Intravascular Imaging for Guidance of Plaque Modification Strategies in Calcified Coronary Artery

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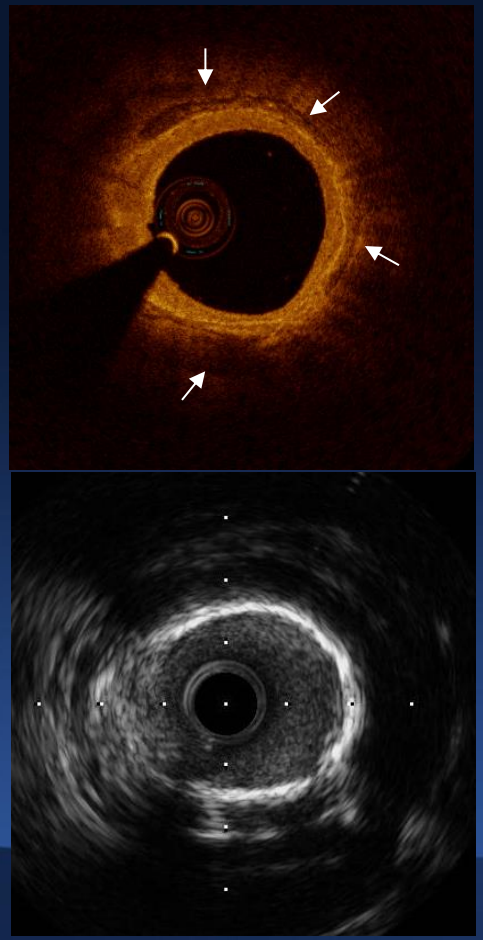
Disclosure Statement of Financial Interest

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

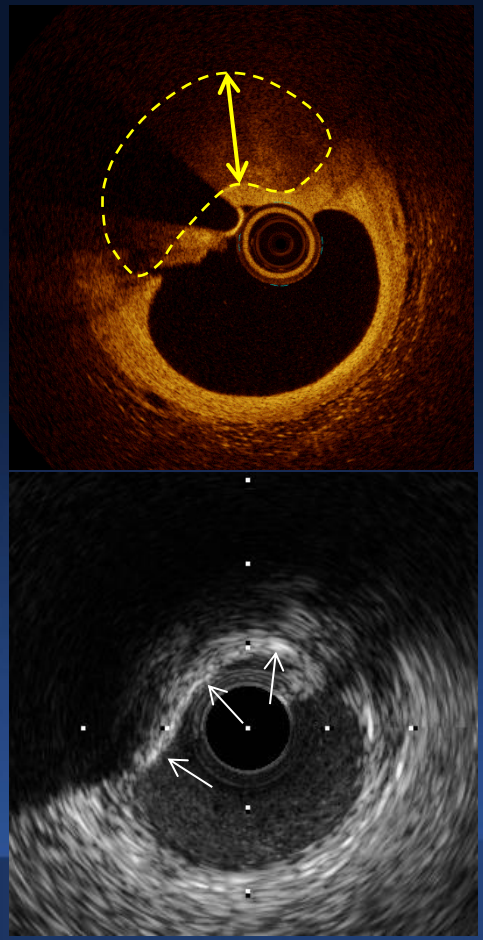
Affiliation/Financial Relationship	Company
• Grant/Research Support	• Boston Scientific, Abbott Vascular

