Angiographic Assessment of Bifurcation Lesions: Beyond the Basics

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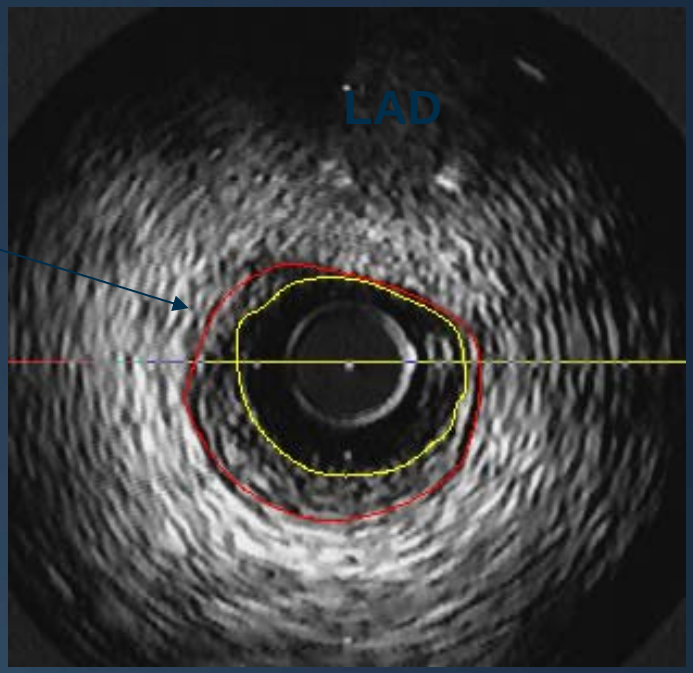
Diagnostic Considerations
Ostial SB Lesion Severity at Baseline



Measurements On Current Frame

	Area (mm^2)	Diameter (mm)			
		Mean	Min	Max	Min/Max
Lumen	3.83	2.23	2.03	2.46	0.82
Vessel	6.31	2.85	2.57	3.10	0.83
Stent					
Plaque	2.48 (39.2% of Vessel)	Comparative Lumen Area			
NIH					

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Diagnostic Considerations
Ostial SB Lesion Severity after SB Jailing

Angiography vs FFR: To treat or Not

Fractional Flow Reserve (FFR <0.75 = ischemia)

- SB FFR measured in 94 pts after side branch jailing
- FFR reflects both degree of stenosis and myocardial territory

Bon-Kwon Koo, MD

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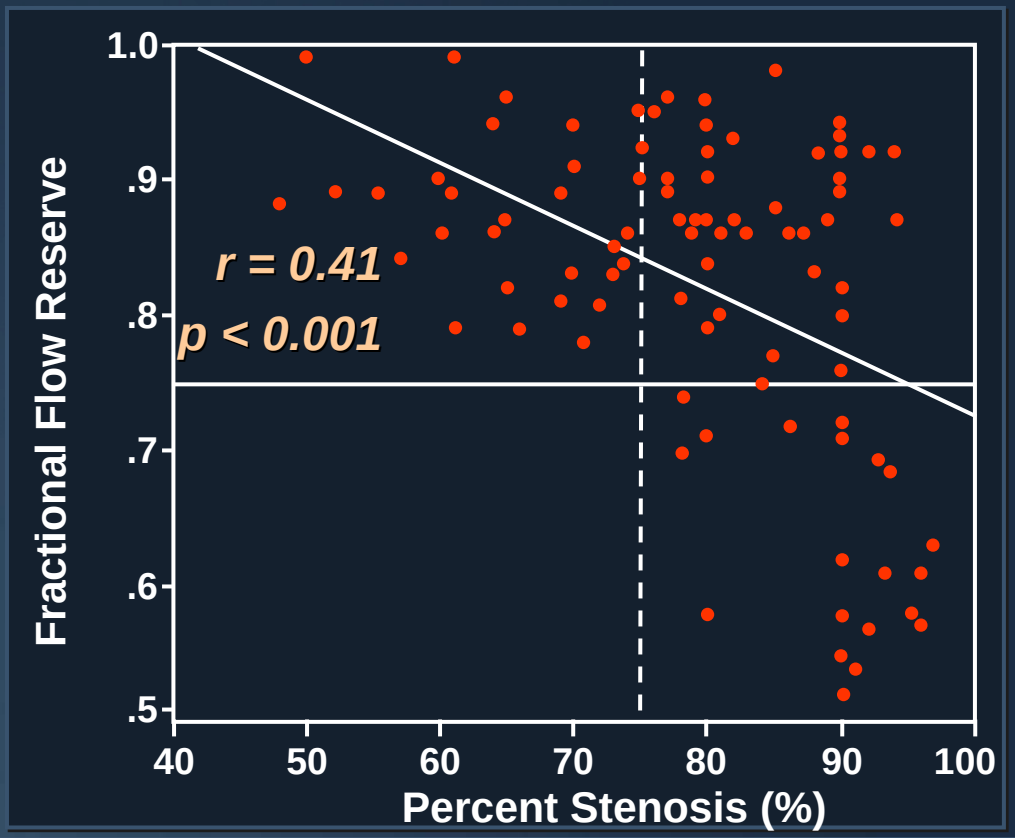
Physiologic Assessment of Jailed Side Branch Lesions Using Fractional Flow Reserve (FFR)

Correlation between FFR and % Stenosis

The optimal cutoff value for percent stenosis to predict functionally significant stenosis was 85% (Sensitivity: 0.80, Specificity: 0.76)



Conclusions: QCA is unreliable in the "functional" assessment of stenosis severity in jailed SBs. Conversely, **FFR** measurements demonstrate that most of stenotic SBs do not have functional significance

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Koo, B.-K. et al. JACC 2005;46:633-637

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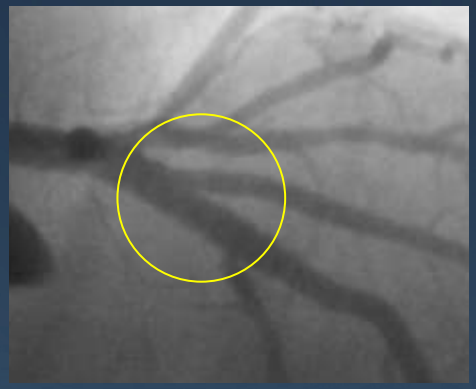
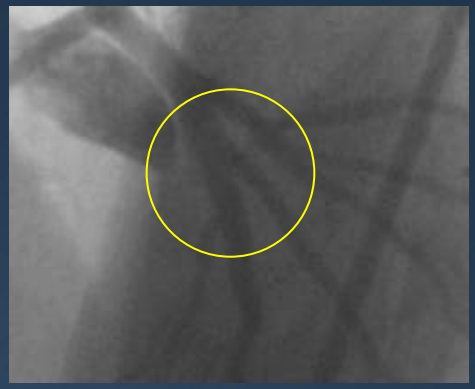
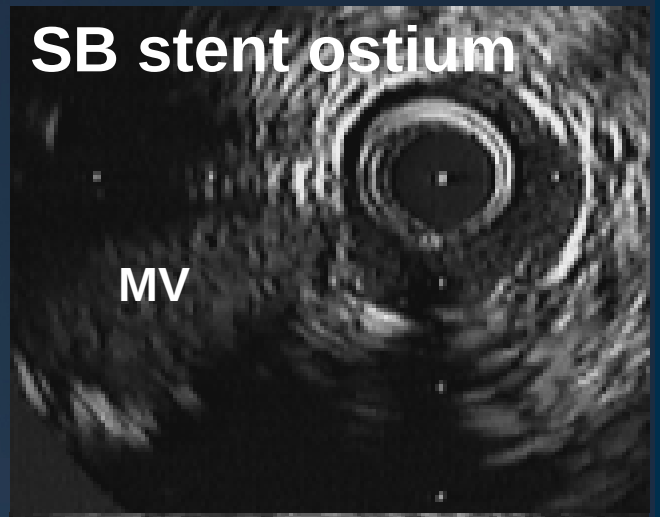
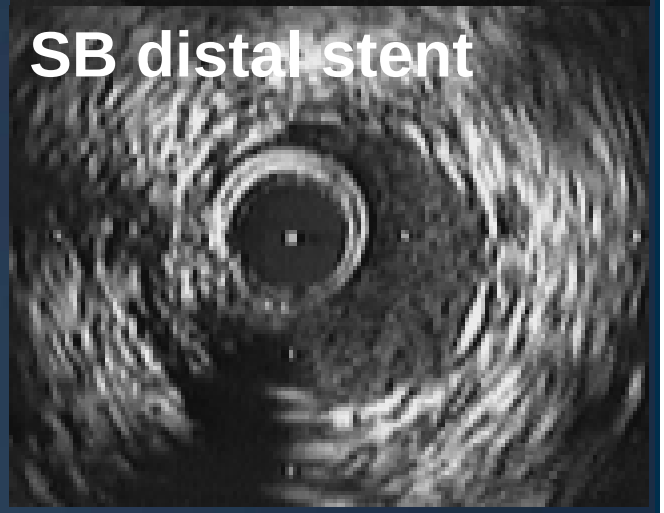
SB Stent Underexpansion After Crush

Final optimal angiographic result









Variable	PV	SB	P
Stent minimum CSA, mm^2	6.5 ±1 .7	3.9 ± 1.0	<0.0001
Stent expansion, %	92.1 ± 1 6.6	79.9 ± 12.3	0.02
Stent CSA<4 mm^2	10% (2/20)	55% (11/20)	0.007
Stent CSA<5 mm^2	20% (4/20)	90% (18/20)	<0.0001

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Costa R. et al, JACC 2006; 46: 599-605.

