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Angiography-Derived FFR for Bifurcation Lesions

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Disclosure

Speaker's name: Shengxian Tu

☑ I have the following potential conflicts of interest to declare:

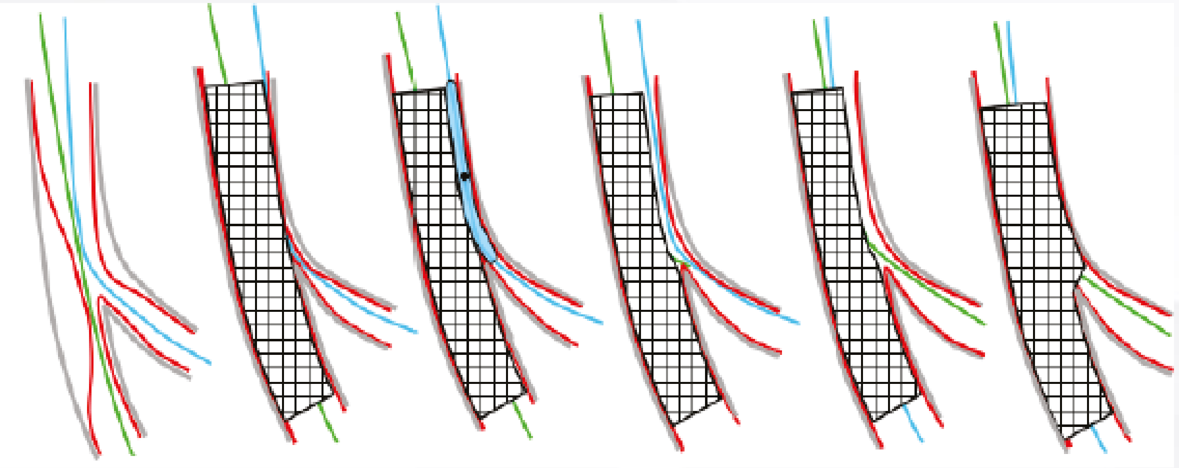
Co-founder: Pulse Medical

Receipt of grants / research support: Pulse Medical

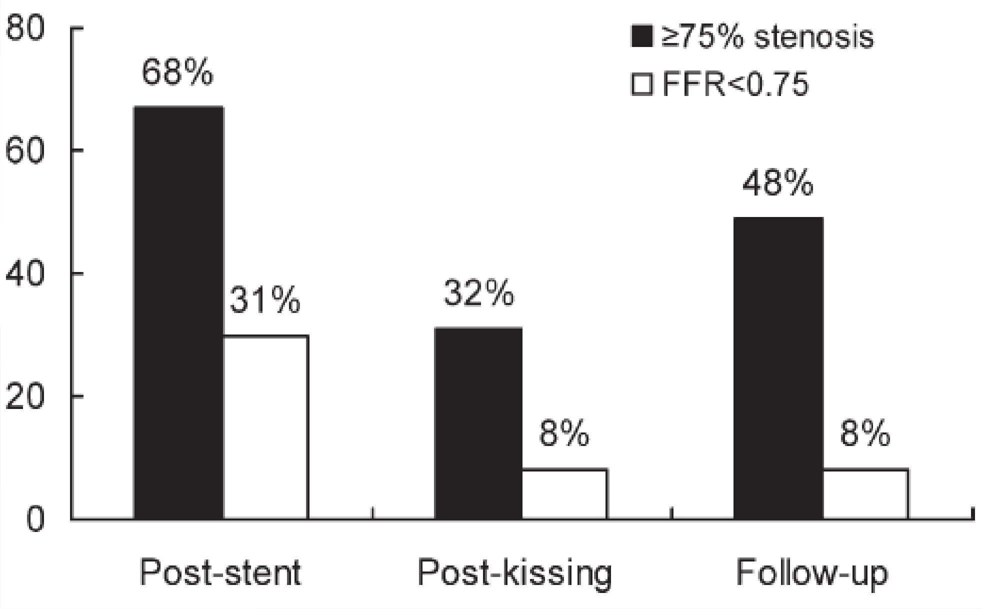
Consultancy: Pulse Medical

FFR in Bifurcation Lesions: Mismatch in SB Evaluation

- There is big **mismatch** between angiographic severity and functional severity
- Jailed SB FFR after MV stenting could **define the functional significance** of SB lesions, **guide stenting strategy**, and **avoid unnecessary complex interventions**