Calcified Lesion

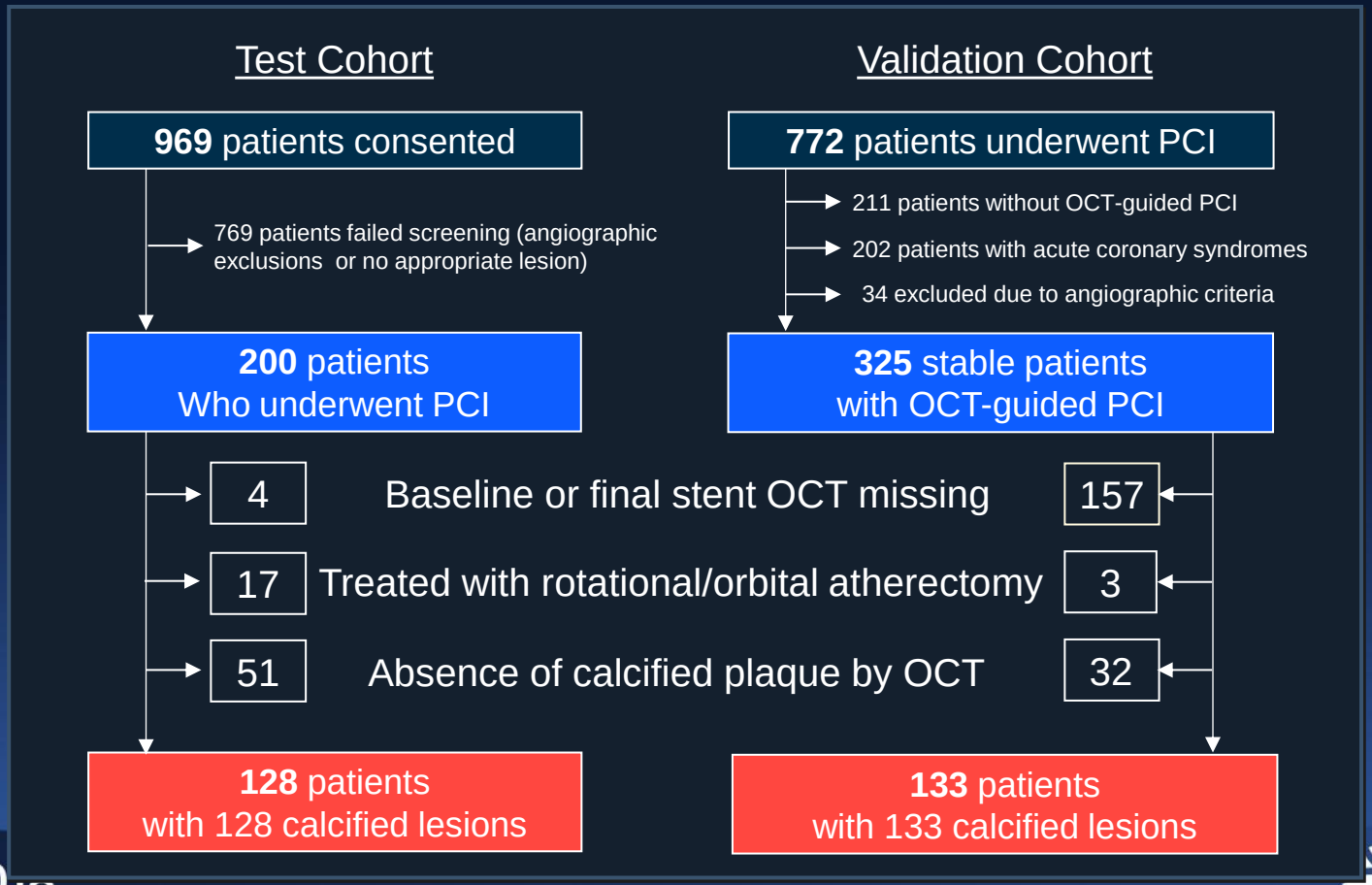
Thin Calcium



Thick Calcium



Study Flow Chart



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

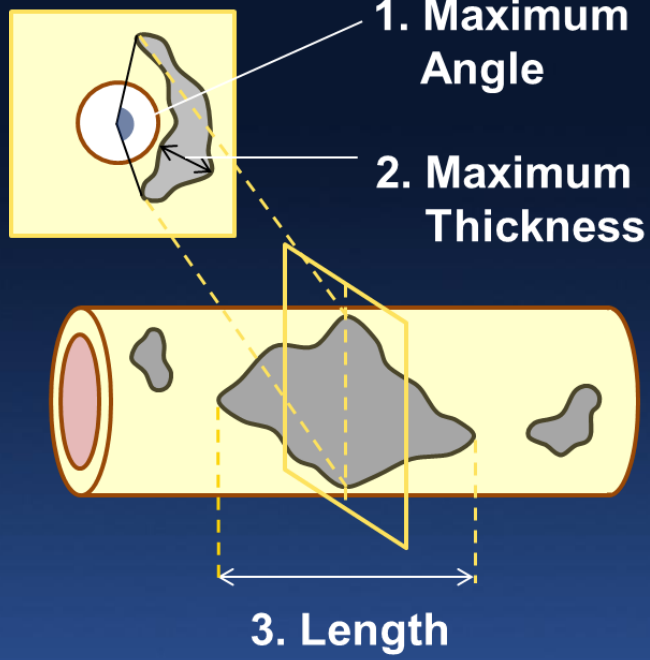
Multivariate Linear Regression Model to Predict Stent Expansion

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.

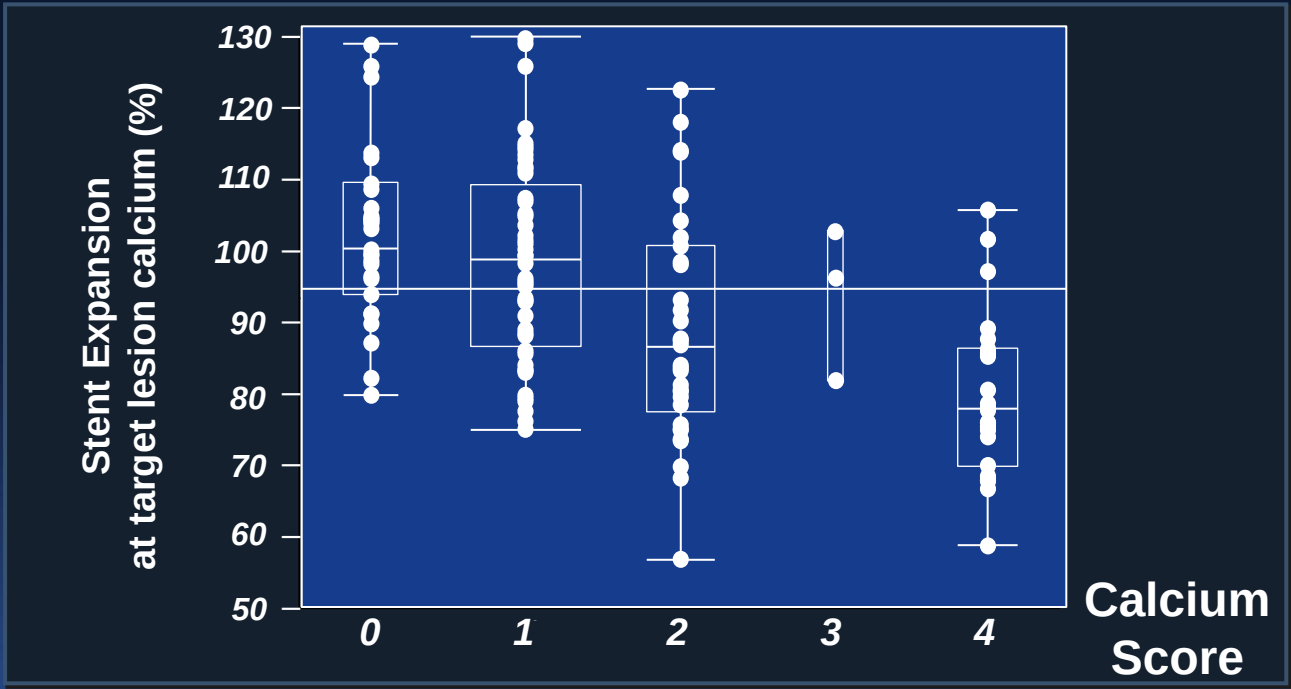
Calcium Scoring System



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	

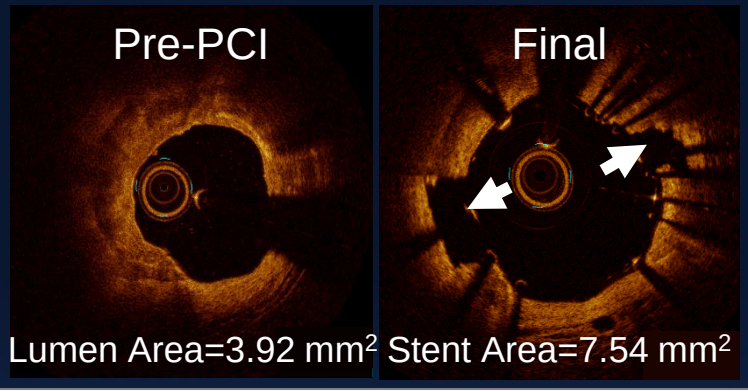
Fujino A et al. EuroIntervention. 2018;13:e2182-9.

Calcium Score Predicts Stent Expansion

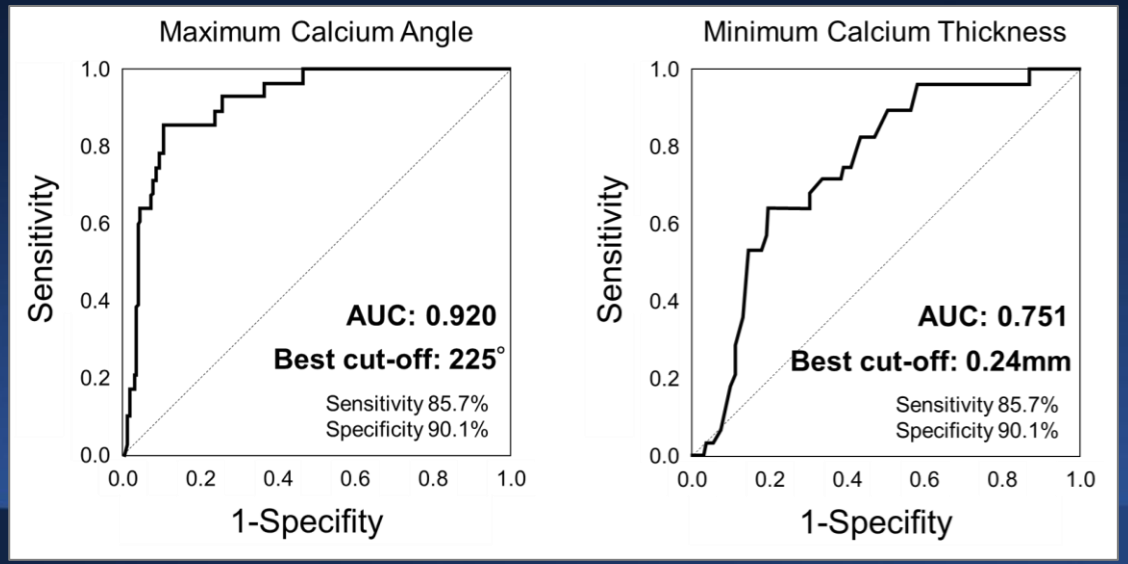


CVI score	0	1	2	3	4	p Value
Expansion at target lesion calcium, %	99	98	86	98	78	<0.01
Expansion at minimum stent area, %	91	85	80	82	69	<0.01