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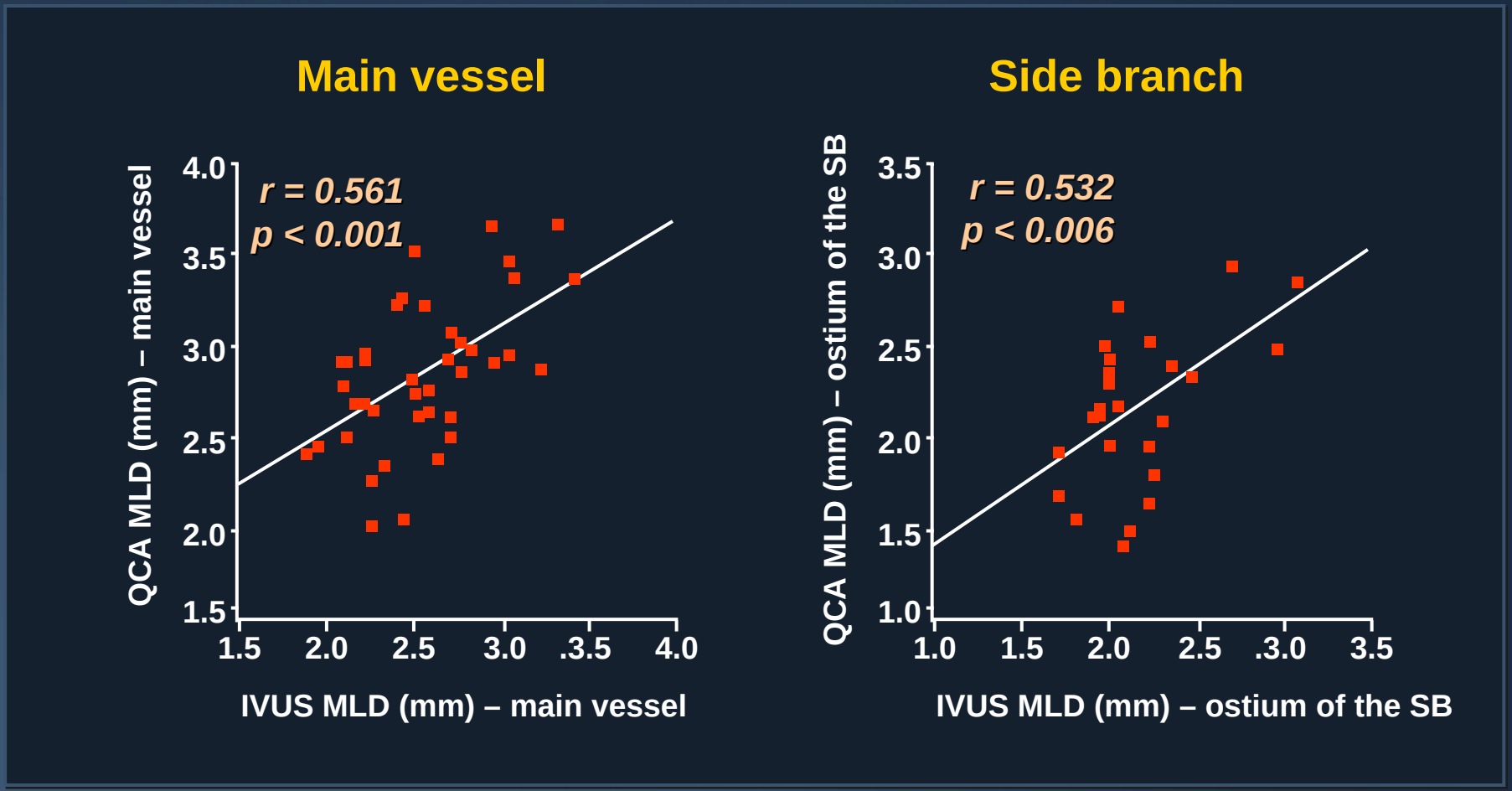
Correlation Between IVUS and QCA

Final MLD in Parent Vessel and Side Branch Following "Crush" Stenting



Costa R. et al, JACC 2006; 46: 599-605.

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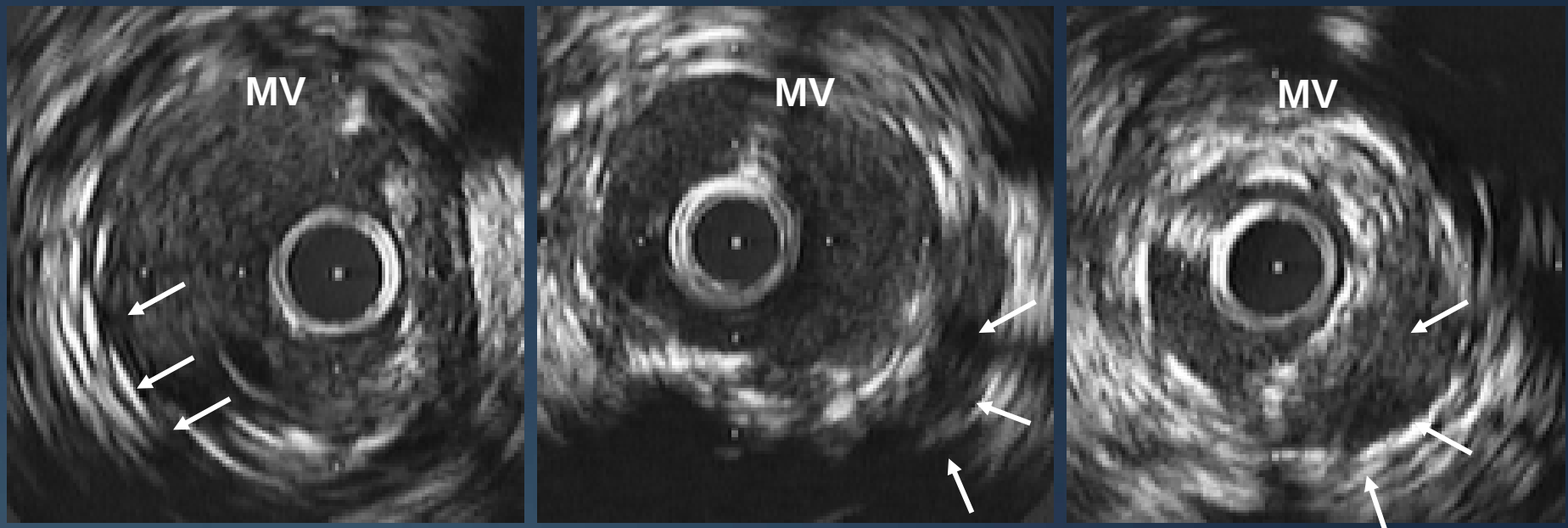
Incomplete “Crush” Apposition



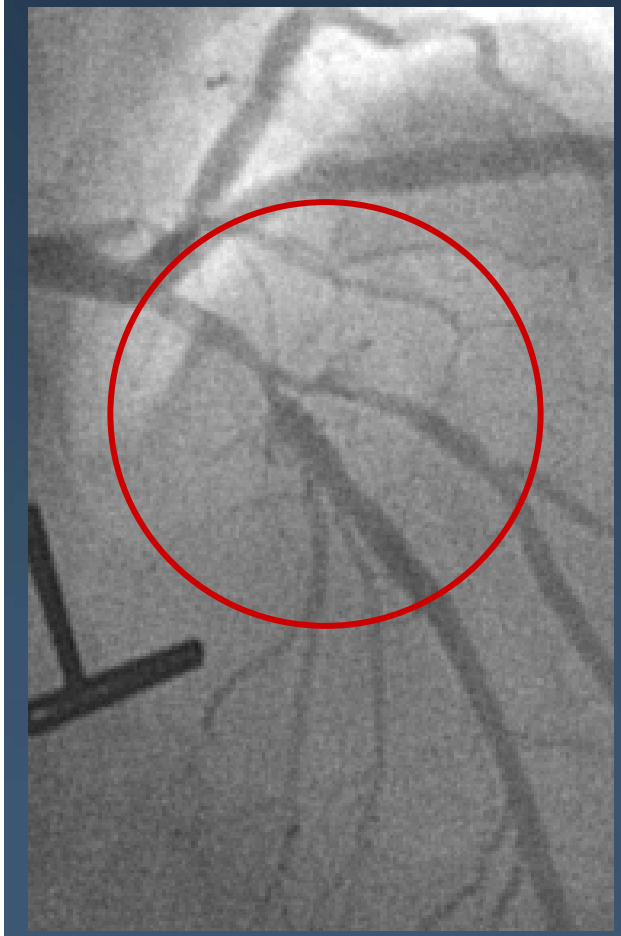
Complete crush (apposition) of the SB stent – arrows indicate the 3 layers of stent struts

Incomplete crushing – incomplete apposition of the SB or PV stent struts against the MV wall proximal to the carina, **found in >60% of non-LM lesions**

