

Prediction of Stent Expansion by IVUS and OCT

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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.

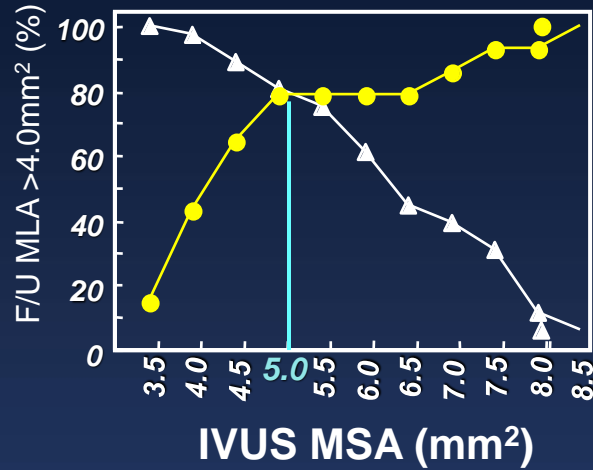
Affiliation/Financial Relationship

- Consultant

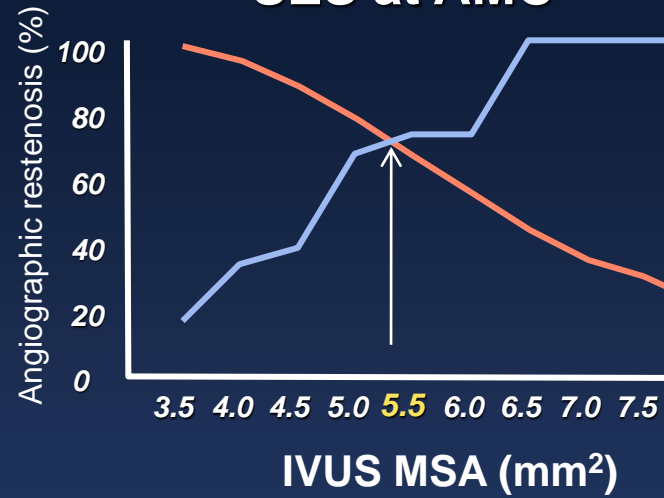
Company

- Boston Scientific, SpectraWave, Shockwave

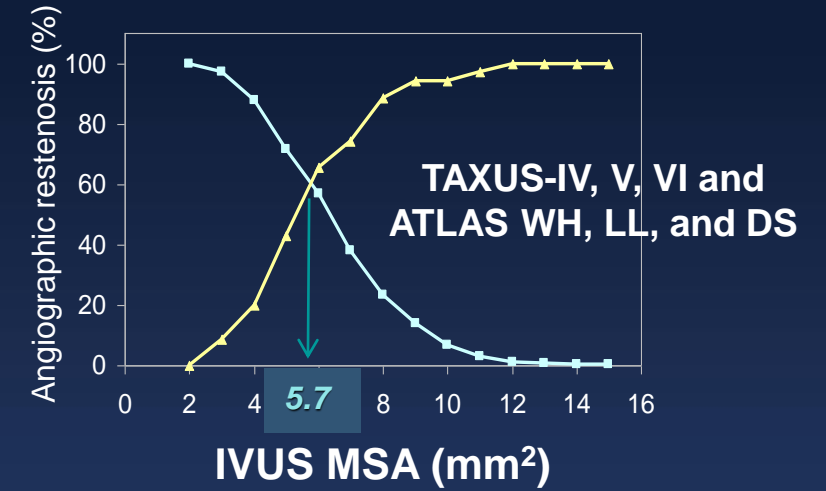
SES in SIRIUS



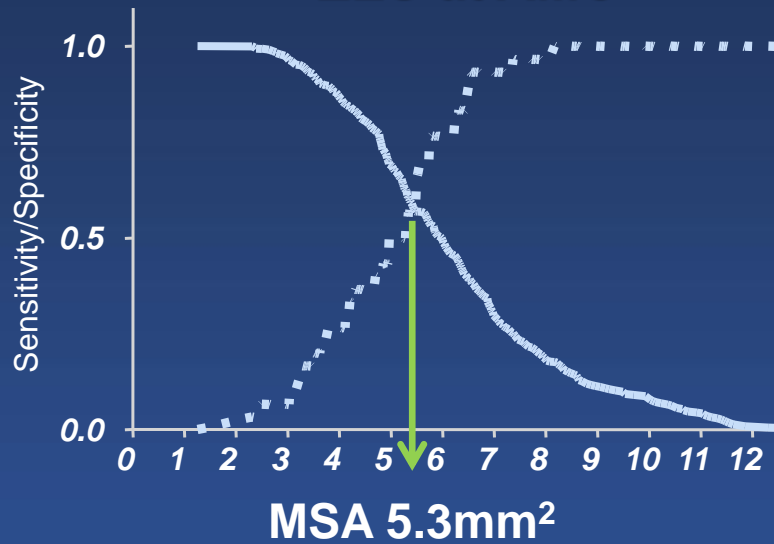
SES at AMC



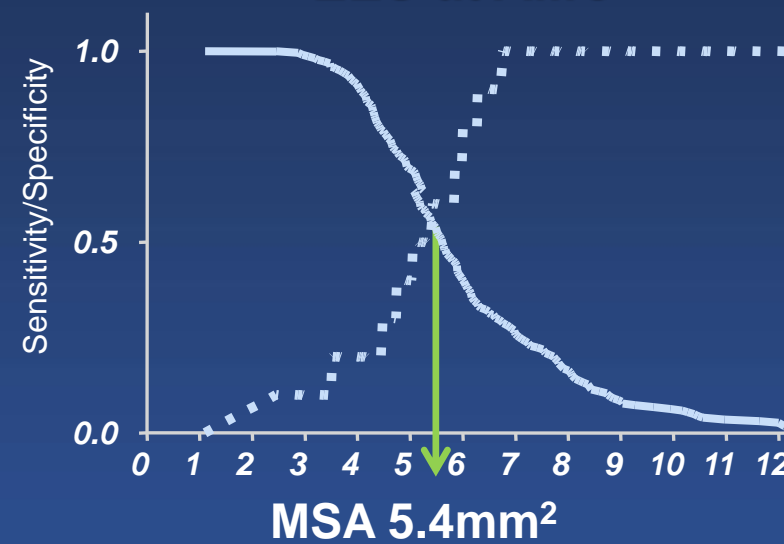
PES



ZES at AMC



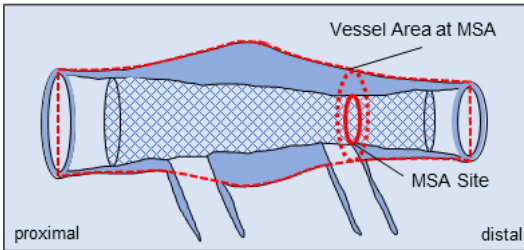
EES at AMC



Sonoda et al. J Am Coll Cardiol 2004;43:1959-63, Hong et al. Eur Heart J 2006;27:1305-10
 Doi et al. JACC Cardiovasc Interv. 2009;2:1269-75 Song et al. Cathet Cardiovasc Interv 2014;83:873-8

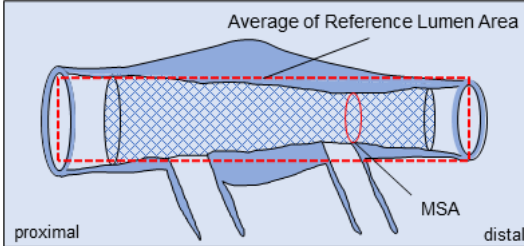
MSA/Vessel Area Stent Exp

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



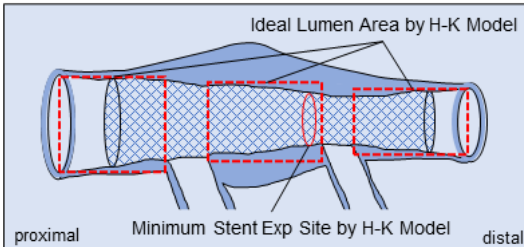
Conventional Stent Exp

$$\frac{\text{MSA}}{\text{Average of Proximal and Distal Reference Lumen Area}} \times 100$$