FFR can be performed before and after MV stenting, and after bifurcation optimization, in both MV and SB



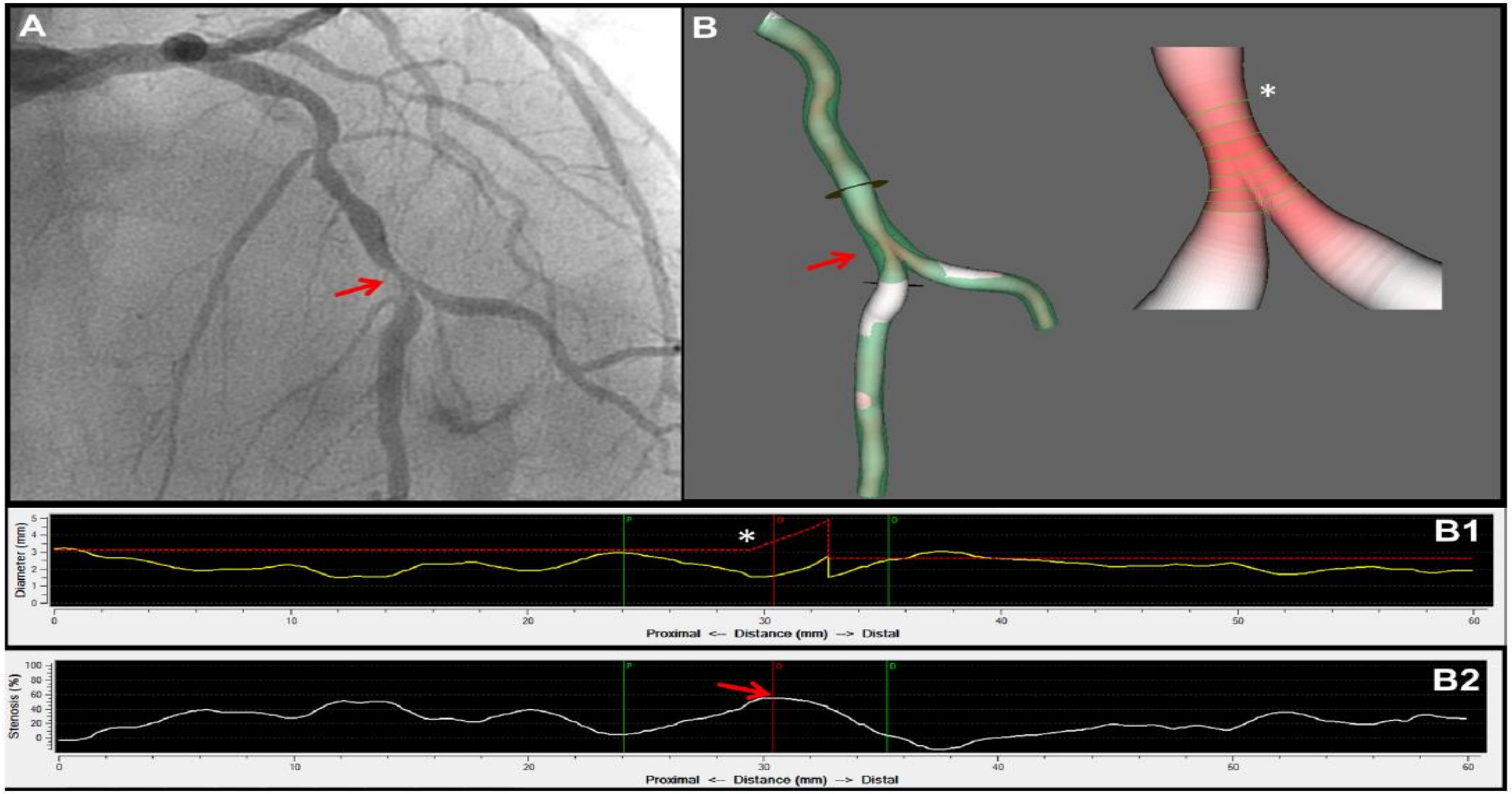
The percentage of SB lesions requiring further intervention according to angiographic and functional criteria