Ca Morphology to Predict Ca Fracture without Atherectomy

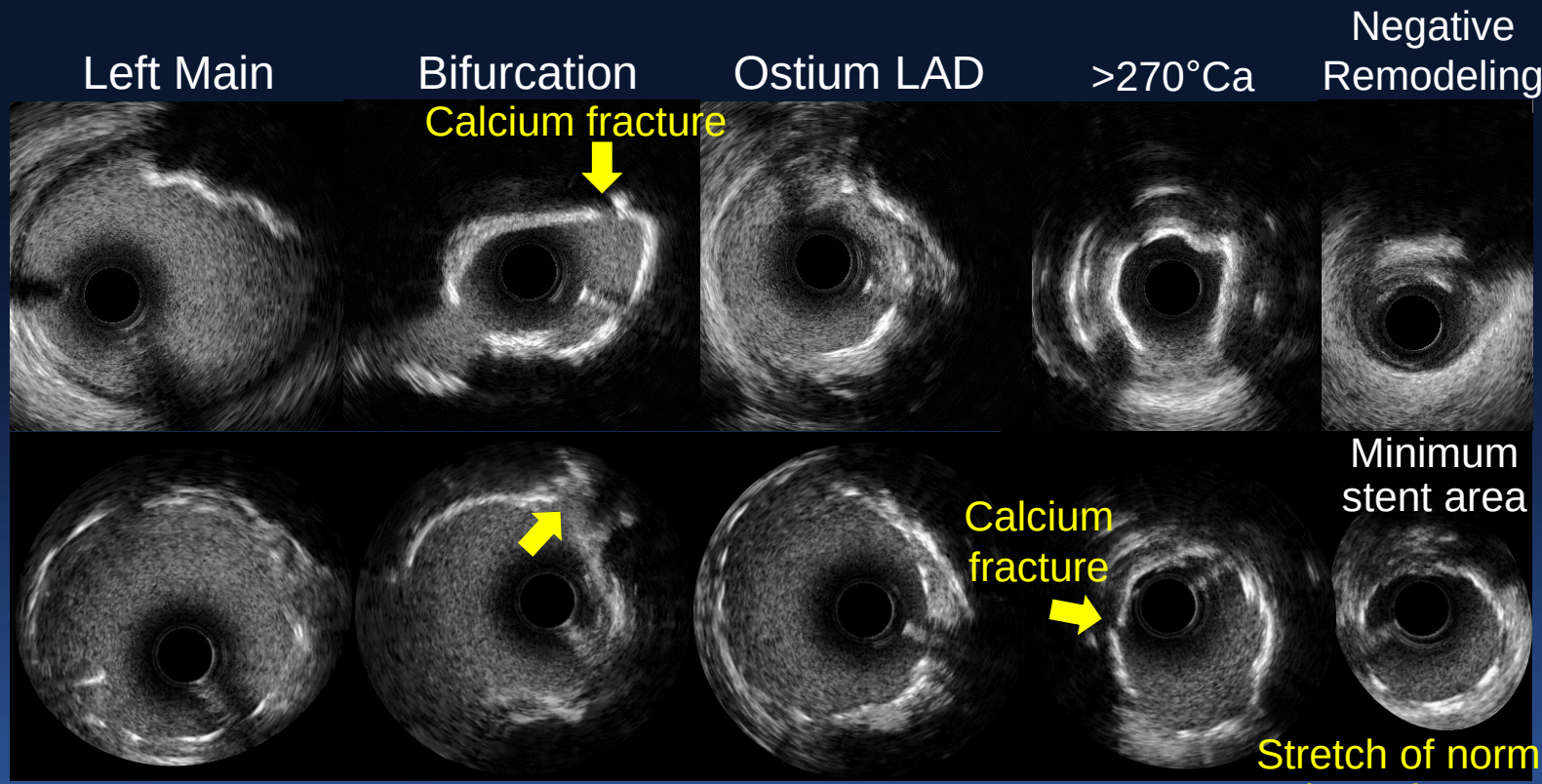


Calcium Fracture



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

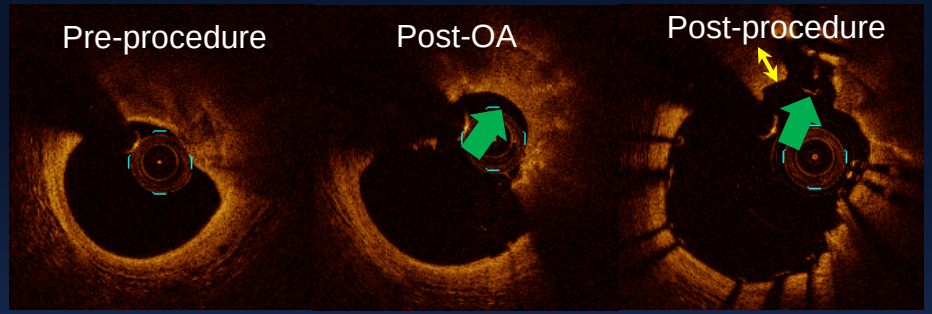
Comparison between Pre and Post IVUS in LAD



Orbital Atherectomy

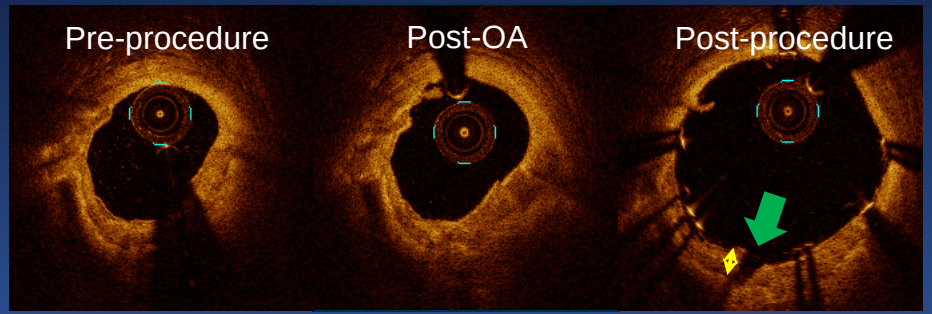
Ca Fracture
With and Without Ca Modification by OAS