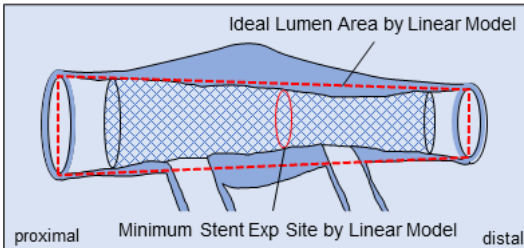
Minimum Stent Exp by H-K Model

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



Minimum Stent Exp by Linear Model

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

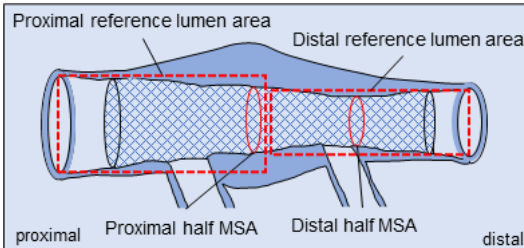


ILUMIEN IV Stent Exp Criteria

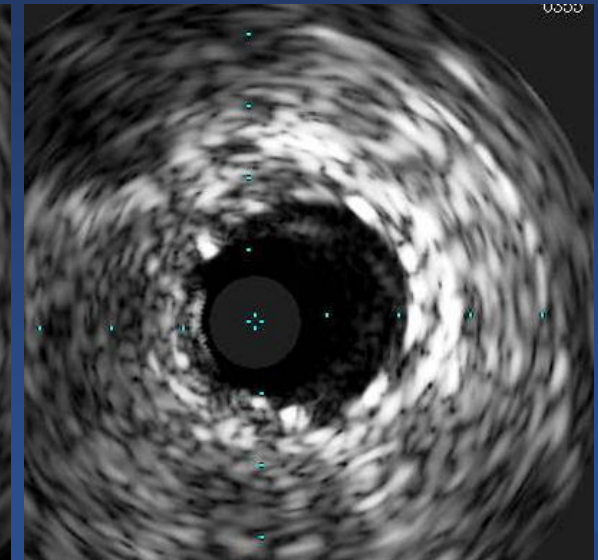
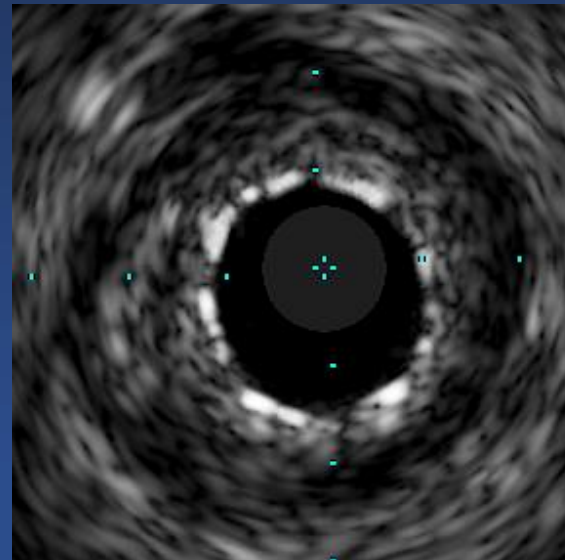
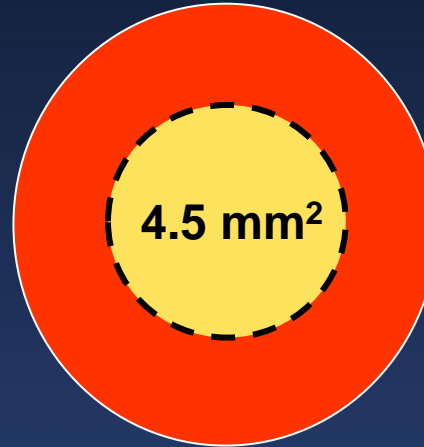
$$\frac{\text{Proximal MSA}}{\text{Proximal Reference Lumen Area}} \times 100 \geq 90\%$$

AND

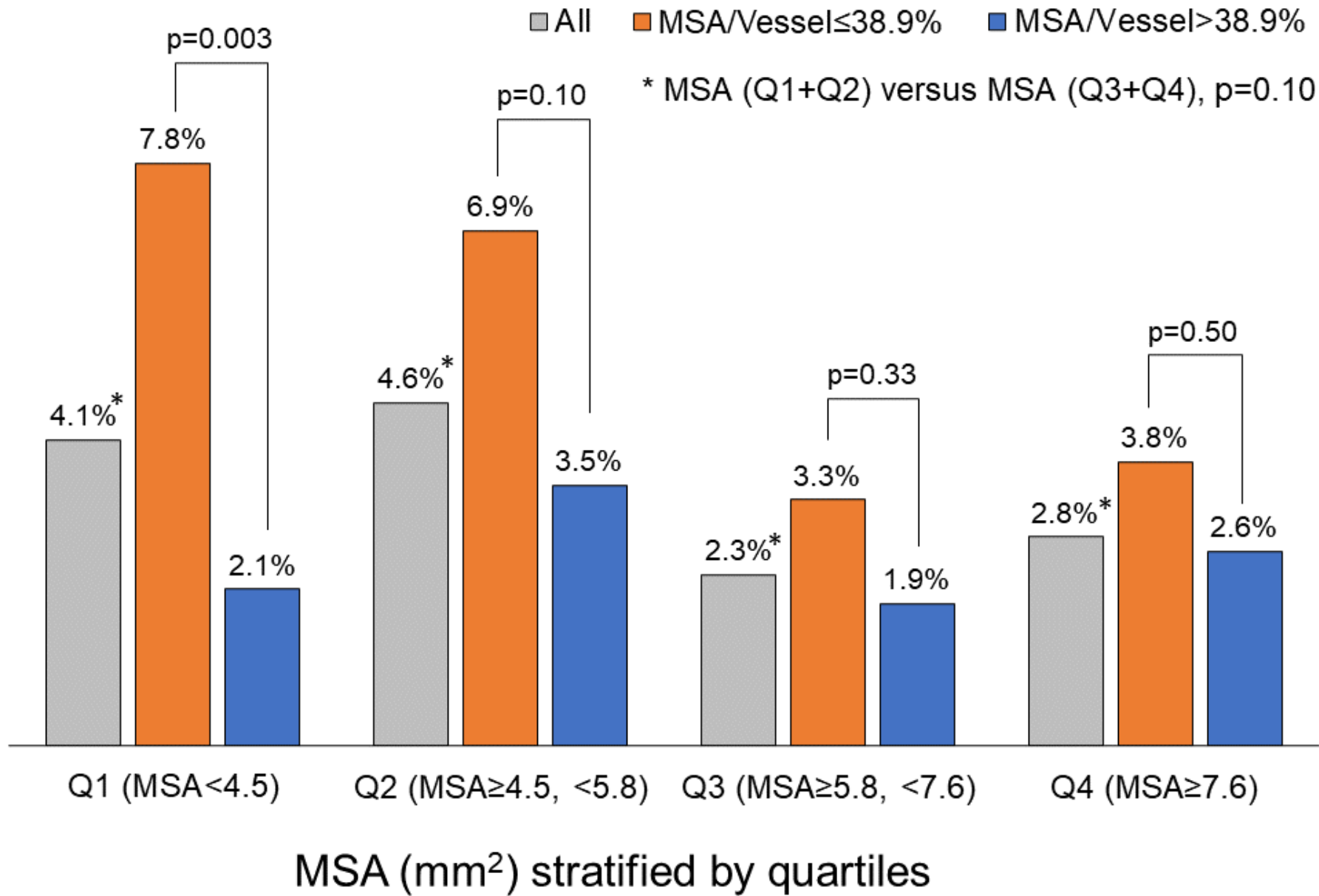
$$\frac{\text{Distal MSA}}{\text{Distal Reference Lumen Area}} \times 100 \geq 90\%$$



- Multicenter registry- ADAPT-DES cohort
- 2140 lesions in 1831 pts
- **MSA=6.2± 2.4mm²**



Clinically- Driven TLR or
Definite Stent Thrombosis (%)



Morphological and Procedural Factors Associated with Stent Expansion (MSA/Vessel Area)