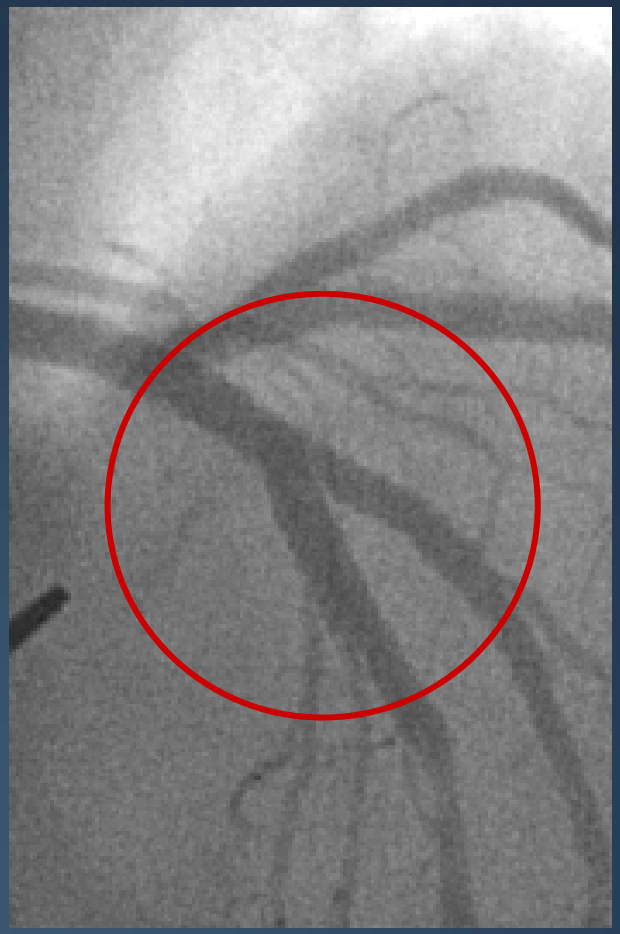
MV= main vessel; SB= side branch

Costa R. et al, JACC 2006; 46: 599-605.

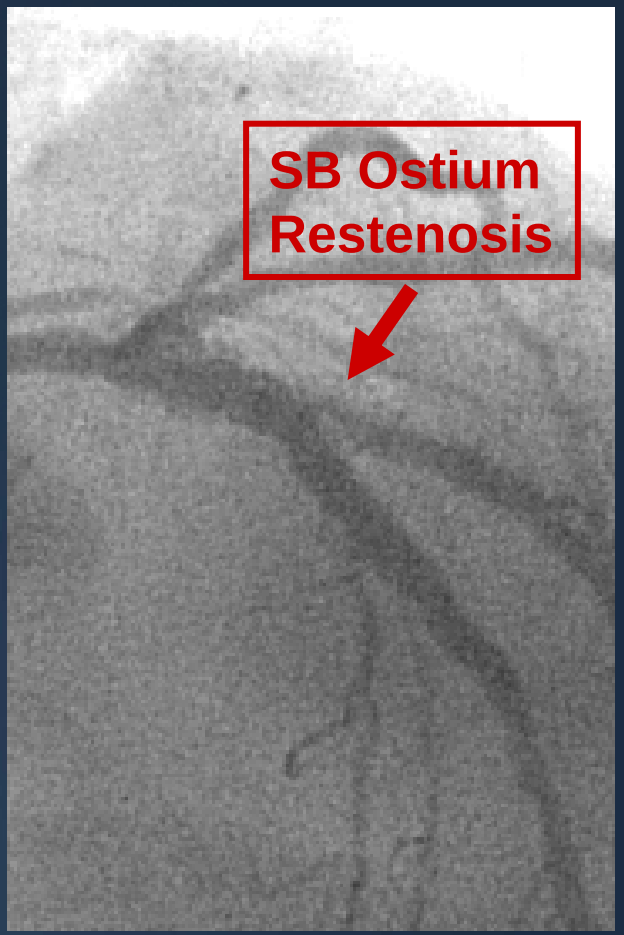
After Bifurcation PCI…A preponderance of Restenosis occurs in the SB Ostium



Preprocedure



Final



6 Months Follow-Up

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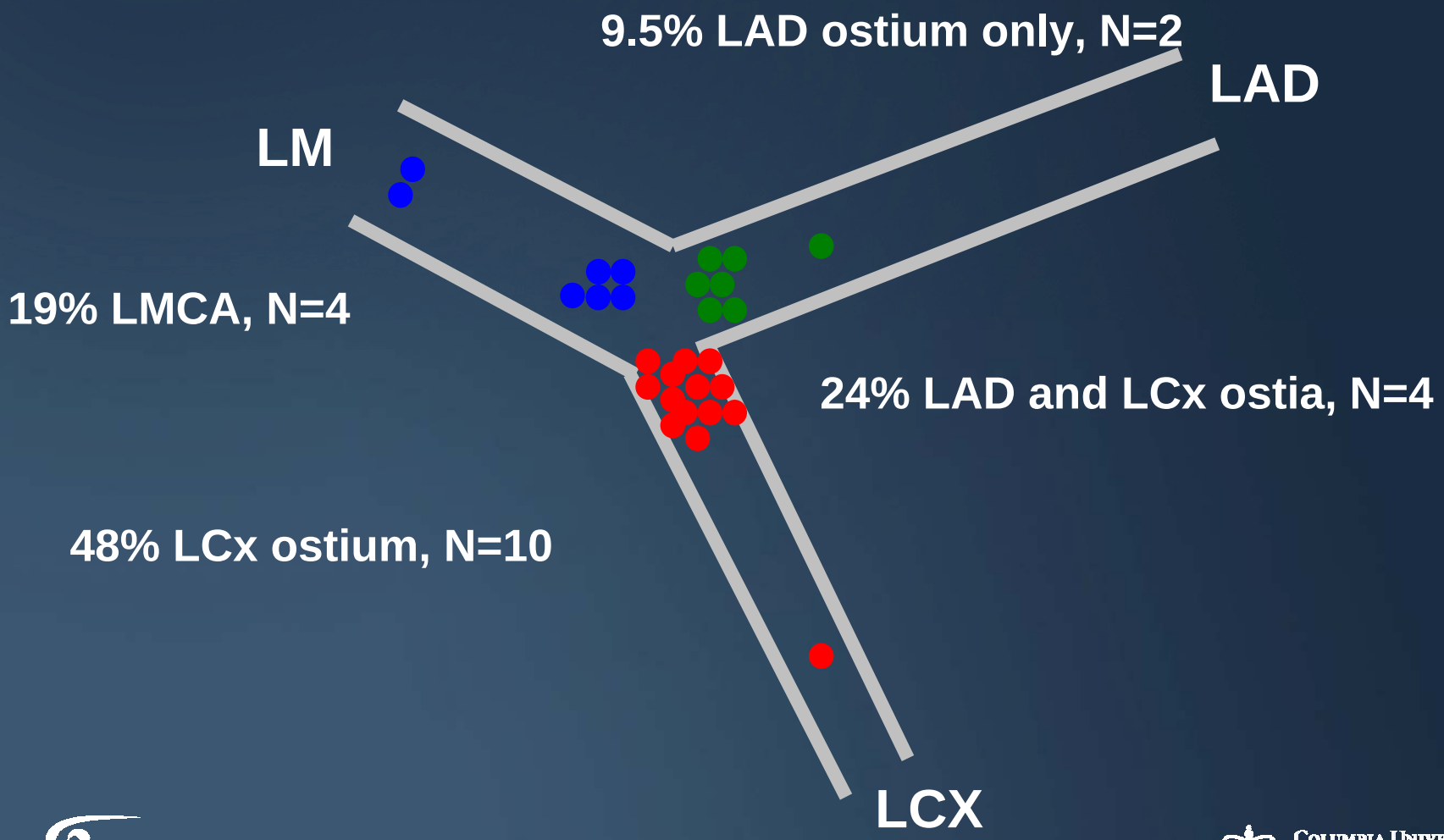
LM Registry – SCRIPPS Clinic, N=50