Ca modification
(+)



Fractured Ca thickness = 0.62 mm

Ca modification
(-)



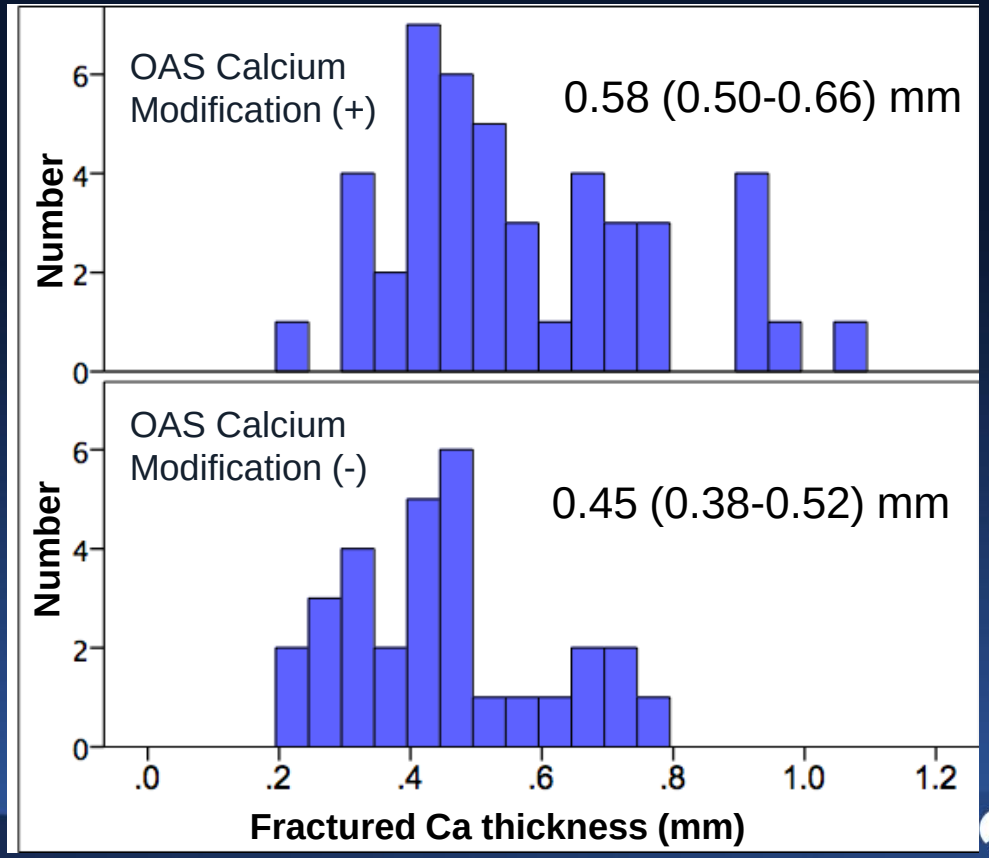
Fractured Ca thickness = 0.32 mm

Yamamoto M JACC Catheter Cardiovasc Interv, *in press*

Fractured Ca Thickness With and Without Ca Modification by OAS

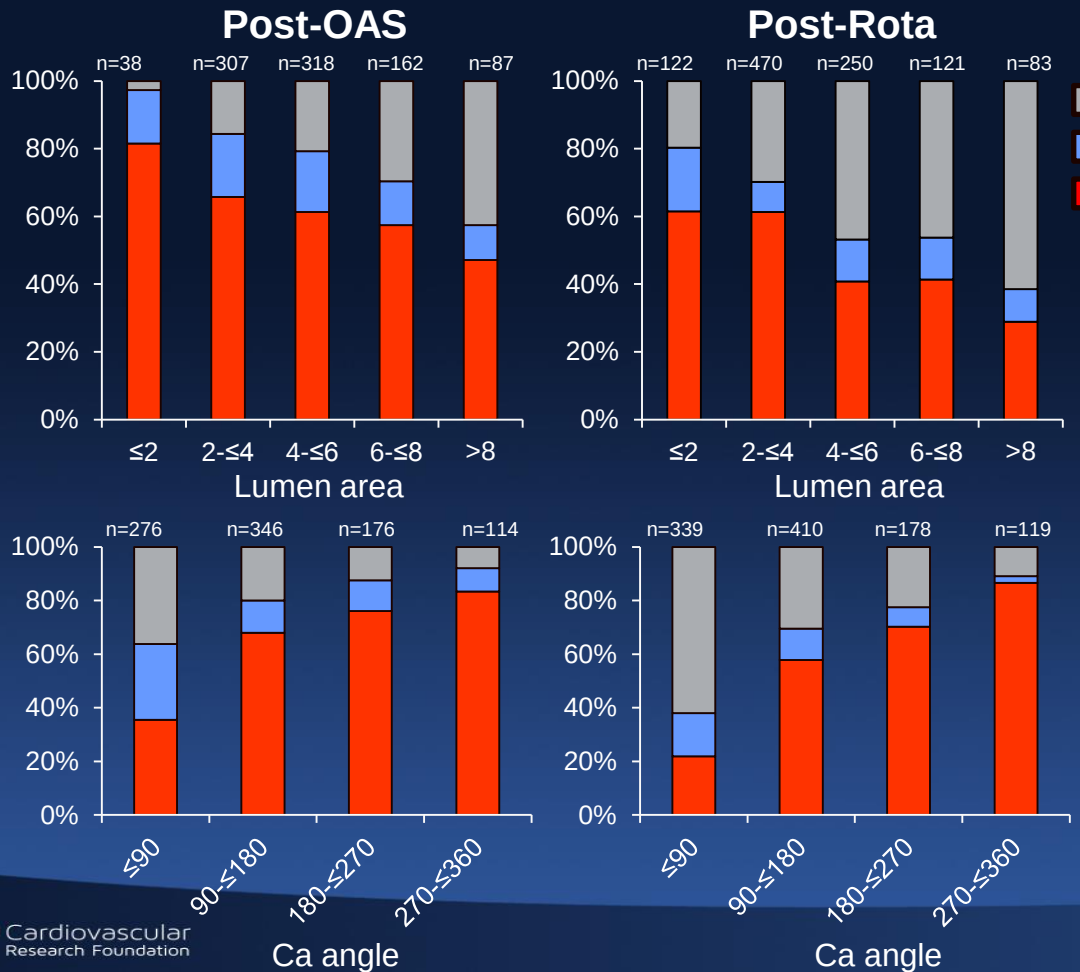
Comparison between OAS Ca Modification (+) vs (-)