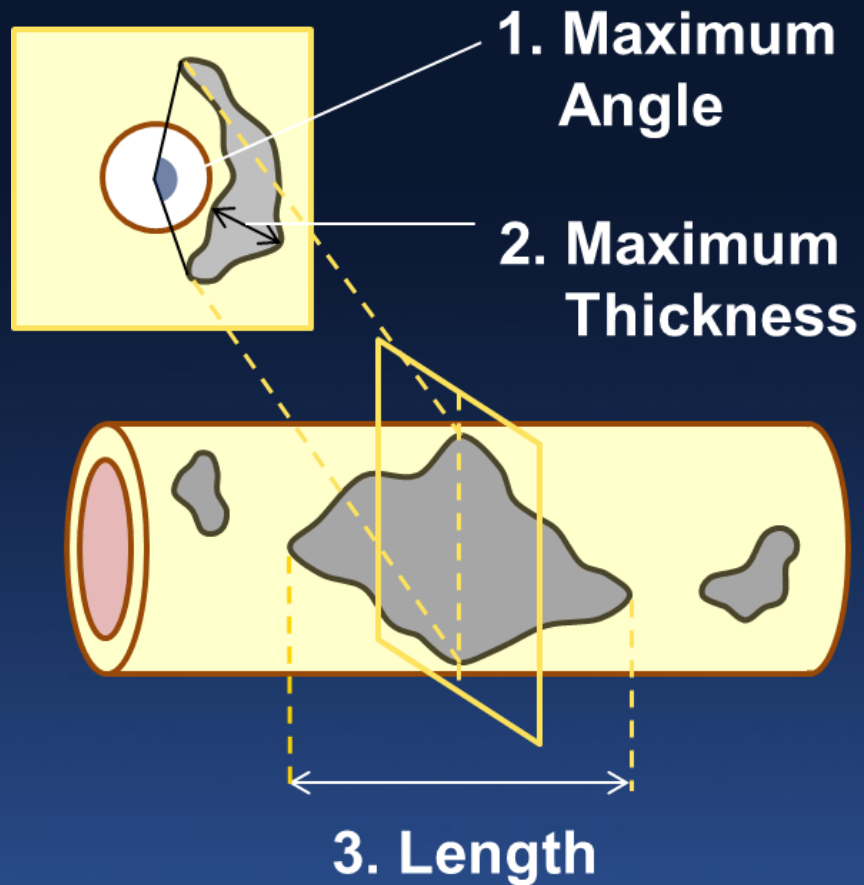
	Regression coefficient (95% CI)	P-value
Arc of max superficial calcium, per 90°	-1.08 (-1.73, -0.42)	<0.001
Arc of max attenuated plaque, per 90°	0.71 (-0.09, 1.51)	0.002
Plaque volume, per 10%	-4.41 (-5.02, -3.79)	<0.0001
Lesion length, per 10mm	0.49 (0.10, 0.87)	0.01
Max device diameter, mm	1.19 (0.19, 2.19)	0.02
Max balloon pressure, atm	0.26 (0.11, 0.41)	0.001
Rotablator usage	0.27 (-4.78, 5.32)	0.92

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

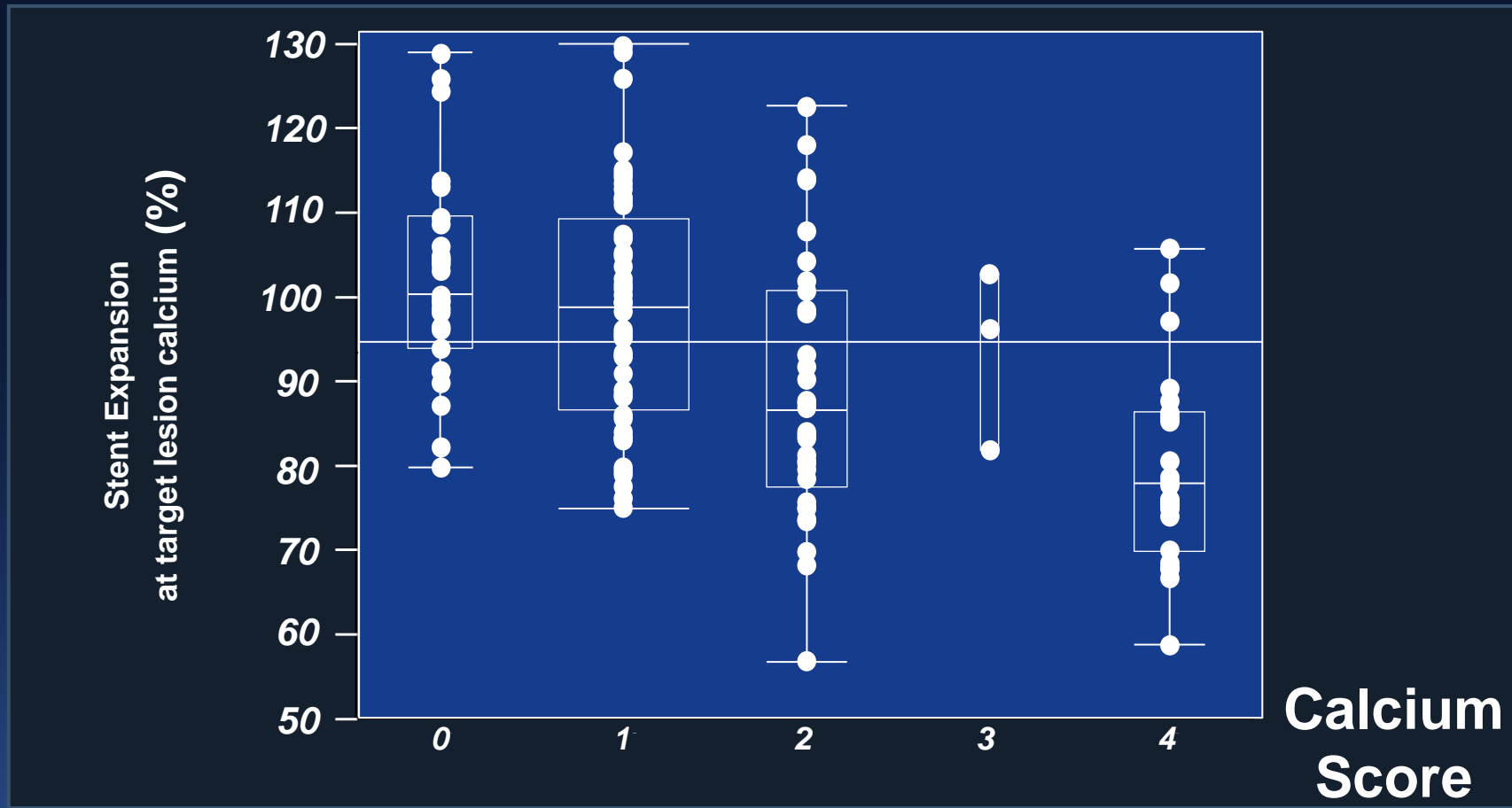
The variables that were included in the model, but found not significant: The number of calcium deposits, Total stent length, Maximum inflation pressure, Balloon-to-artery ratio.