42% Restenosis rate, 85% focal



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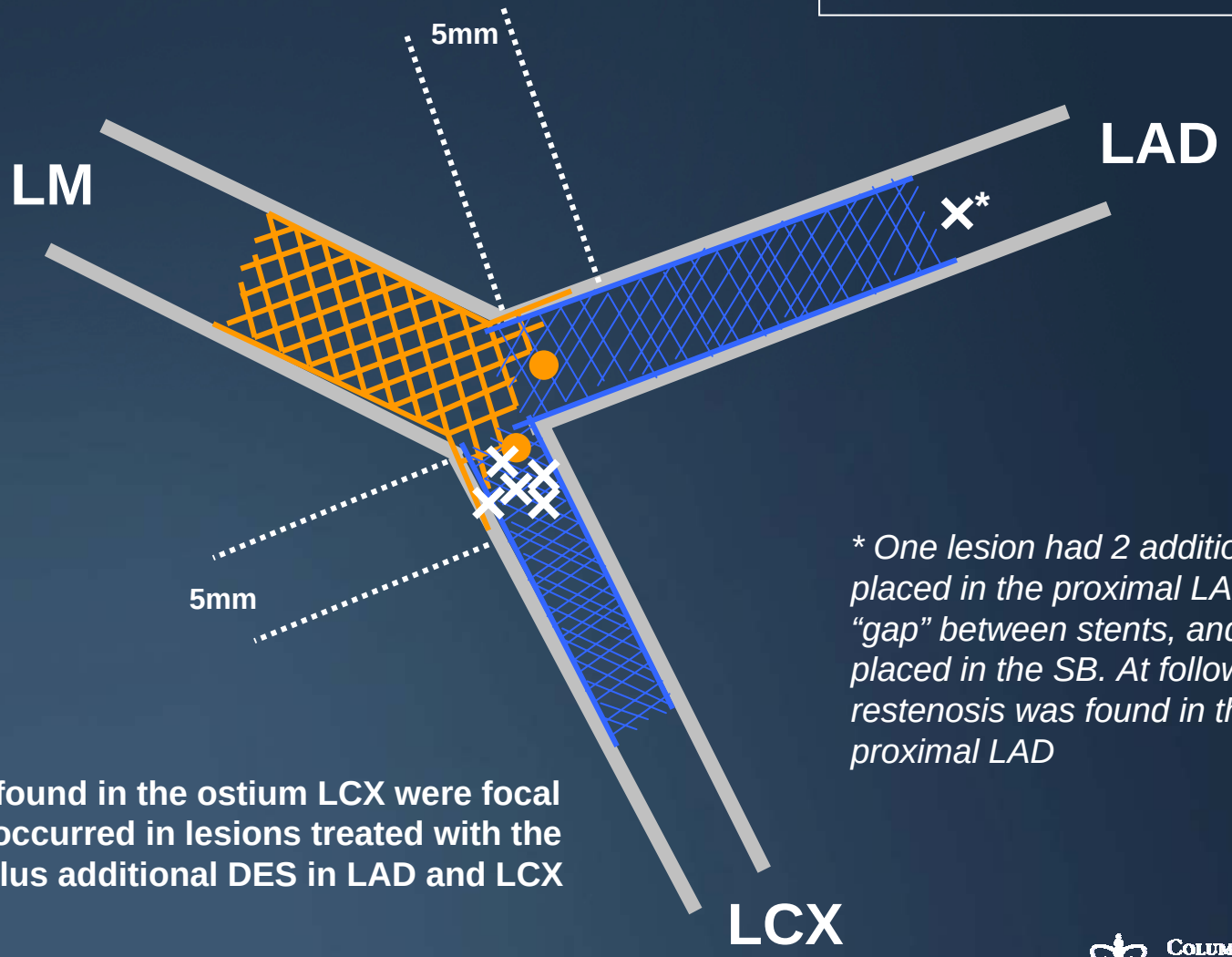
AXXENT Trial
Restenosis Location



** One lesion had 2 additional stents placed in the proximal LAD with a "gap" between stents, and no stent placed in the SB. At follow-up, restenosis was found in the "gap" in proximal LAD*

All restenosis found in the ostium LCX were focal (<10mm), and occurred in lesions treated with the DEVAX stent plus additional DES in LAD and LCX

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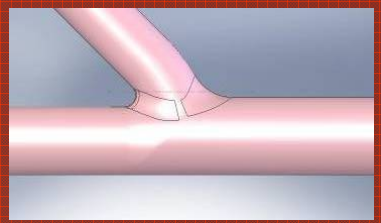
Coronary Casts: Understanding Ostial Geometry
Oval and Asymmetric Rather than Round

Courtesy of Mary Russel, MD, PhD

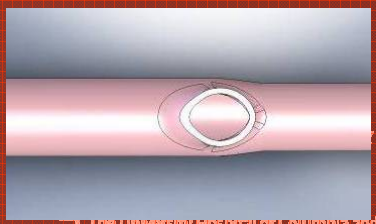
Example: Side Branch of RCA

Sketches of ostium

conical taper



elliptical



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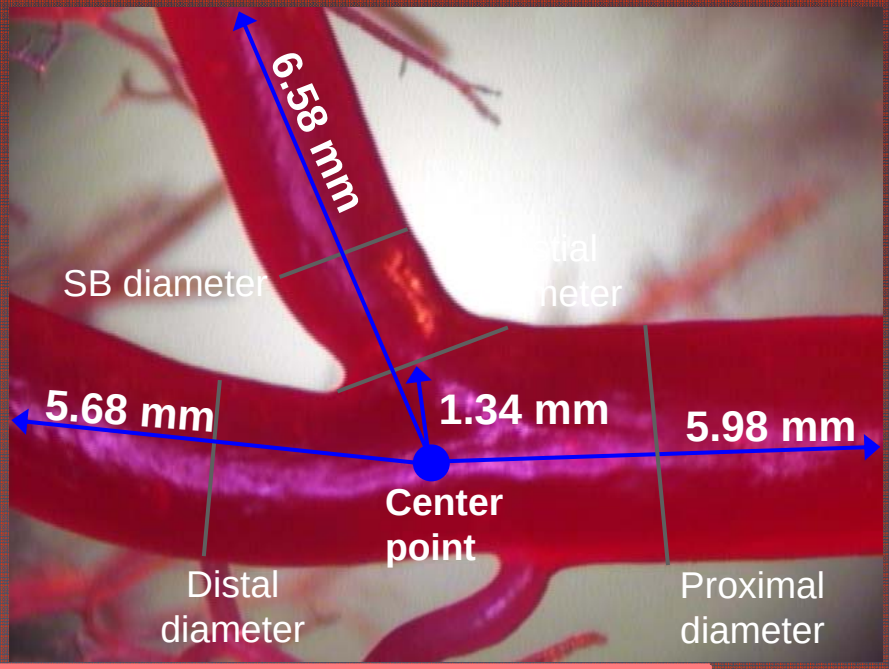
Understanding Ostial geometry: Transition Zone Taper Greater by 3-fold