GEE adjusted p-value=0.003



Yamamoto M JACC Catheter Cardiovasc Interv, *in press*

Difference between Rota and OAS

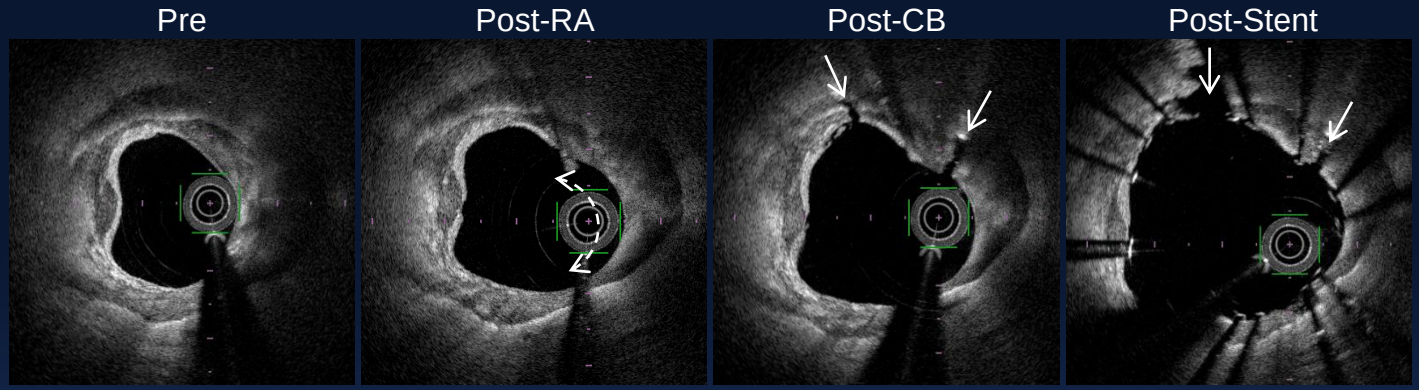


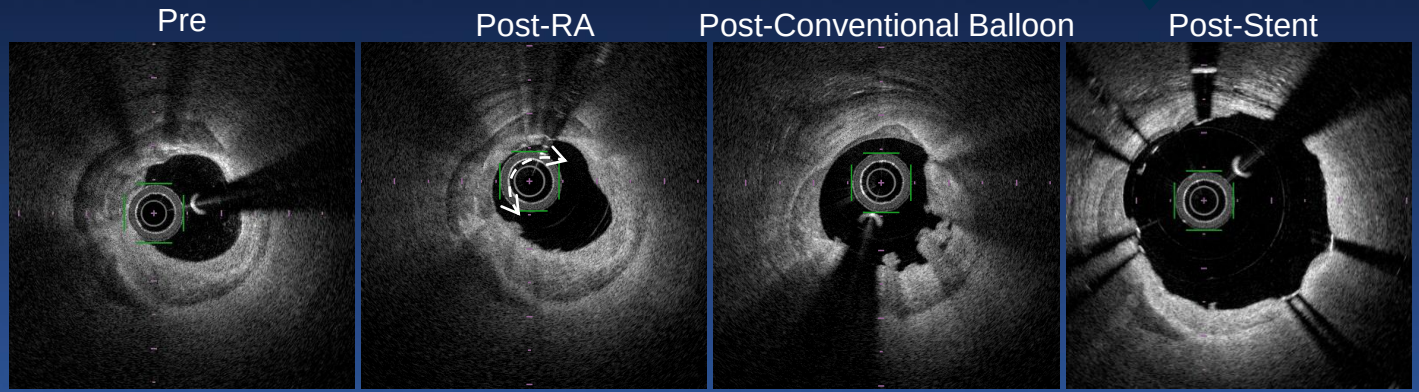
	OAS	Rota	P
Slice # with any Ca	912	1042	
LA>4mm^2, %	64%	52%	0.09
LA≤4mm^2, %	71%	67%	0.81

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

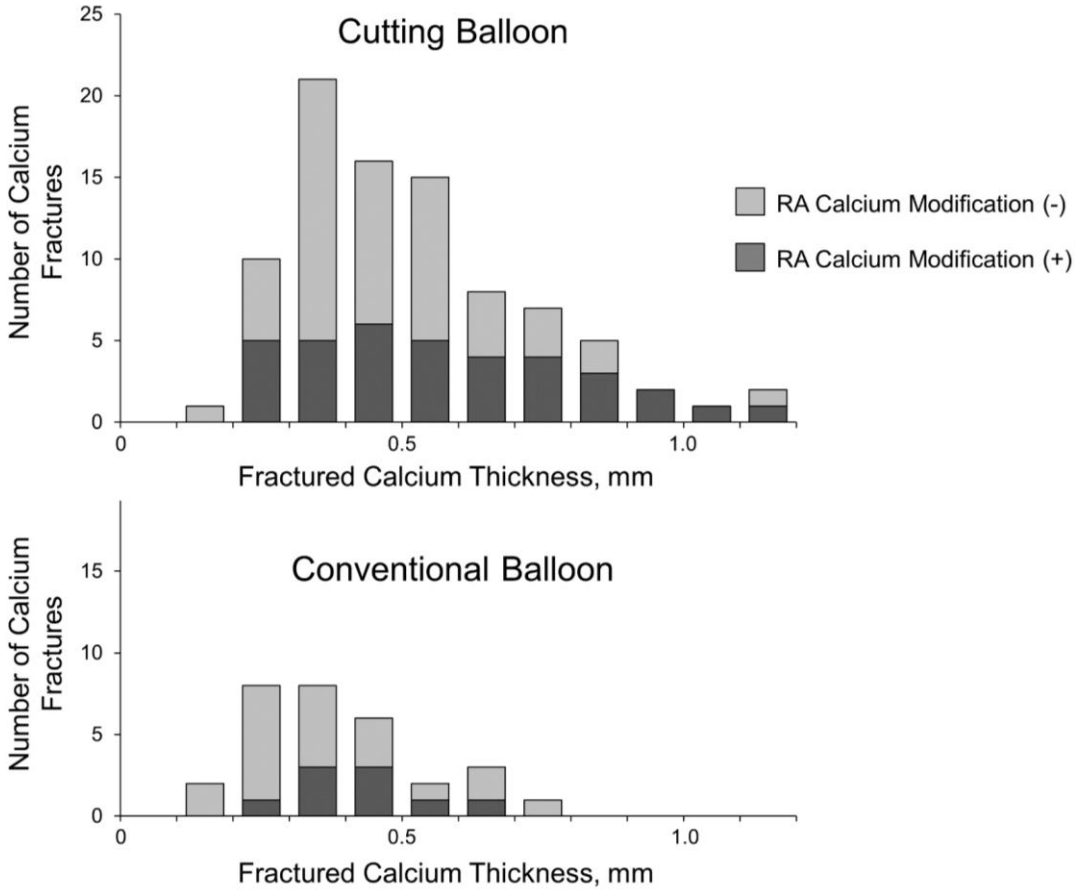
Yamamoto M JACC Interv 2017; 10:2584-6.