Calcium Scoring System



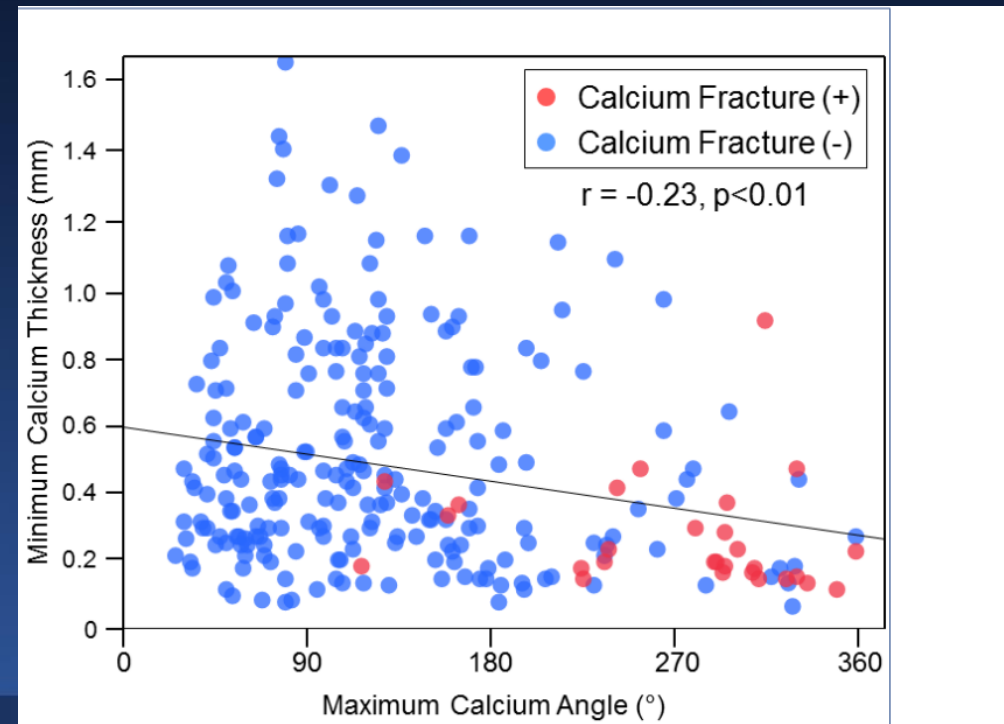
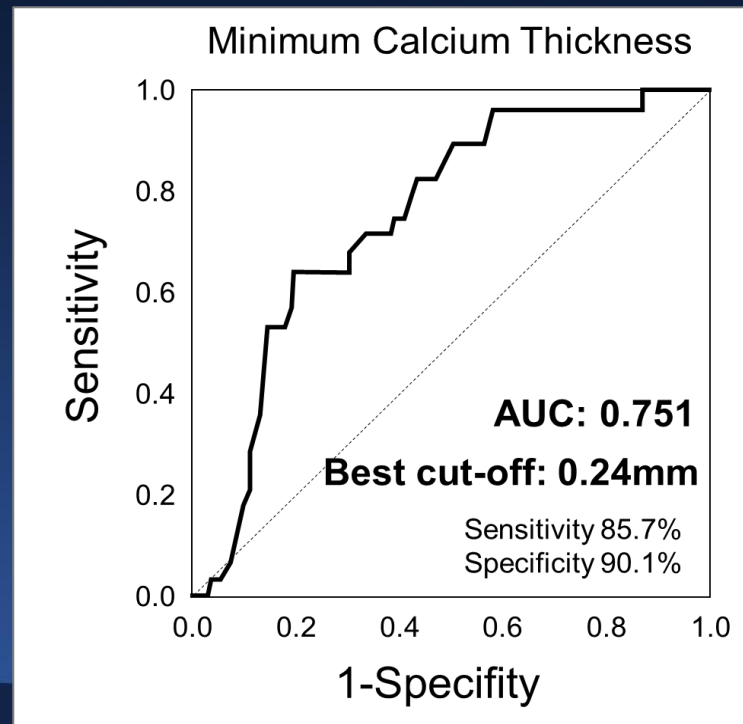
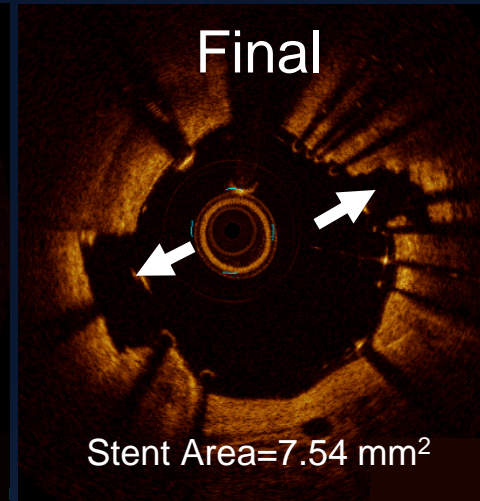
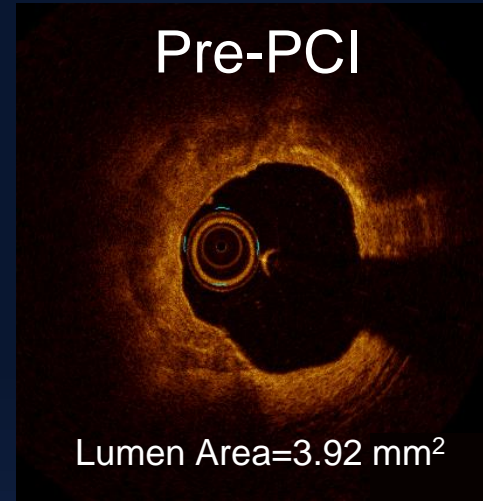
OCT-based CVI Score	
Angle	$\leq 180^\circ$ → 0 point
	$> 180^\circ$ → 2 points
Thickness	≤ 0.5 mm → 0 point
	> 0.5 mm → 1 point
Length	≤ 5.0 mm → 0 point
	> 5.0 mm → 1 point
Total score: 0 to 4 points	

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

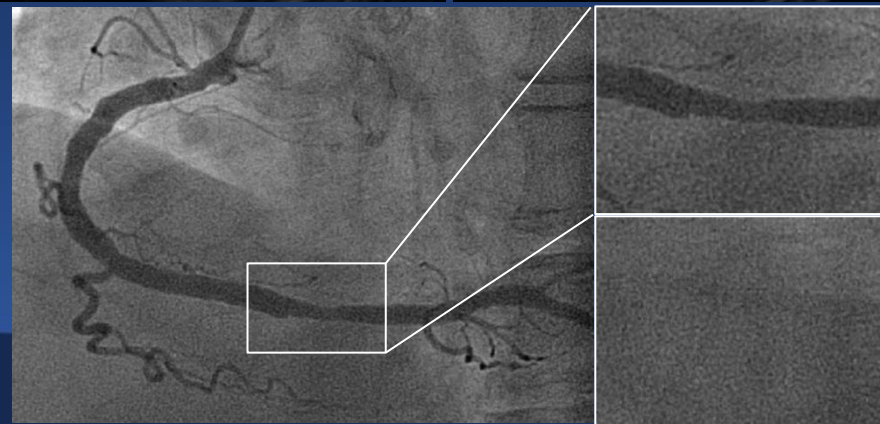
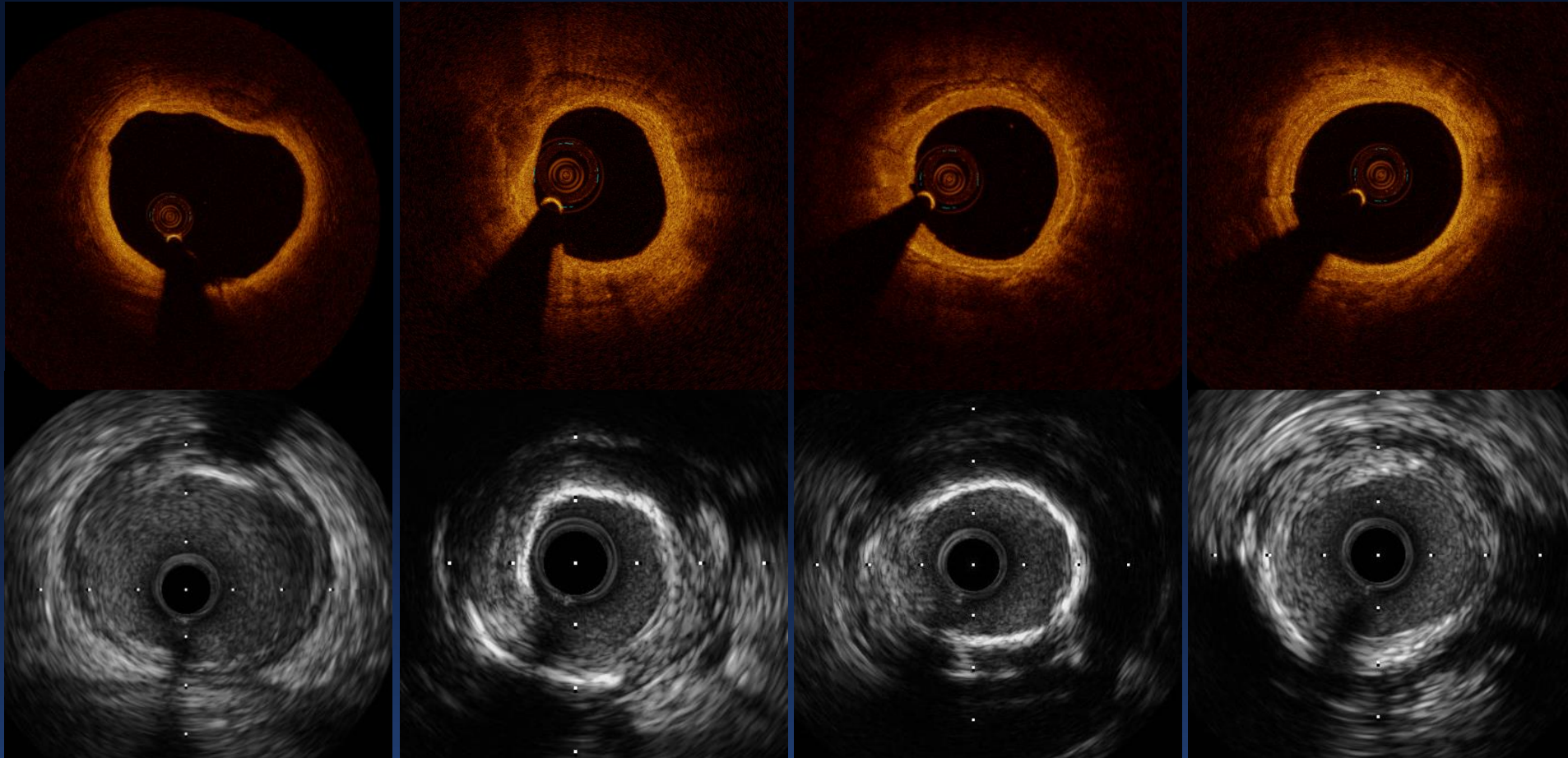
Ca Morphology to Predict Ca Fracture without Atherectomy



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.