Courtesy of Mary Russel, MD, PhD

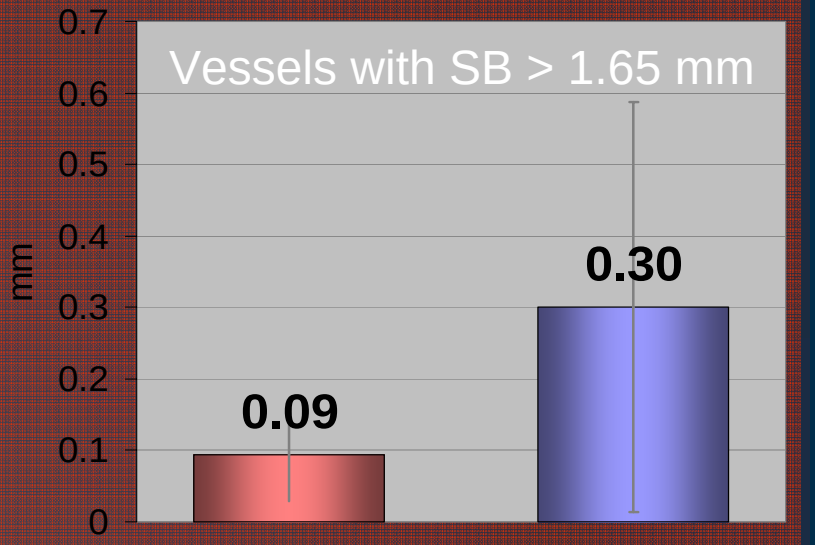
Example of Diameter Measurements



	At 3 mm	At 6 mm
Proximal diameter	3.14	3.15
Distal diameter	2.44	2.56

	At ostium	At 3 mm	At 6mm
Side branch diameter	2.50	1.96	2.03

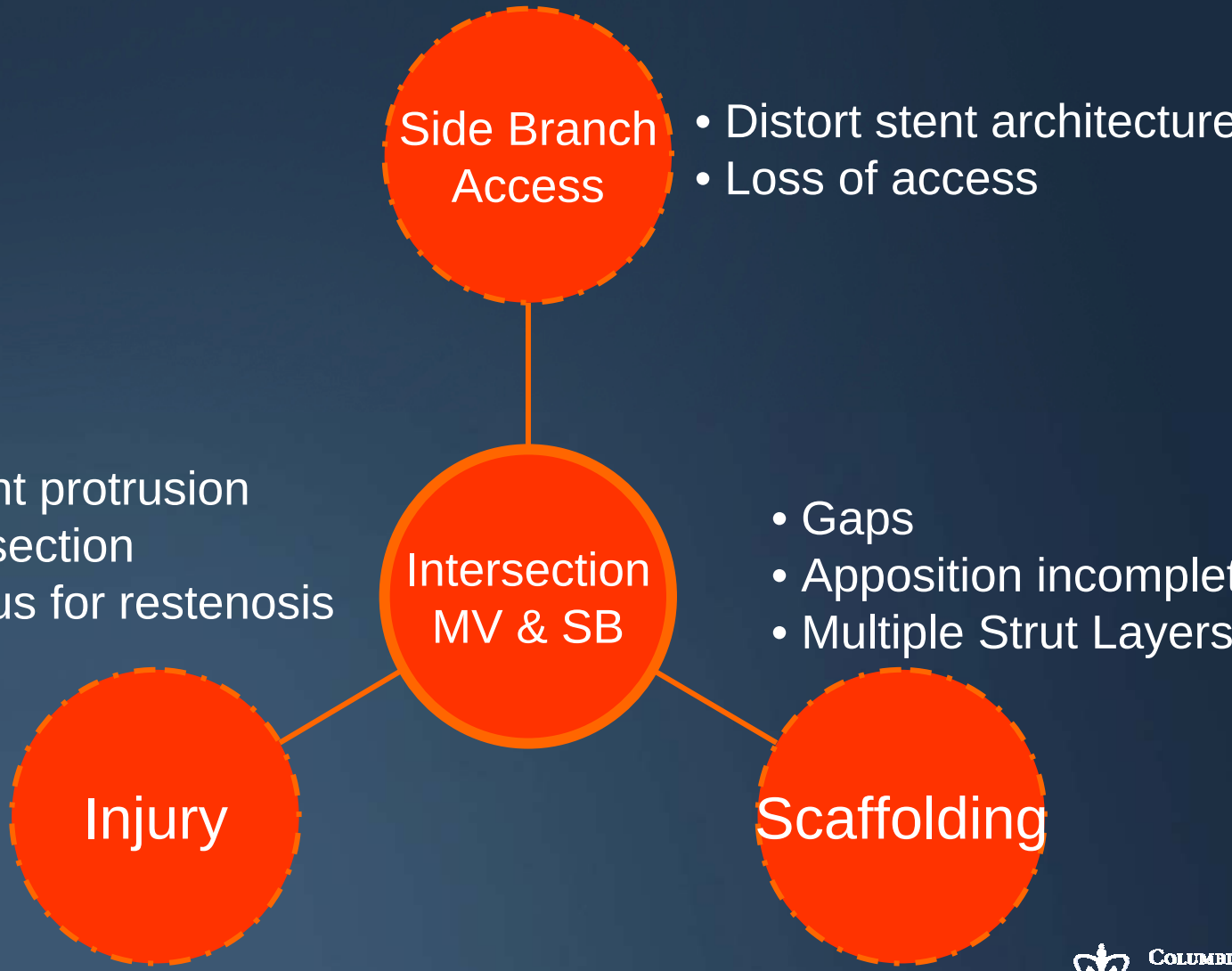
Average Taper



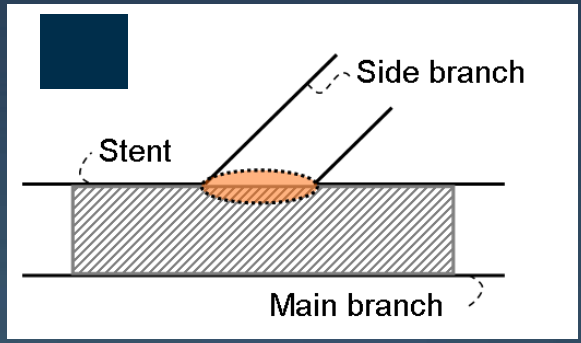
Main Vessel
Tapers 0.56 mm over 6.00 mm distance

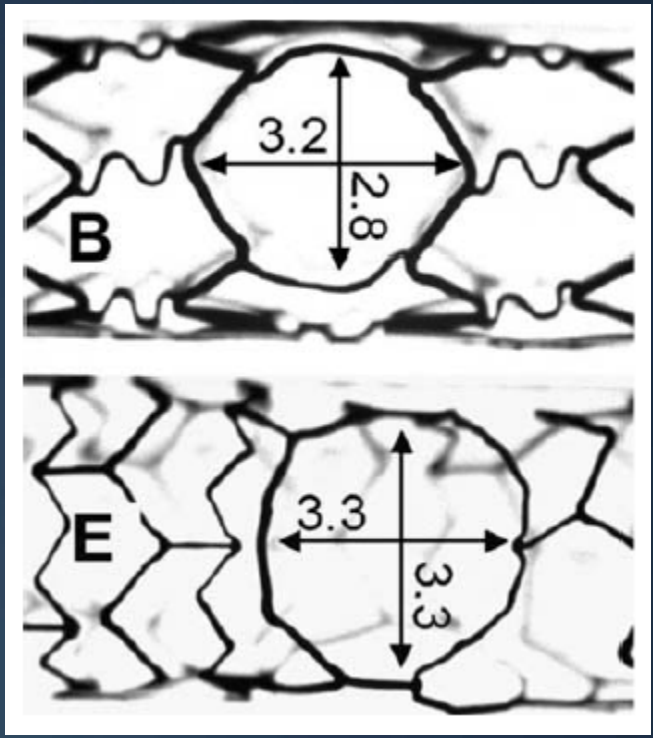
Side Branch
Tapers 0.53 mm over 1.75 mm distance

Technical Challenges with Bifurcations Using Straight, Concentric Tubular Systems



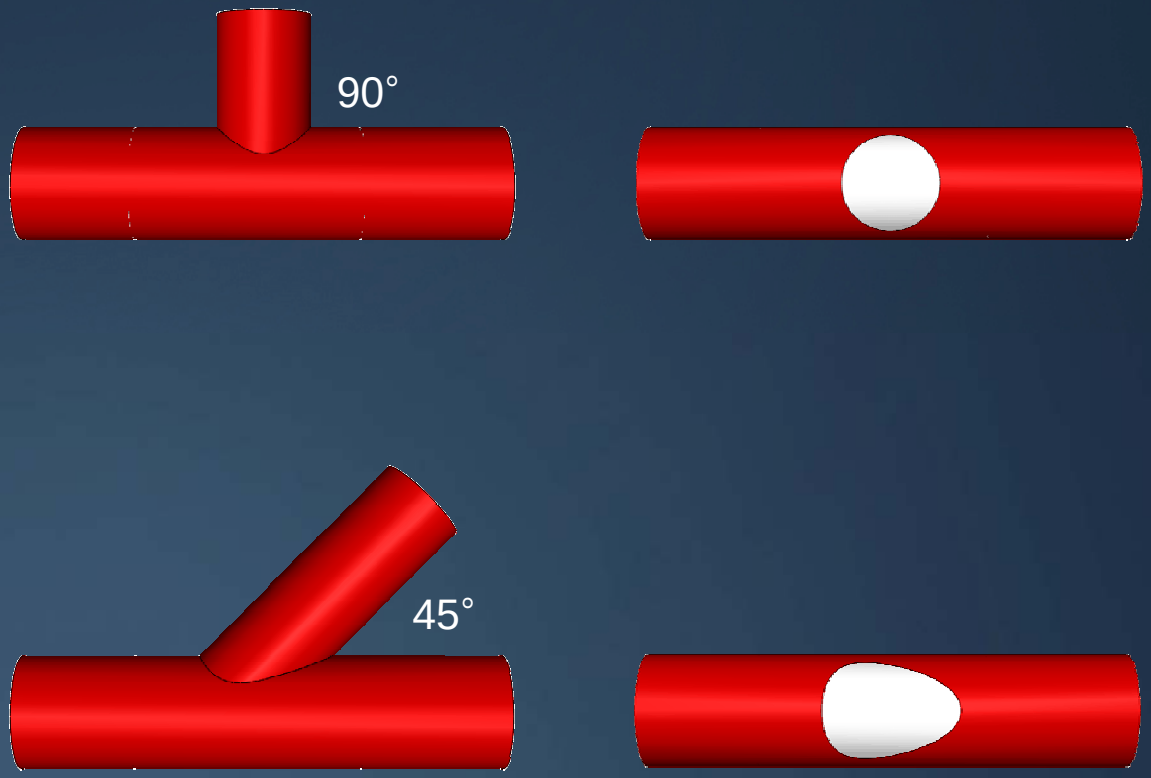
During provisional stenting, stent cells are distorted by PTCA