Rota and Cutting Balloon

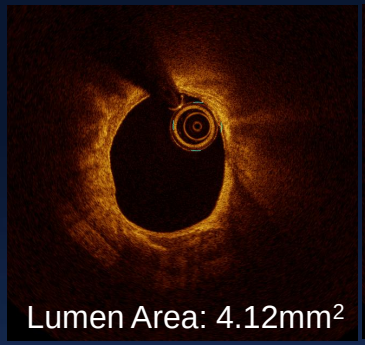
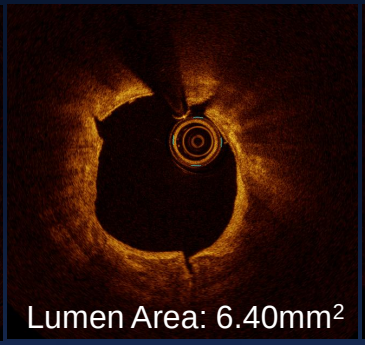
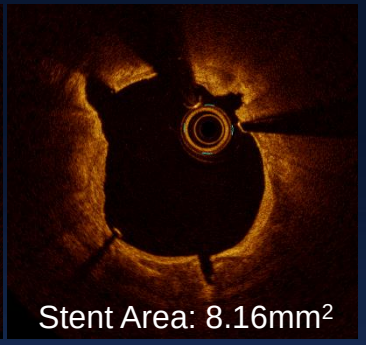
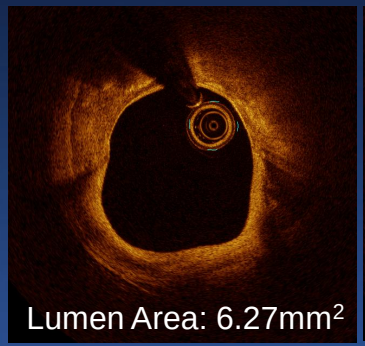
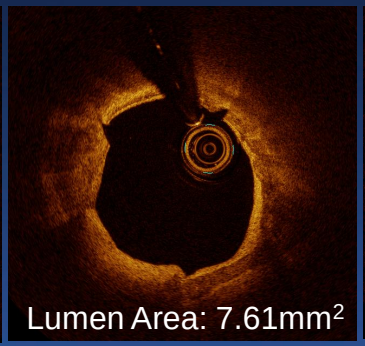
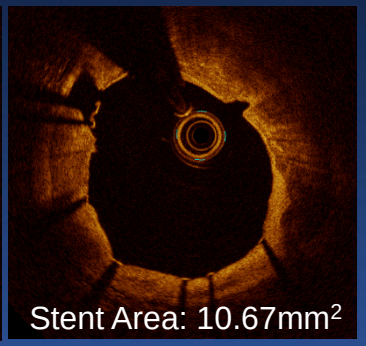




Effect of CB following Rota



Shockwave - Lithotripsy -

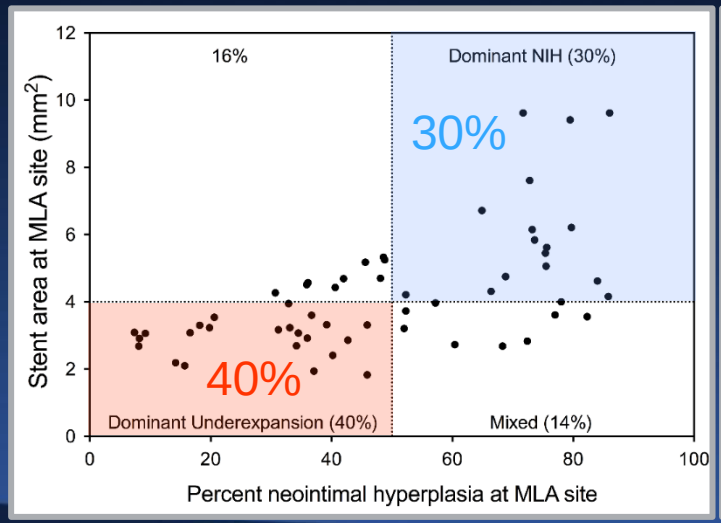
Pre	Post-Lisotripsy	Post-Stent
 Lumen Area: 4.12mm^2	 Lumen Area: 6.40mm^2	 Stent Area: 8.16mm^2
 Lumen Area: 6.27mm^2	 Lumen Area: 7.61mm^2	 Stent Area: 10.67mm^2

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

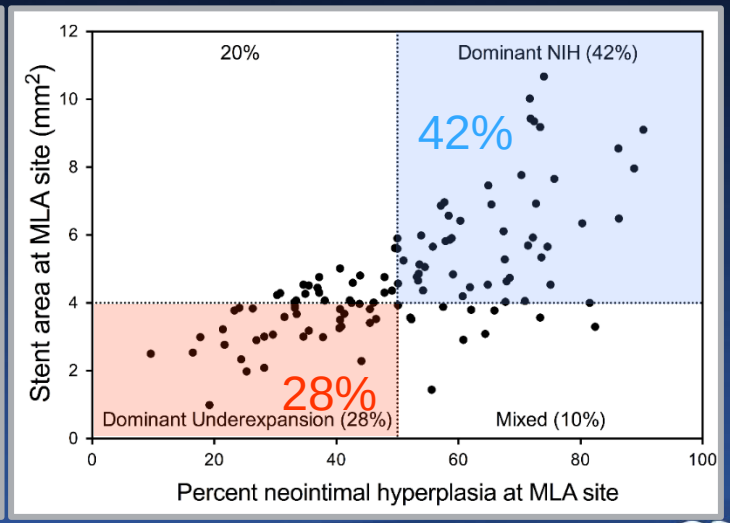
Different Mechanism between ISR ≤1 Year vs >1 Year in 2nd GEN DES by OCT

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

Duration from implantation ≤ 1year (n=57)