Angiographic calcium ?

Yes ↓

IVUS: Maximum Calcium >270° ?

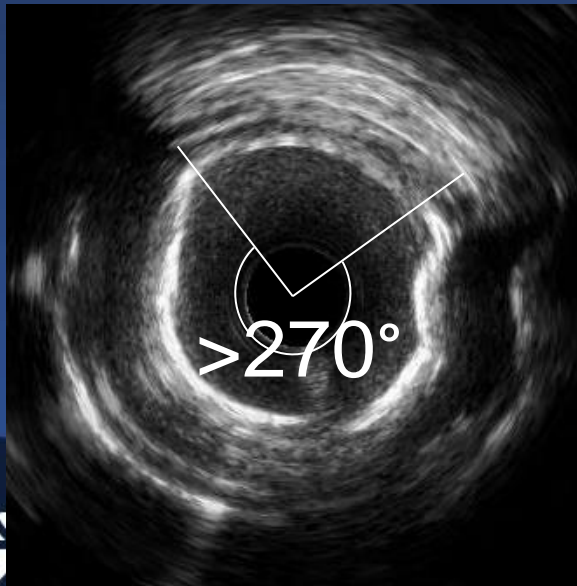
Yes ↓

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

Yes = Point 1, No = Point 0 ↓

Consider atherectomy

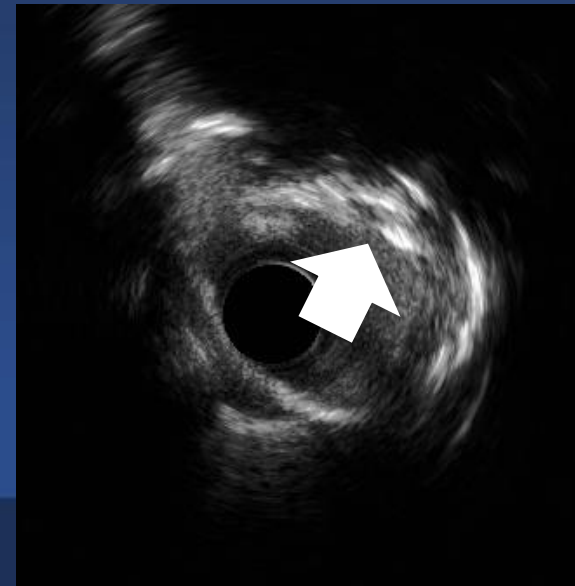
Calcium >270°
longer than 5mm?



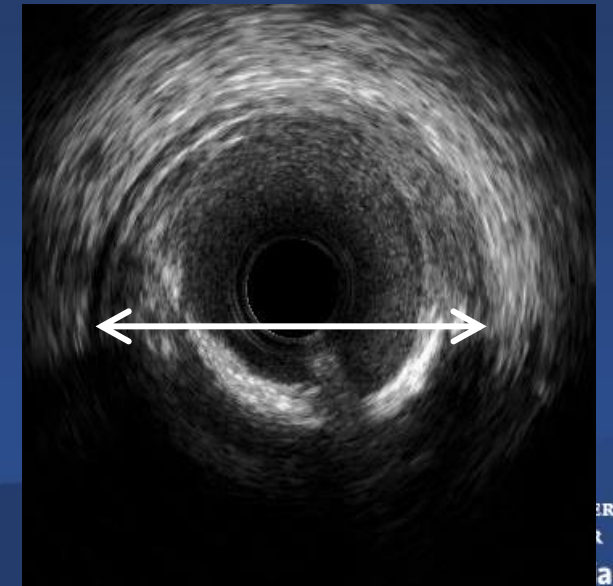
360° of calcium?



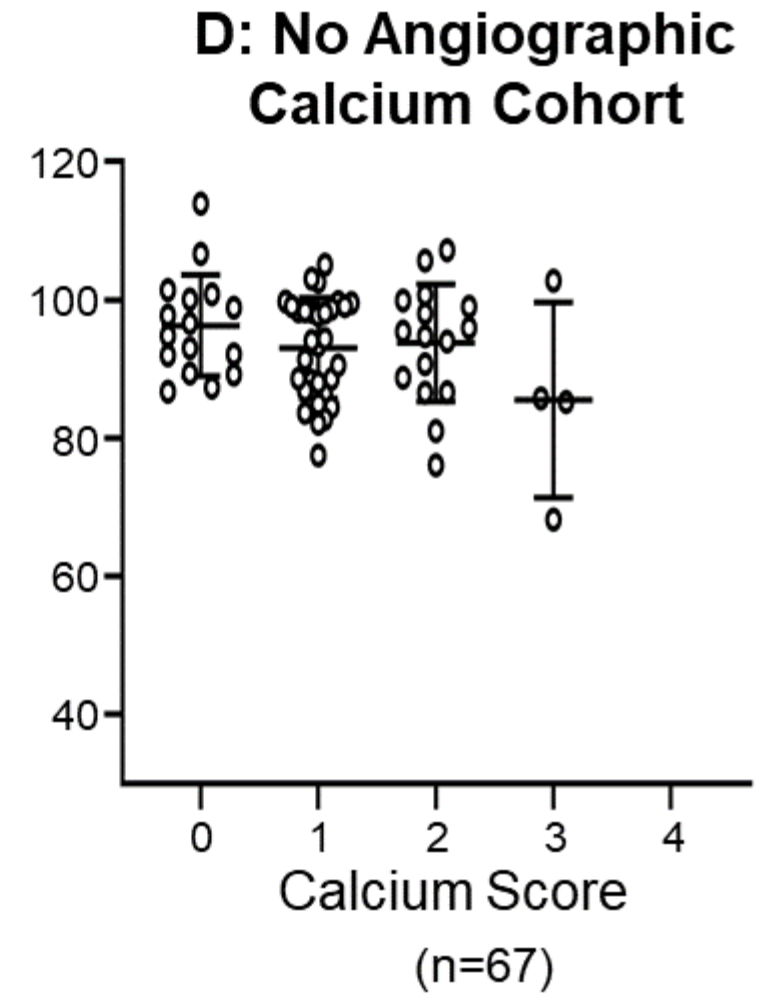
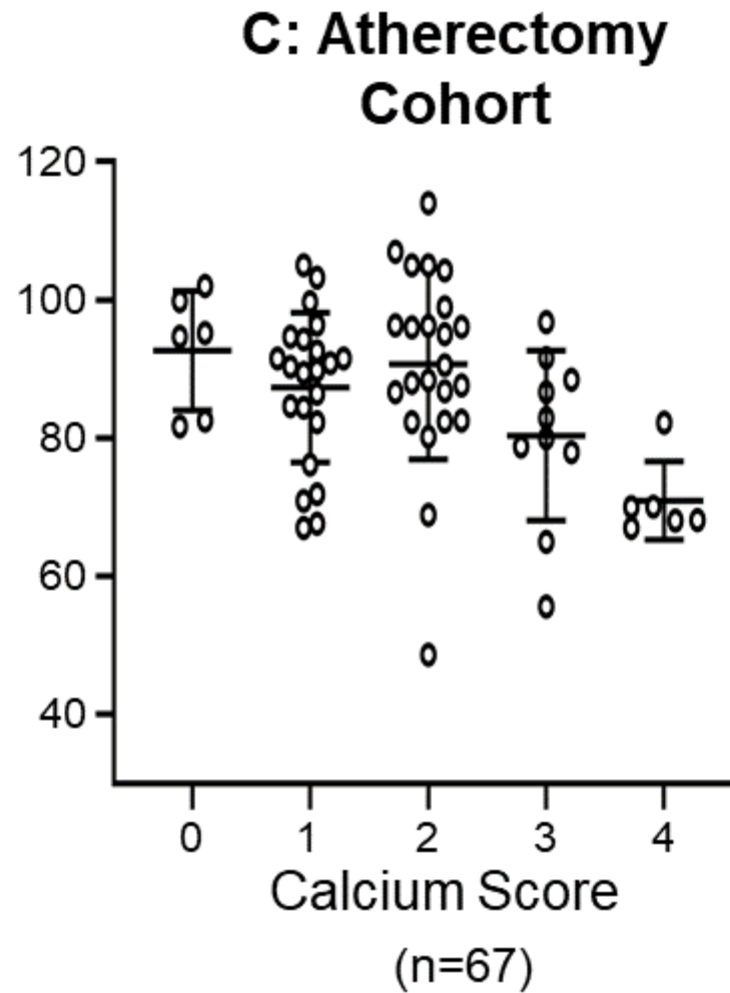
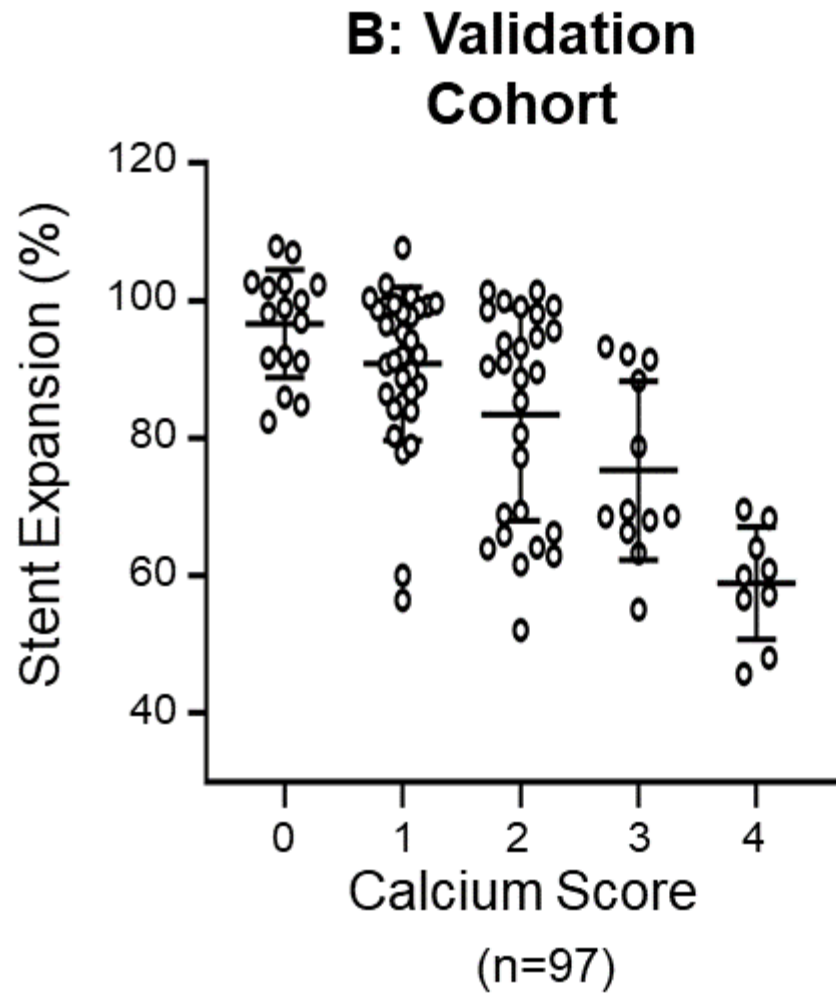
Calcified nodule?



