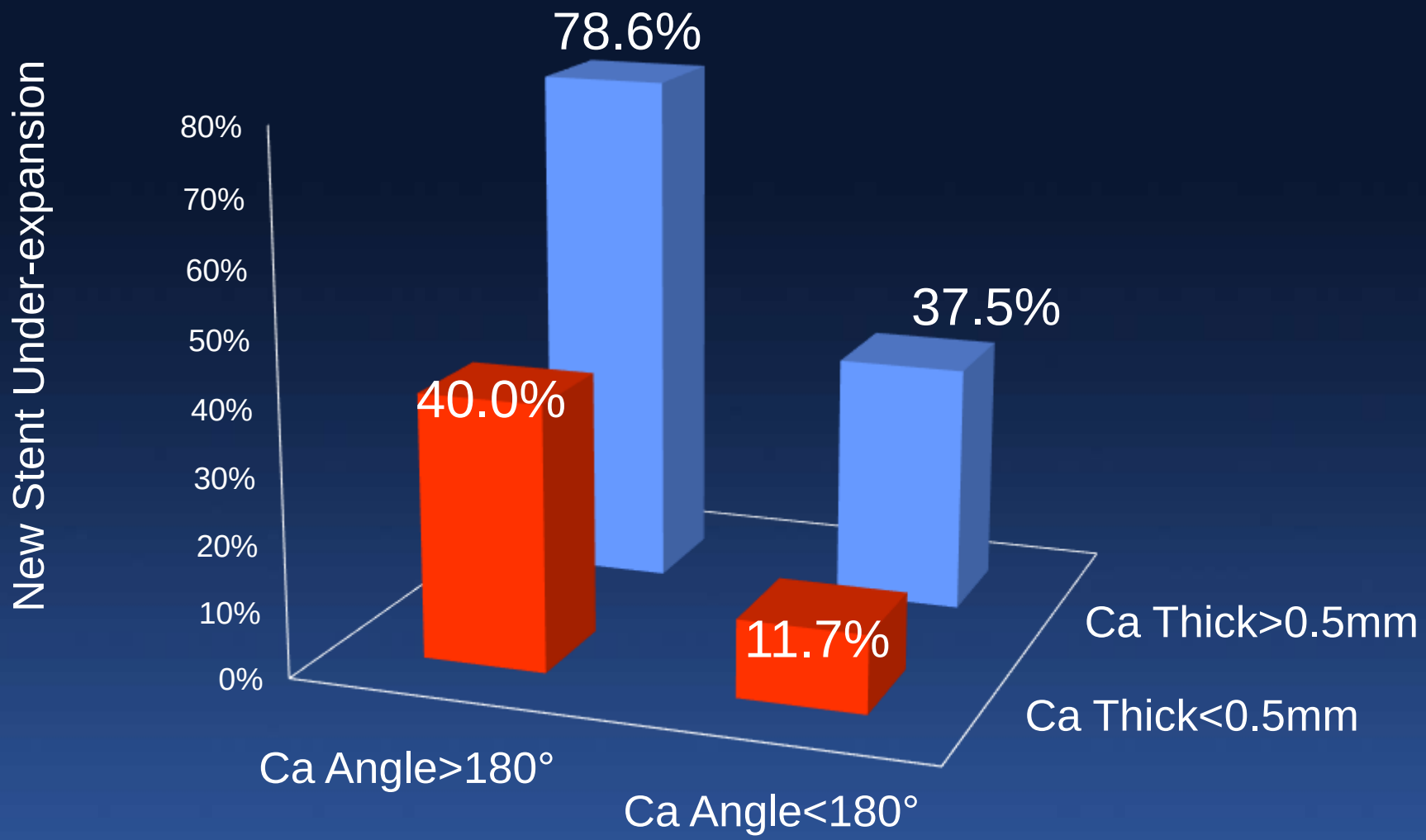
Neointimal calcified nodule





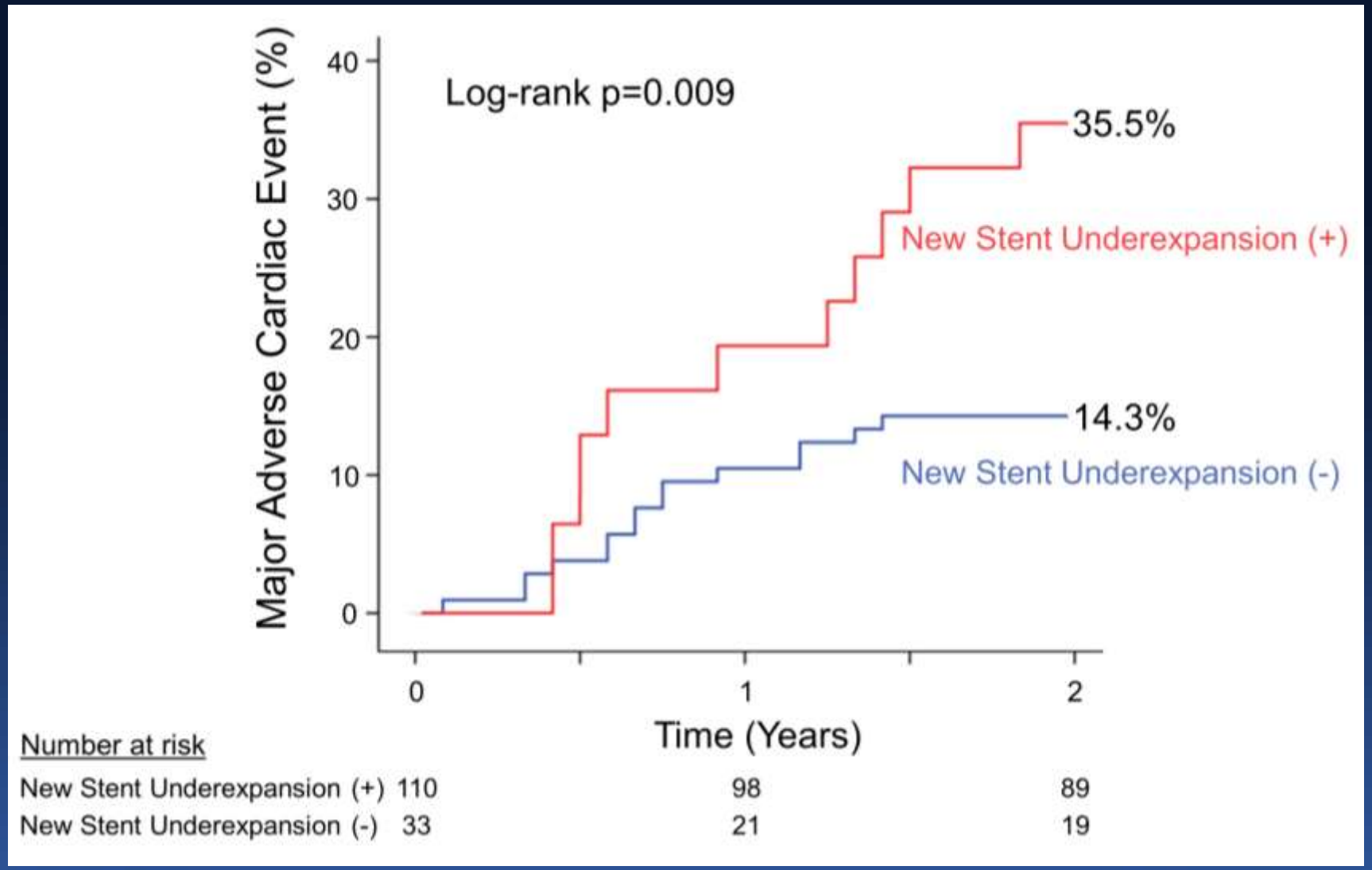
Chen Z et al. ACC2019

Neointimal Calcium Predict New Stent Expansion



Yin D et al. Eurointervention 2020 16 e335-343.

New Stent Expansion Predict Subsequent Outcome



Yin D et al. Eurointervention 2020 16 e335-343.

CONCLUSION

1. Angiographic invisible calcium is thin calcium and it dose not inhibit stent expansion.
2. Calcium volume (thickness, angle, length) predicts stent expansion in *de novo* and ISR calcified lesions.
3. Calcium fracture is a key mechanism of good stent expansion.
4. Calcium modification (atherectomy, lithotripsy) facilitate calcium fracture even in thick calcium and result in good stent expansion.