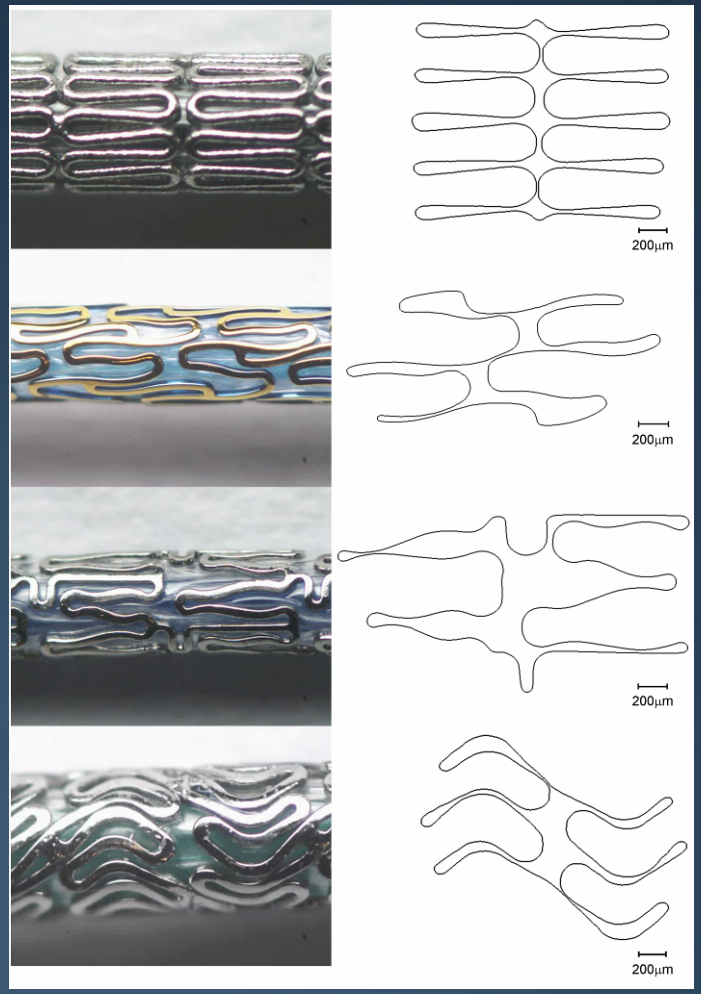
Courtesy El-Jack et al

Size of the ostium changes with the angle of bifurcation



Courtesy P Mortier et al

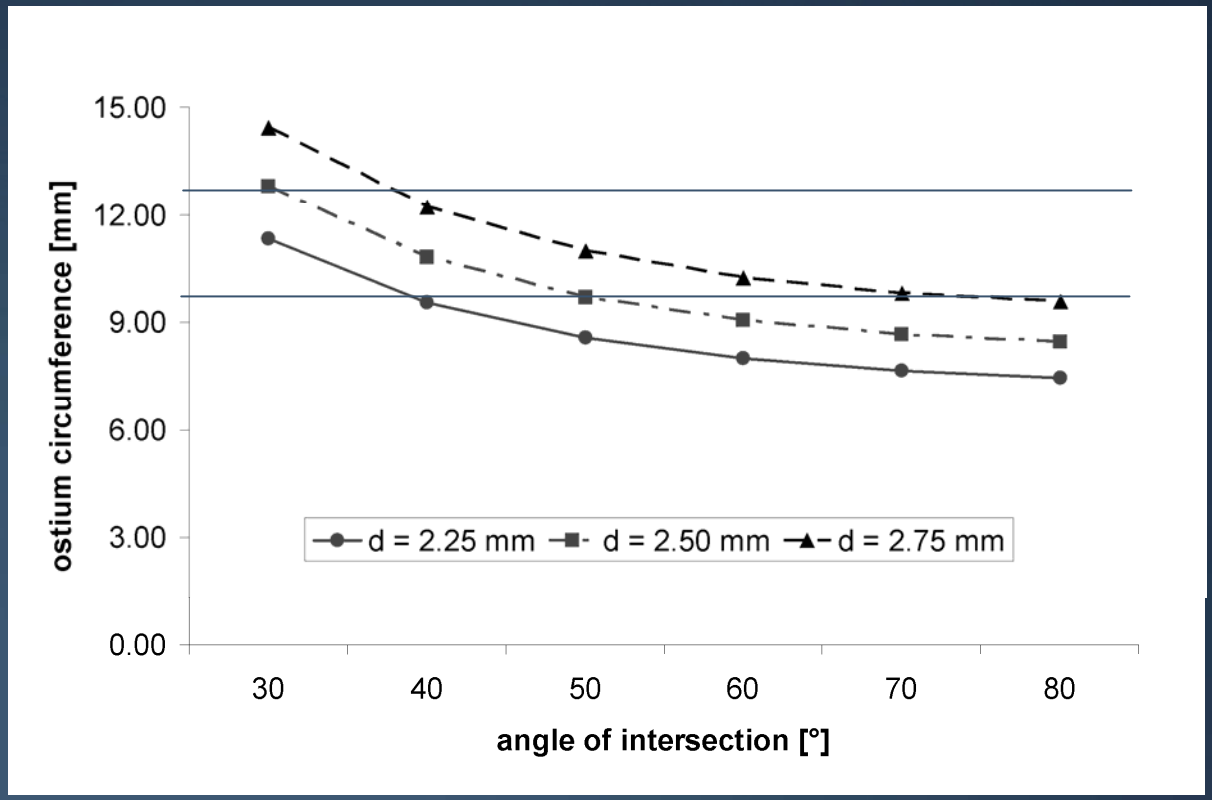
Overview of investigated stents

		Cell circumference [mm]	Equivalent diameter [mm]
Endeavor (Medtronic)		9.5	3.0
PRO-Kinetic (Biotronik)		19.8	6.3
Promus (Boston Scientific)		10.8	3.4
Taxus Liberté (Boston Scientific)		12.6	4.0
		12.6	4.0

Courtesy P Mortier et al

The ostium circumference increases rapidly for smaller bifurcation angles

- For a 3 mm main branch



Promus Stent

Cypher Stent

3 different side branch diameters

Courtesy P Mortier et al

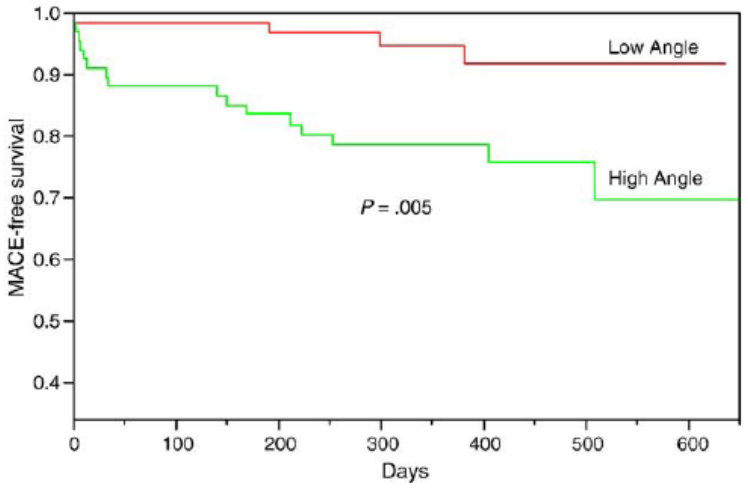
Greater Bifurcation Angle associated with higher mortality and MACE with Crush Technique

133 pts undergoing crush stenting:

- 66 pts with low angle (<50 degrees)
- 67 pts with high angle (>50 degrees)

MACE

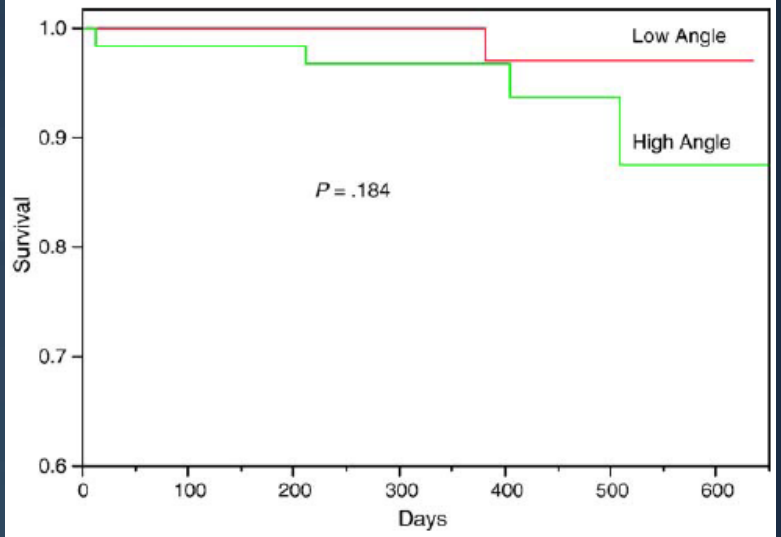
Figure 3



Kaplan-Meier plot comparing MACE-free survival up to 648 days between the low-angle group (BA <50° and high-angle group (BA ≥50°).

Survival

Figure 4



A Kaplan-Meier plot indicating survival up to 648 days in the low-angle (BA <50°) and high-angle group (BA ≥50°).

Dzavik V et al. Am Heart J. 2006

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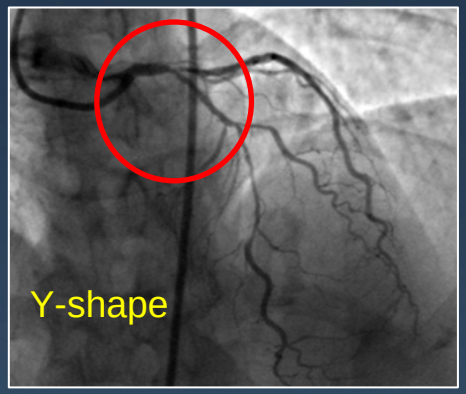
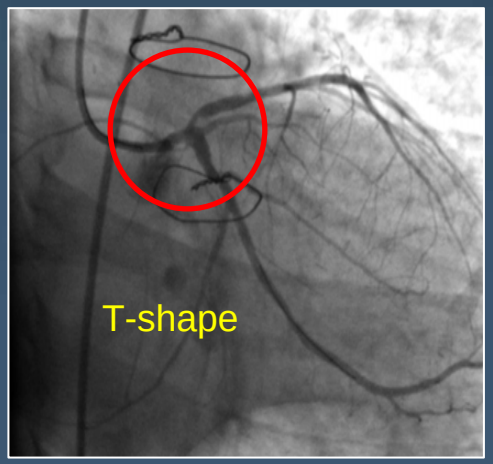
French Left Main Taxus Registry