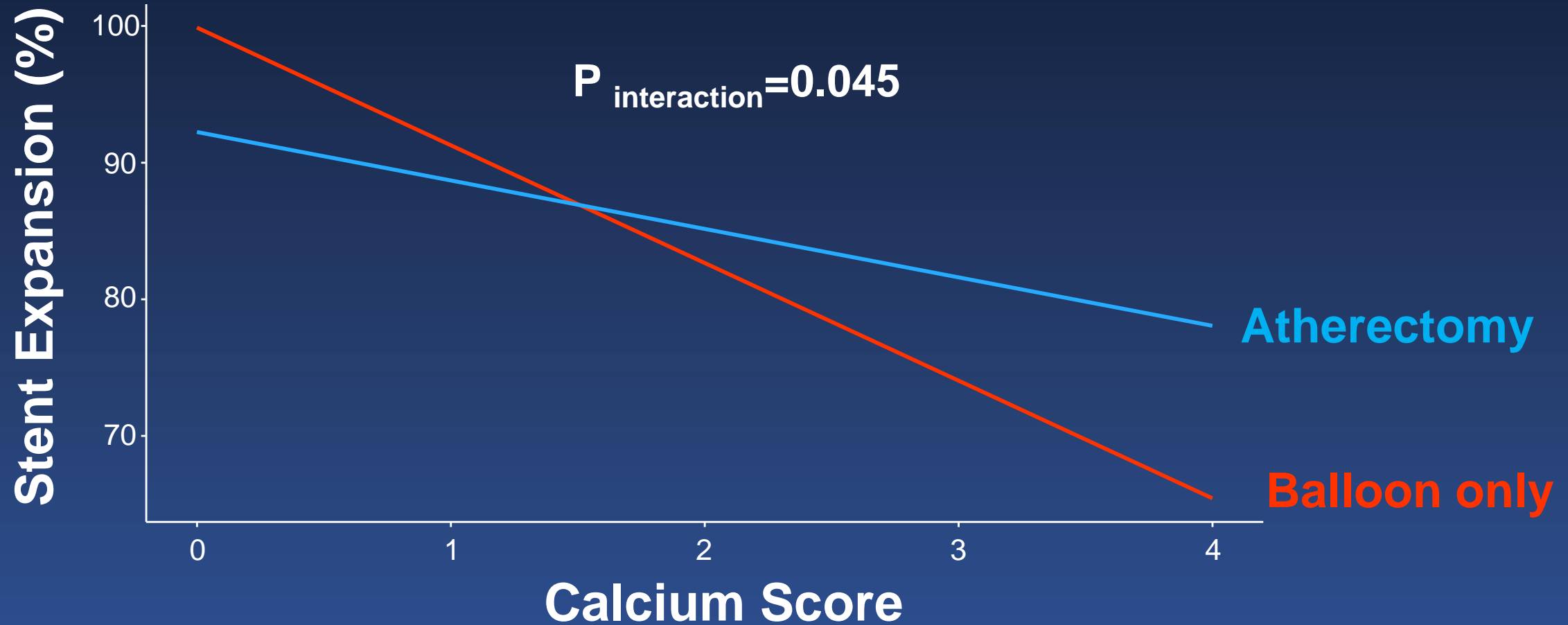
Vessel diameter
<3.5mm ?