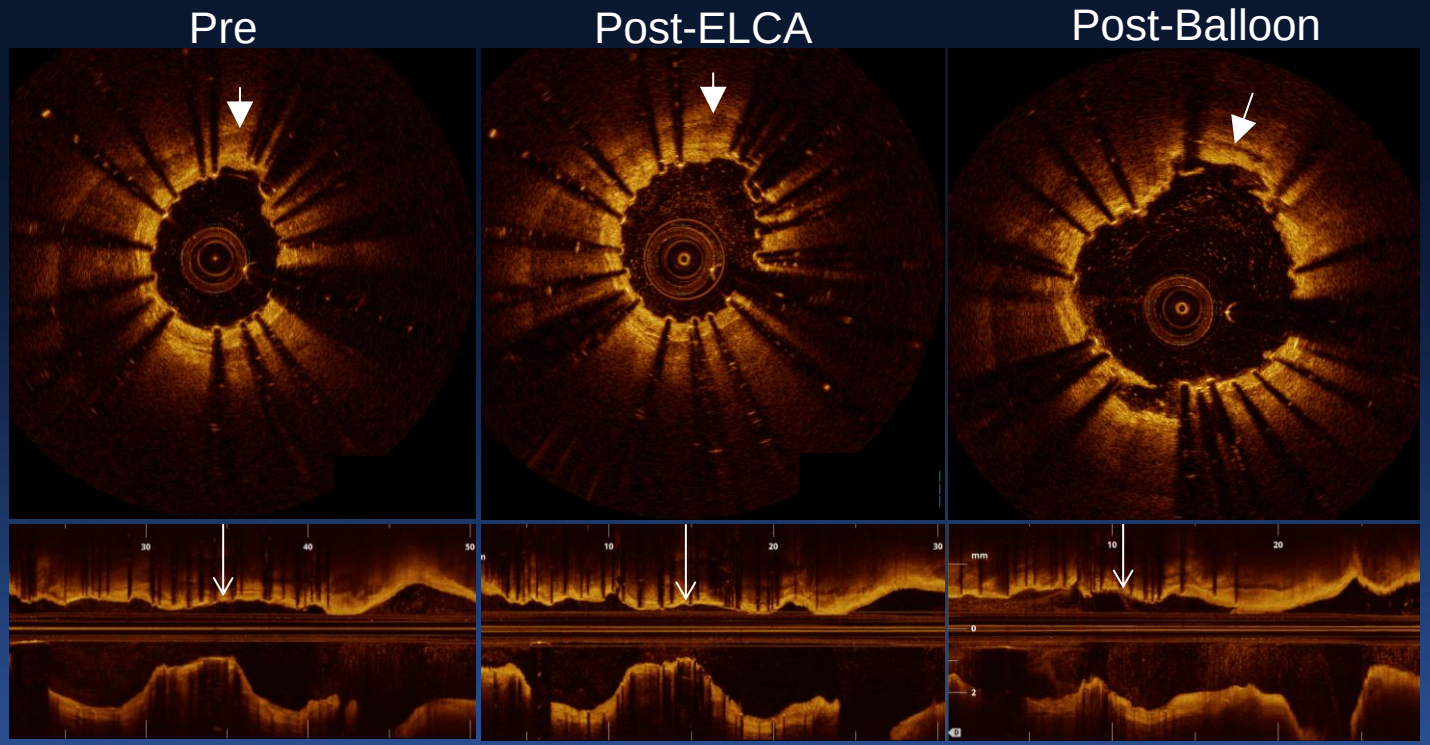


Duration from implantation > 1year (n=114)



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

Successful Treatment by ELCA for ISR - Stent Under-expansion due to Underlying Calcium



Minimum Lumen Area
2.76 mm^2

Minimum Lumen Area
6.34 mm^2

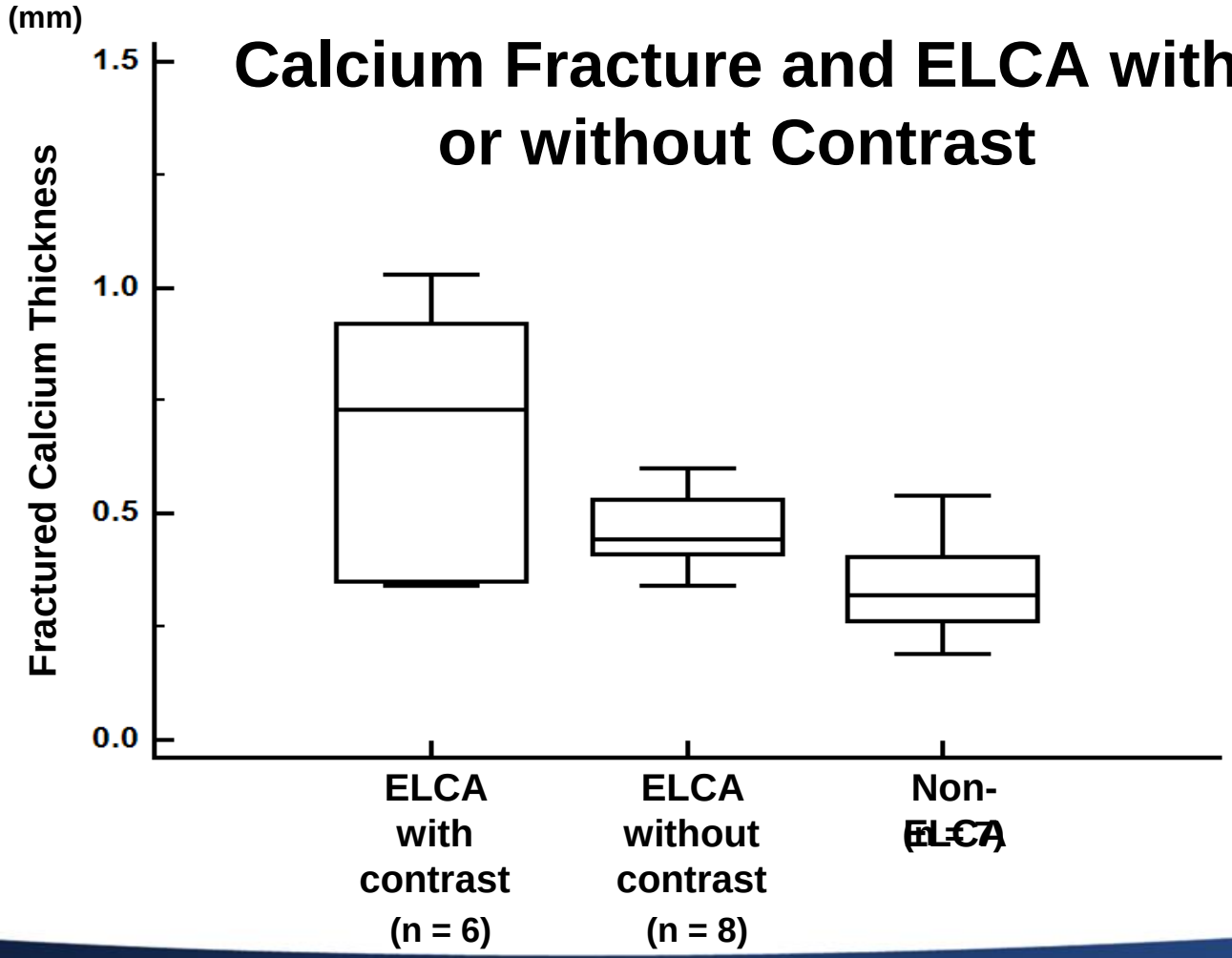
Yin D et al. JACC Interv, 2015; 8: e137-9.

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

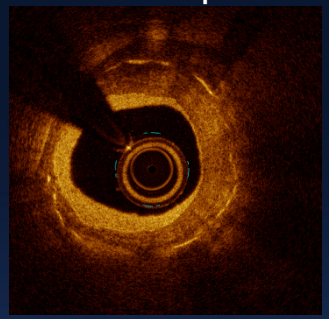
Lee C, et al. *EuroIntervention* doi 10.4244/EIJ-D-18-00139.