Role of Bifurcation Angle following Provisional T in 92%





Role of Bifurcation Angle

2-years FU	Y-Shape (137)	T-Shape (84)	*P value*
Stent thrombosis* (%)	0	2.3	<0.05
TVR (%)	8.7	8.3	0.41
Cardiac death (%)	2.9	9.5	0.021
Death (%)	4.4	17.8	0.001

- **Definite and probable stent thrombosis according to ARC definition**
- **T shaped bifurcation was an independent predictor of Death at 2 years**

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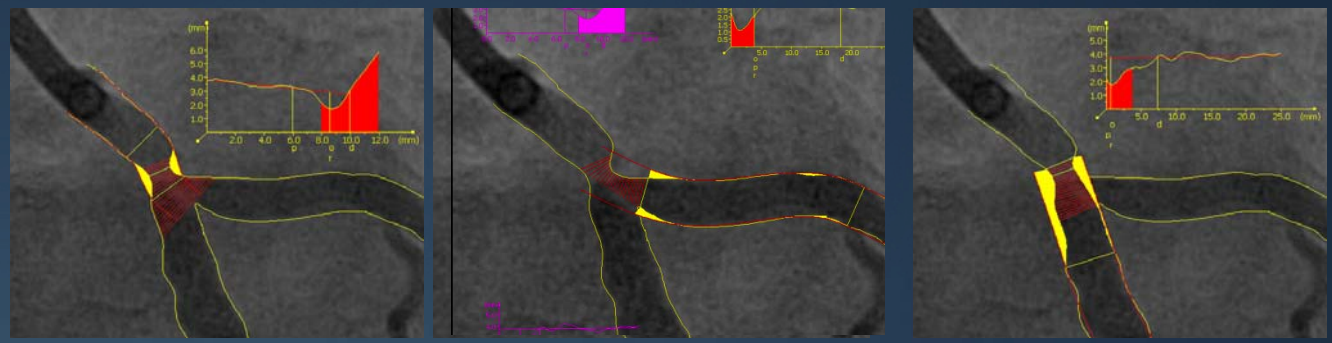
Limitation of Current QCA software
Different Results for Same Lesion

Artificial “interpolation” of RVD across carina

Carinal segment reported 3 times with differing results



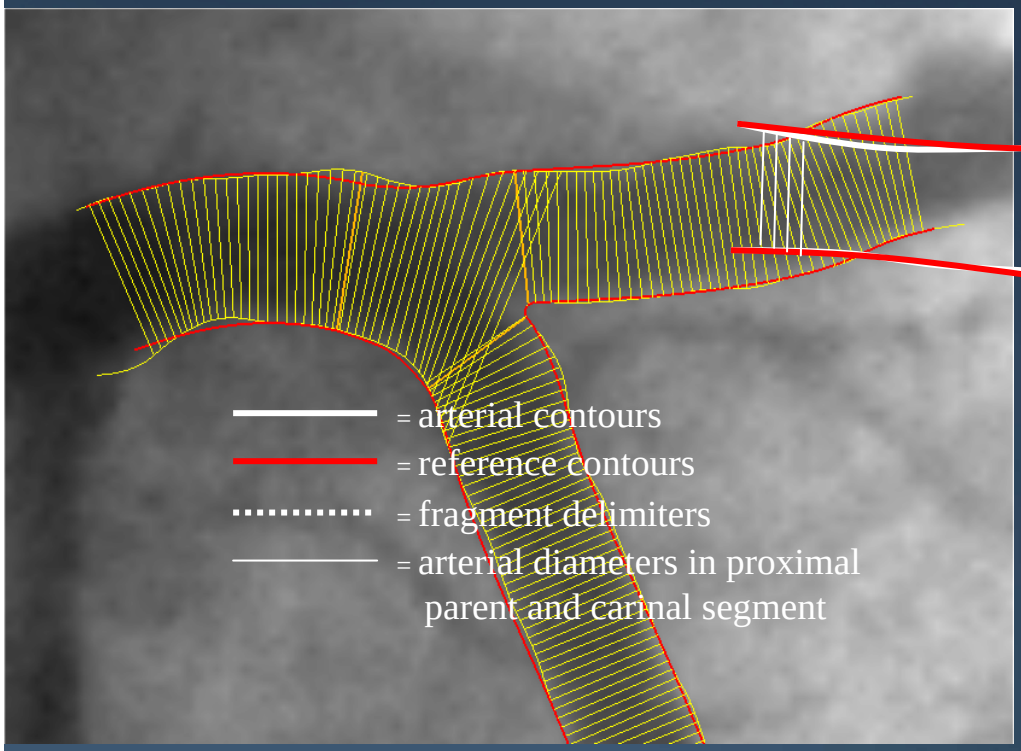
LCA Main	LCA Main	LCA Main
LAD Proximal	LAD Proximal	LAD Proximal
LCX Proximal	LCX Proximal	LCX Proximal
Obstruction diam.	Obstruction diam.	Obstruction diam.
1.72 mm	2.02 mm	1.71 mm
Reference diam.	Reference diam.	Reference diam.
2.92 mm	3.13 mm	3.70 mm
Diameter stenosis	Diameter stenosis	Diameter stenosis
41.15 %	35.45 %	53.74 %
Obstruction length	Obstruction length	Obstruction length
3.98 mm	14.36 mm	7.35 mm