Stent Expansion Correlates with Calcium Score

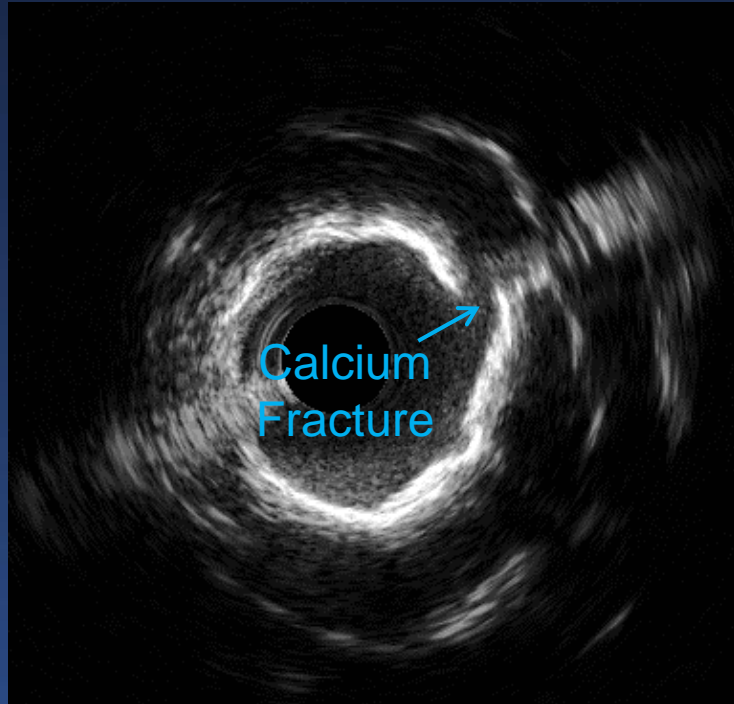


Effect of Atherectomy for Stent Expansion

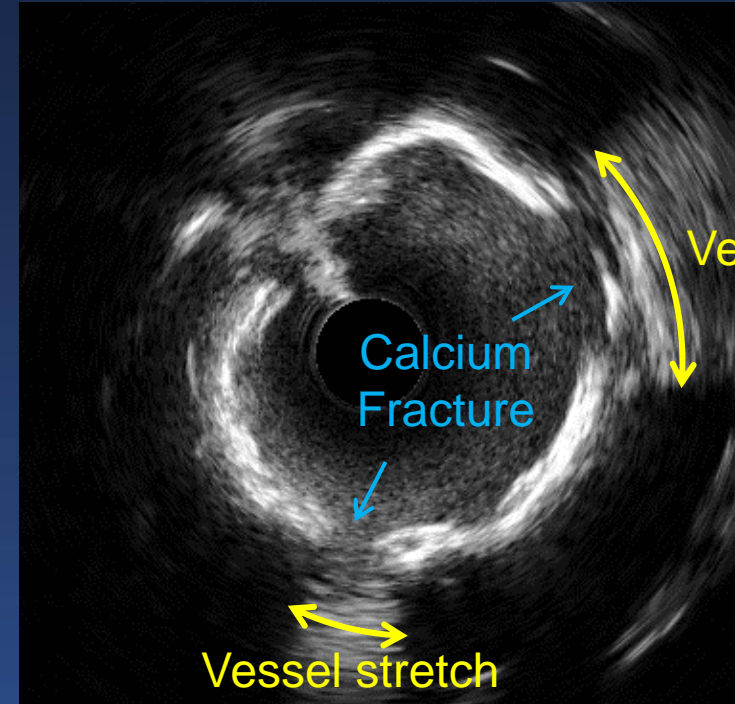


Detection of Calcium Fracture

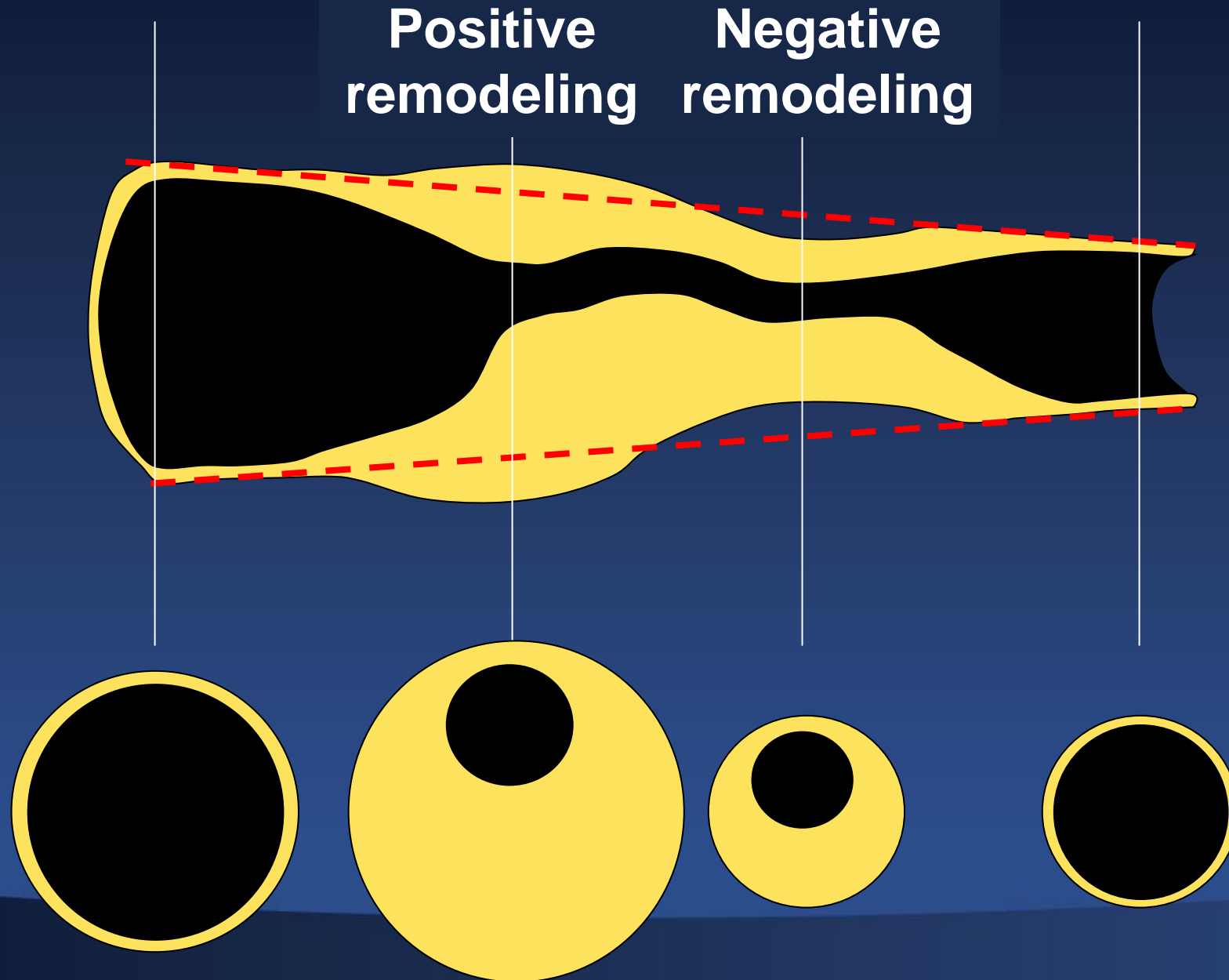
Post-Balloon



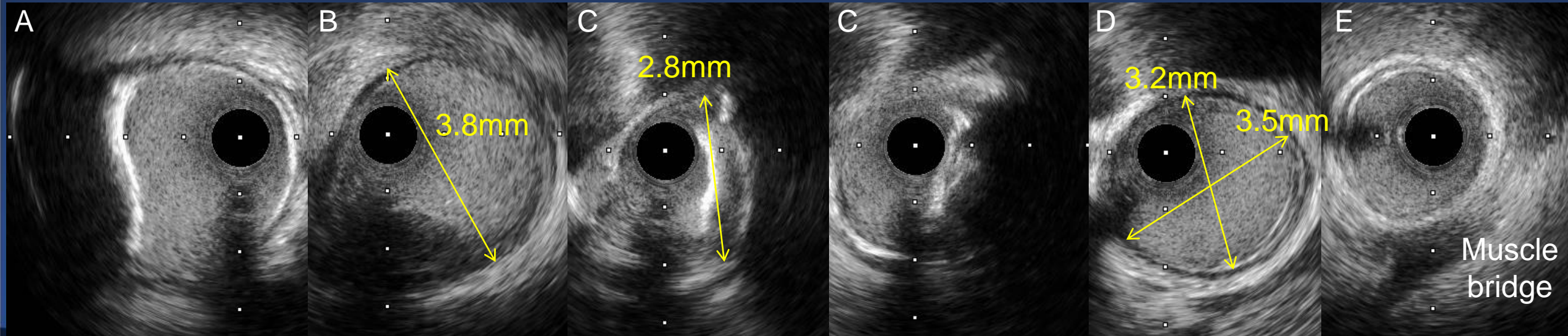
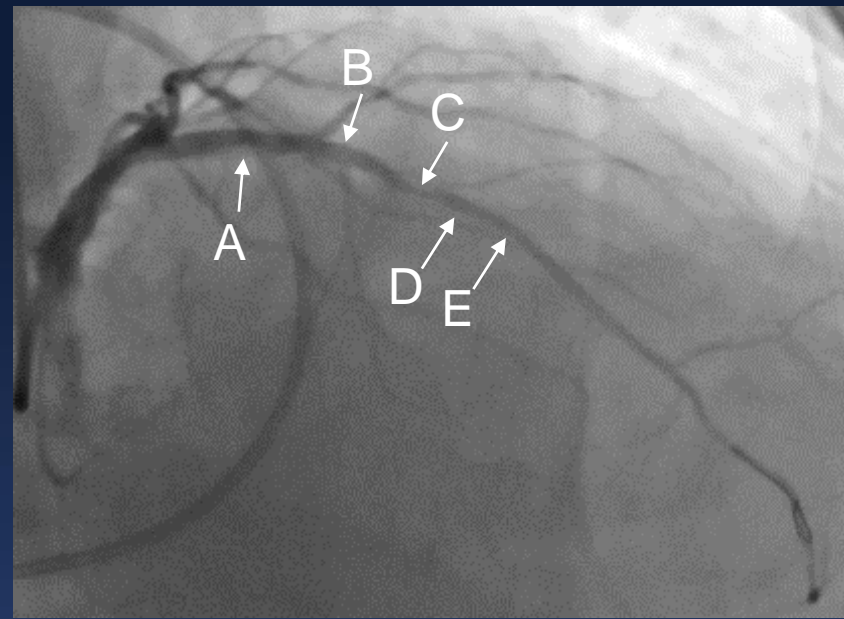
Post-Stent Final