Calcium Fracture and ELCA with or without Contrast

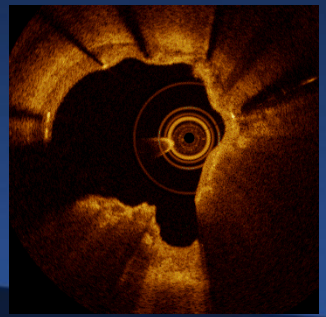


Prevalence of Neoatherosclerosis (NA) in 2nd GEN DES

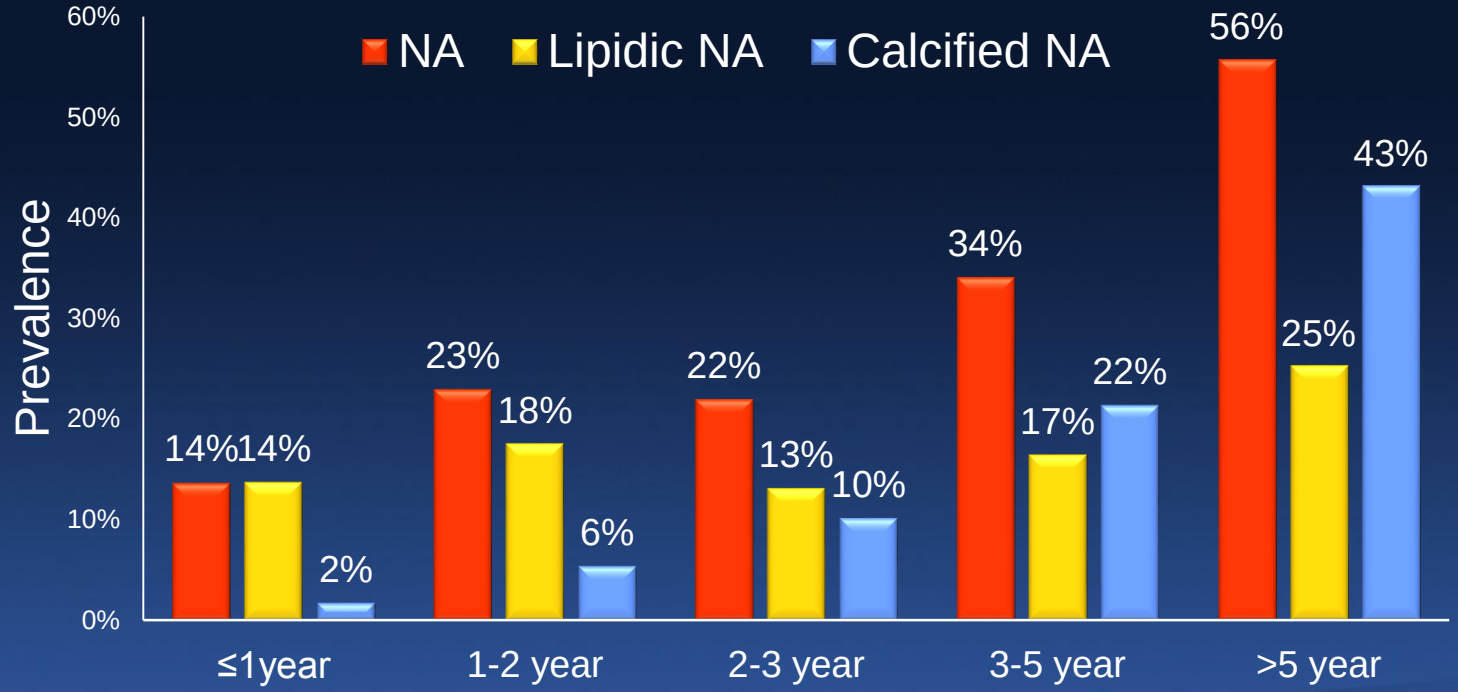
Neointimal calcified plate



Neointimal calcified nodule

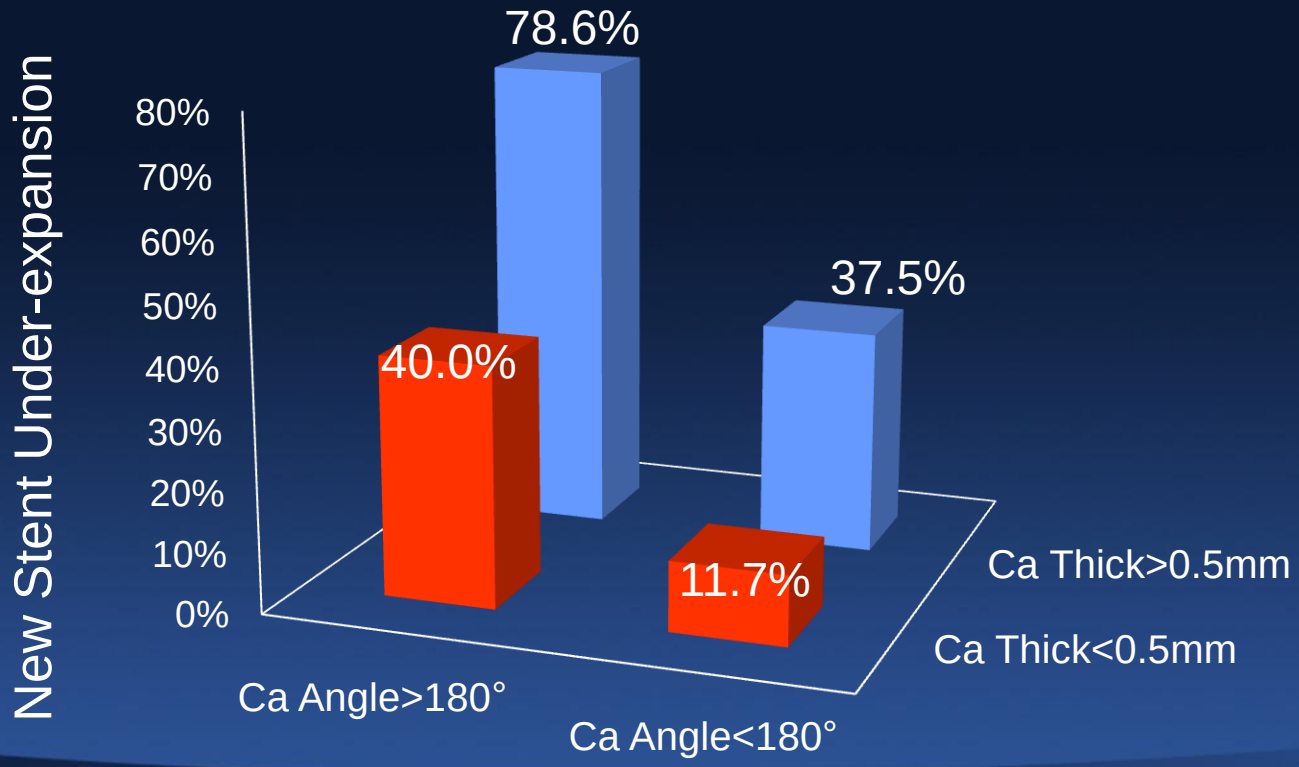


N=442



Chen Z et al. ACC2019

Neointimal Calcium Predict New Stent Expansion



Yin D et al. TCT2017

Summary

1. The prediction of new stent expansion of de novo or neointimal calcium in the old stent is similar (calcium thickness, angle, length=calcium volume is important).
2. The mechanism of good stent expansion in the severe calcified lesion is calcium fracture which can be achieved by modification of surface of calcium.
3. Calcium modification (atherectomy) facilitate calcium fracture even in thick calcium and good stent expansion.