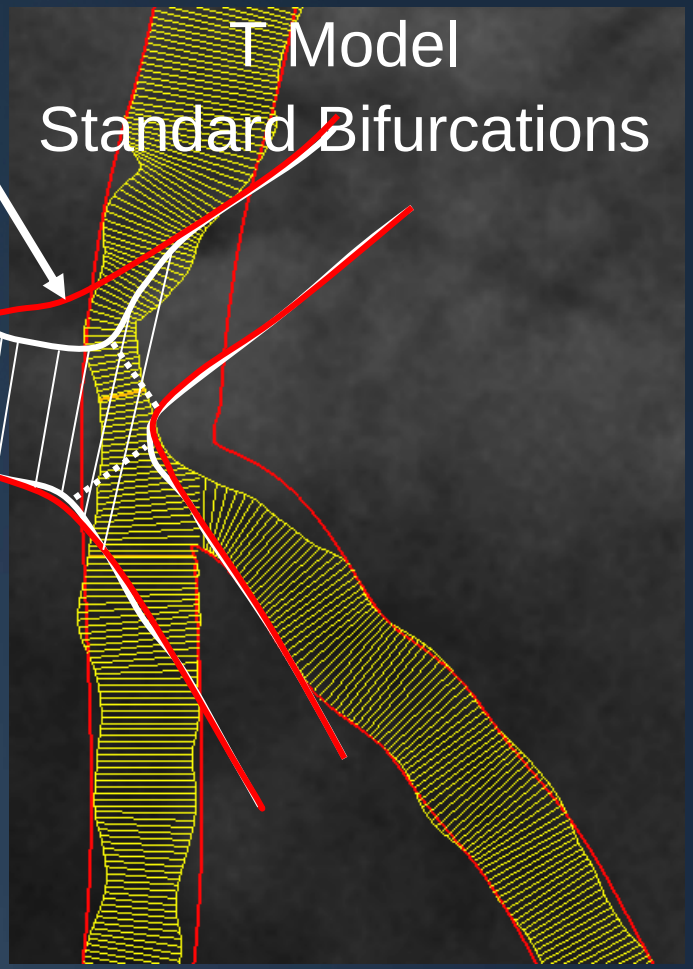
Challenge in measuring Bifurcations

Innovative derivation of RVD in carina segment

Y Model: LM

T Model
Standard Bifurcations





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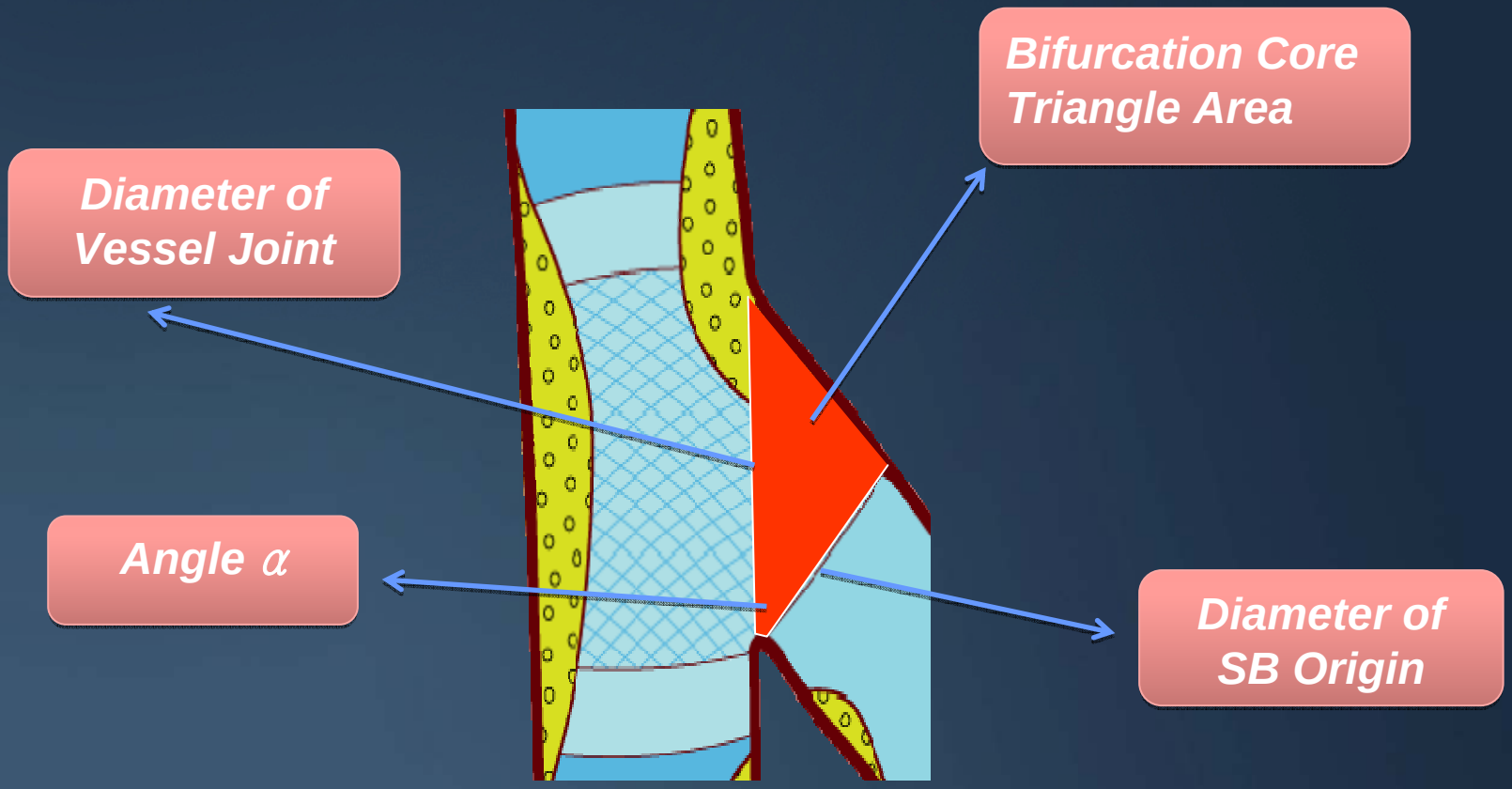
Bifurcation Core Triangle as a Measure for Carina Shift, Ostial Scaffolding, and Ostial Preservation



Intra-Observer Results
T-shaped analysis

Pre- and Post-intervention (n=18)	Prox. Parent Vessel incl. Bifurcation Core	Dist. Parent Vessel	Side Branch
Obs D (mm)	0.01 ± 0.03	-0.01 ± 0.04	0.01 ± 0.05
Ref D (mm)	0.08 ± 0.10	0.01 ± 0.08	0.04 ± 0.10
%D Stenosis	0.8 ± 1.7	0.5 ± 2.0	0.5 ± 3.0
Obs Length (mm)	0.7 ± 1.2	-0.1 ± 1.0	0.4 ± 1.2

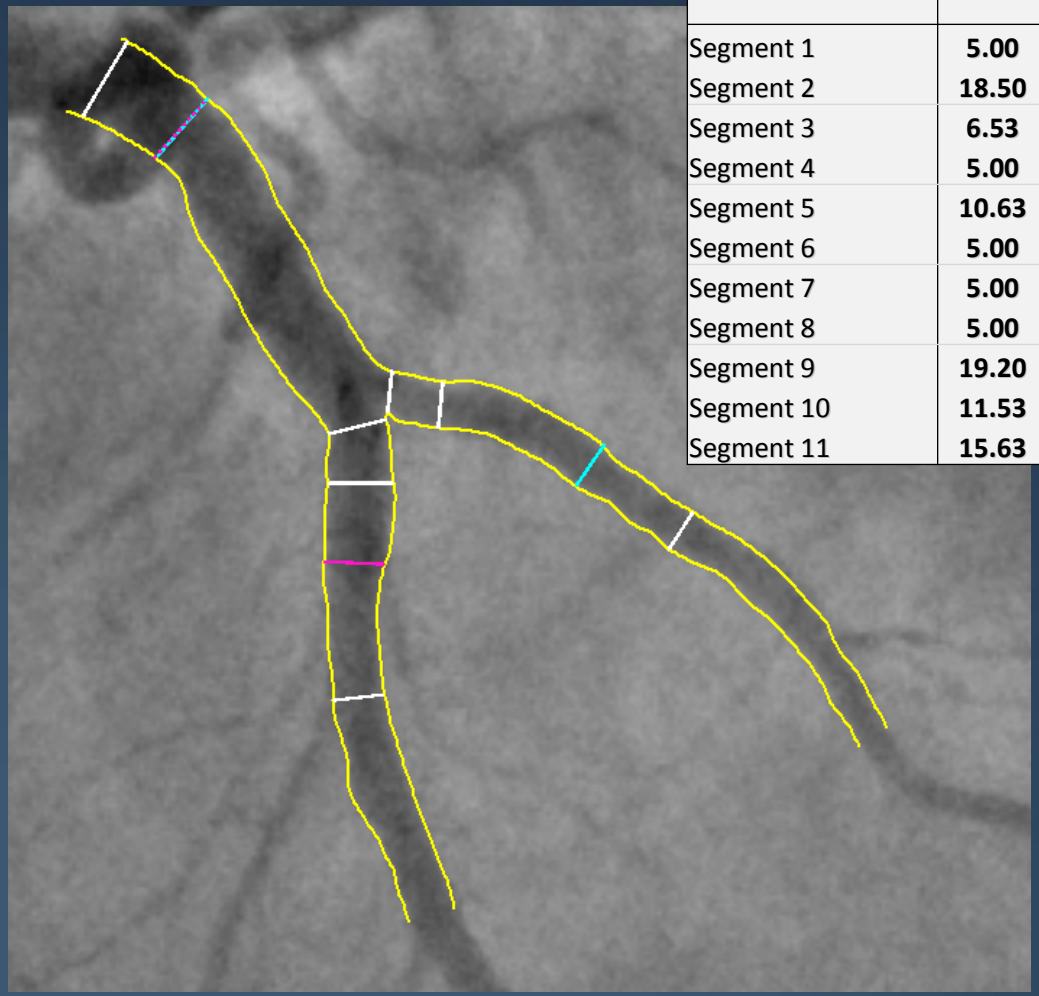
All results expressed as mean difference ± standard deviation

Intra-Observer Results
Y-shaped analysis

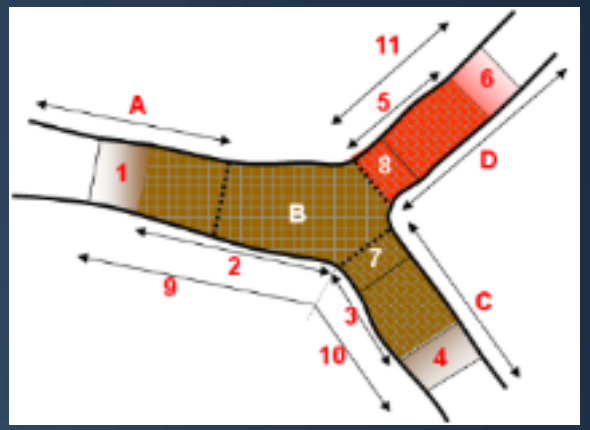
Pre- and Post-intervention (n=18)	Prox. Parent Vessel incl. Bifurcation Core	Dist. Parent Vessel	Side Branch
Obs D (mm)	0.00 ± 0.03	0.02 ± 0.08	-0.01 ± 0.06
Ref D (mm)	0.03 ± 0.11	-0.03 ± 0.09	0.02 ± 0.10
%D Stenosis	0.5 ± 1.7	-1.8 ± 3.7	1.3 ± 4.5
Obs Length (mm)	0.0 ± 1.4	-0.4 ± 1.0	-0.5 ± 4.0

All results expressed as mean difference ± standard deviation

Edge Segment Definitions



	Length	Position MLD	MLD	Ref D	% DS	Distance MLD-stent	Max D	Mean D
Segment 1	5.00	0.523	3.843	3.728	-3.07	0.174	3.845	3.844
Segment 2	18.50	6.099	3.407	3.709	8.14		3.854	3.604
Segment 3	6.53	25.724	2.560	2.462	-3.96		3.231	2.975
Segment 4	5.00	27.485	2.229	2.443	8.76	1.761	2.560	2.380
Segment 5	10.63	19.253	1.786	2.368	24.57		5.400	2.160
Segment 6	5.00	30.012	1.685	1.944	13.31	1.056	2.035	1.815
Segment 7	5.00	24.198	2.876	2.478	-16.04		3.231	3.049
Segment 8	5.00	19.253	1.786	2.368	24.57		5.400	2.158
Segment 9	19.20	6.099	3.407	3.709	8.14		3.854	3.613
Segment 10	11.53	27.485	2.229	2.443	8.76		3.231	2.717
Segment 11	15.63	19.253	1.786	2.368	24.57		5.400	2.050



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Conclusions

- Angiography has many limitations in assessing bifurcation lesions
- Given the asymmetry at the MV and SB transition zone, traditional QCA miss dimensions relevant to the ostial intersection
- Novel QCA software is designed to accurately derive reference measures and minimal luminal diameters
- Bifurcation Core area and angle measures provide ostial SB geometry changes from baseline to final treatment
- This new QCA analysis should provide critical information to guide intervention procedures and new device development