Vessel Tapering and Vessel Remodeling



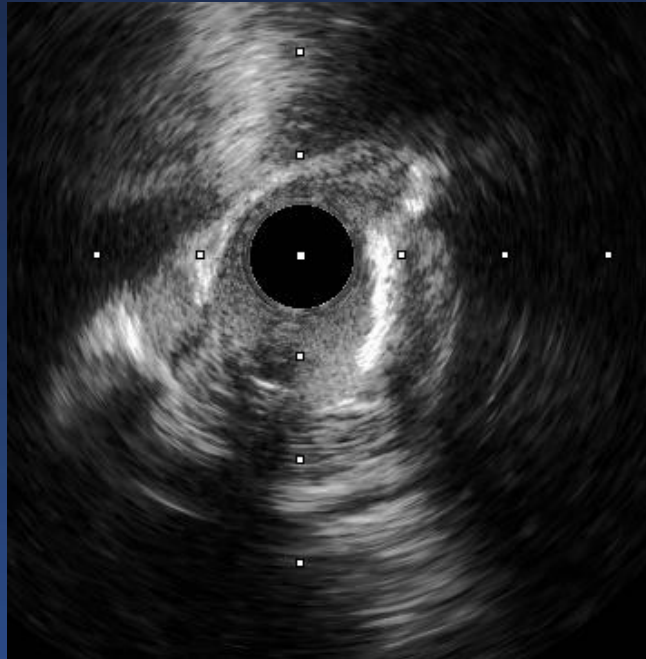
Eccentric calcium with negative remodeling



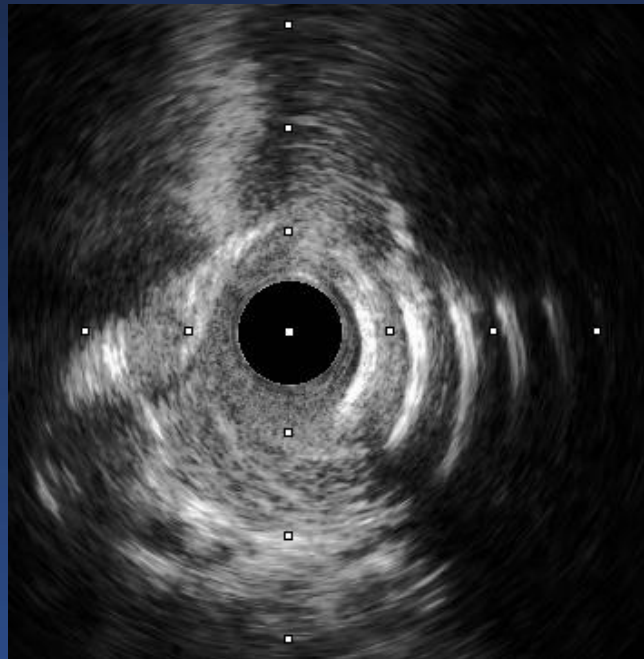
16.3mm

Modify Lesion Morphology

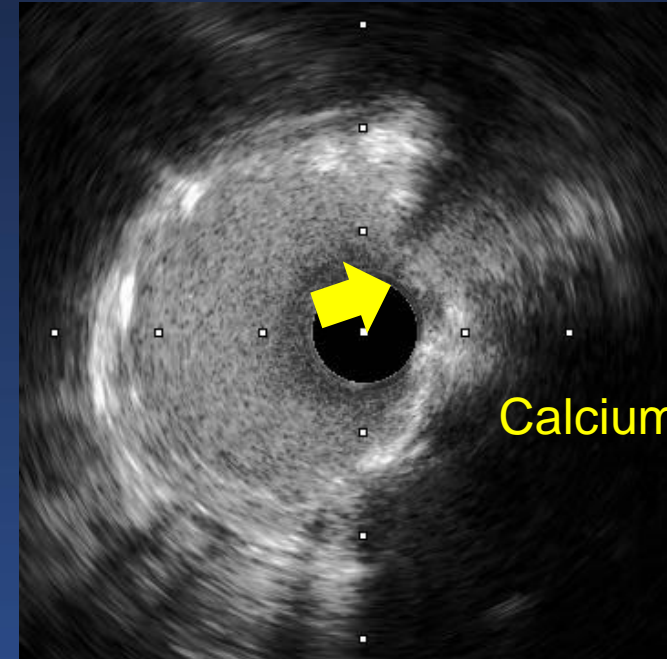
Pre-PCI



Post-OAS



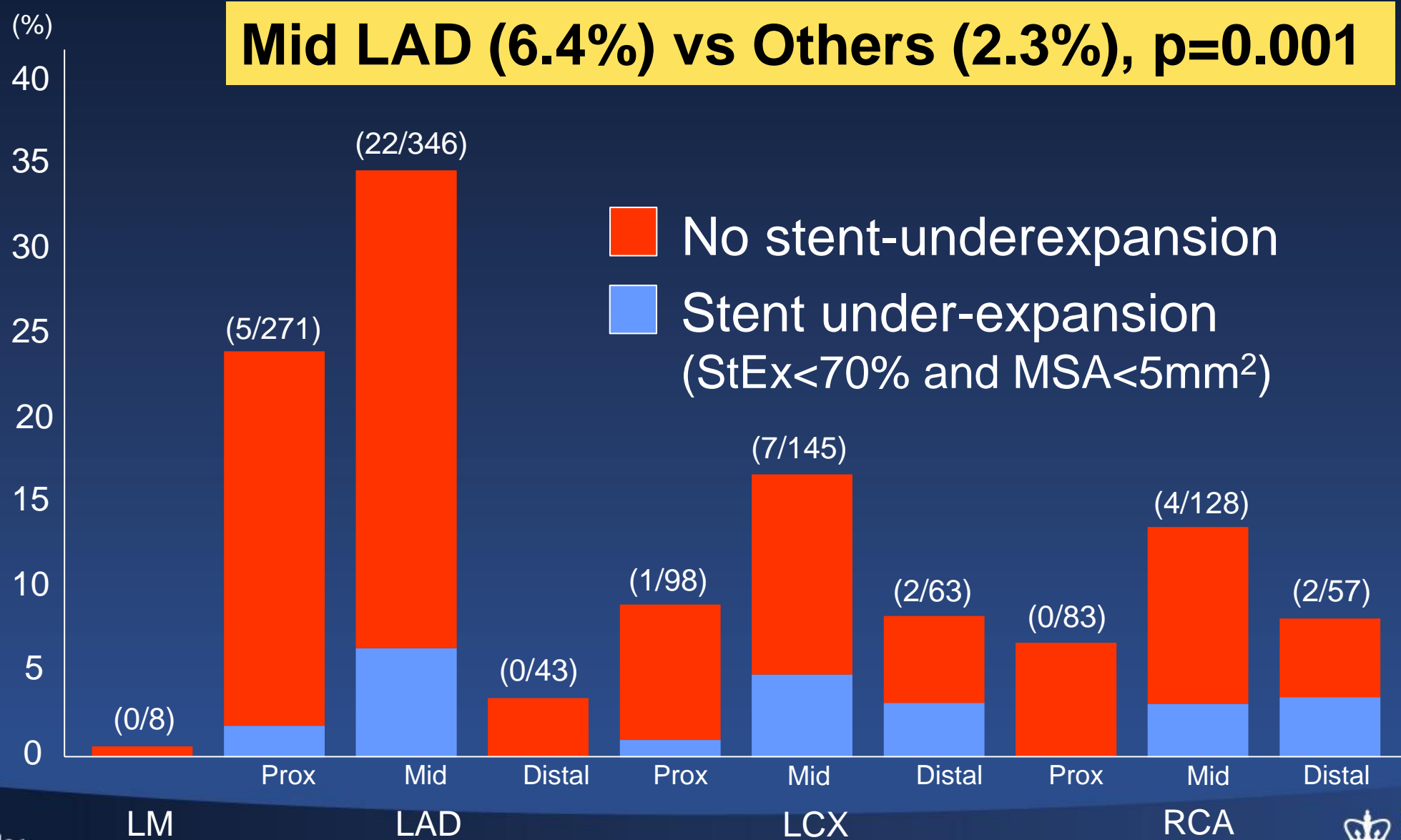
Post-Stent



Calcium Fracture

Minimum Stent Area=7.2mm²

Rate of Stent Under-Expansion in the Lesions with Calcium<math><180^\circ</math>



Morphological and Procedural Factors Associated with Stent Expansion by Linear Model

	Regression coefficient (95% CI)	P-value
Arc of max superficial calcium, per 90°	-3.7 (-6.7, -0.6)	0.02
Remodeling index	23.3 (17.1, 29.5)	<0.001
Vessel diameter, per 1mm	2.0 (0.1, 3.9)	0.03
Balloon to artery ratio	27.5 (20.4, 34.6)	<0.001

Summary

- 1. The key morphological factors to be associated with stent expansion are 1) total amount of calcium (arc, length, thickness) and 2) negative remodeling.**
- 2. OCT may be superior to IVUS for the prediction of stent expansion, but IVUS is also good.**