Lee et al., JACC Cardiovasc Interv 2022;15:1297–1309

Koo et al., Eur Heart J 2008;29:726-732

A New Bifurcation Model to Quantify Stenosis Severity

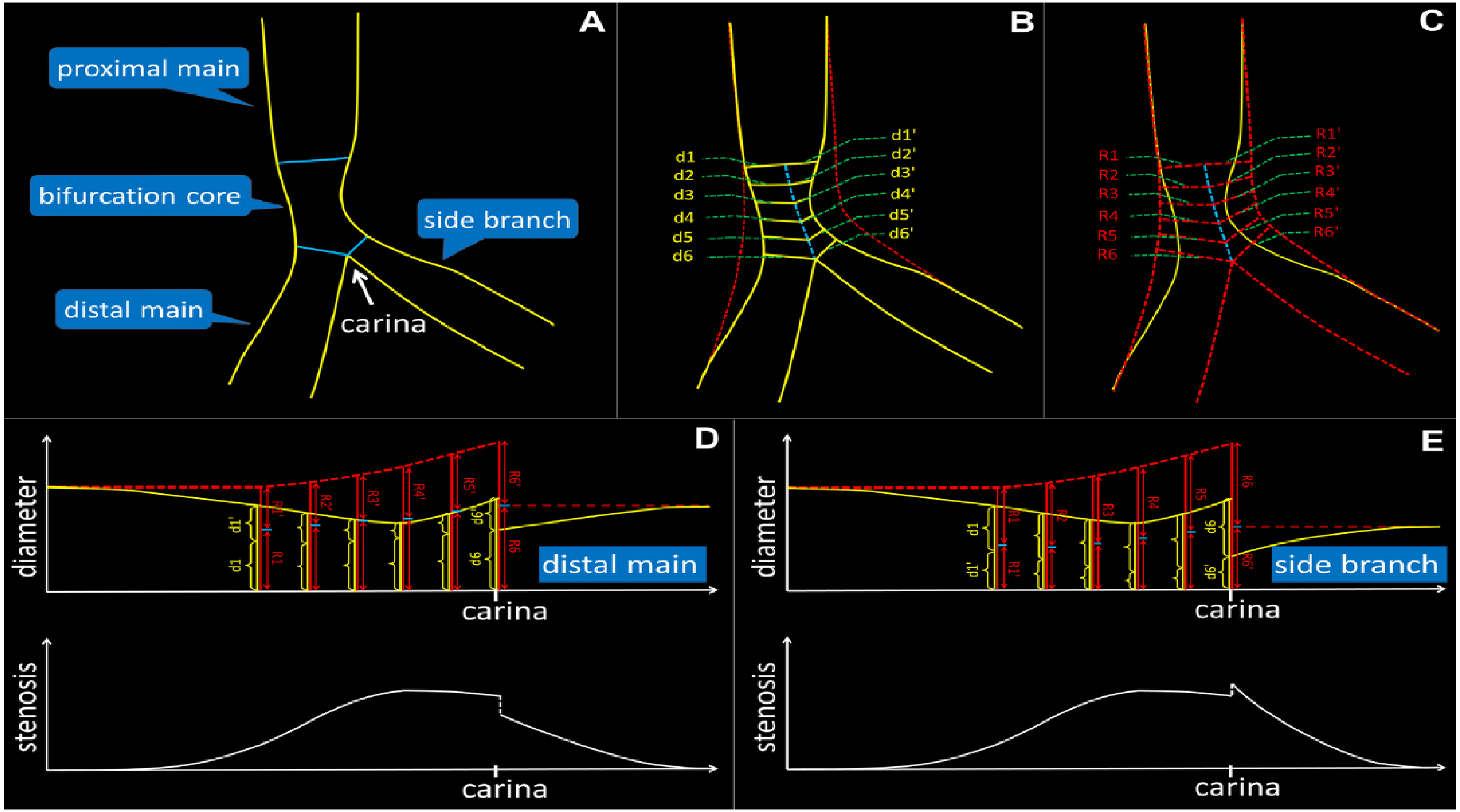
FIGURE 2 In Vivo Assessment of Stenosis Severity in Bifurcation Lesions By the New Bifurcation Model



Tu et al. J Am Coll Cardiol Interv 2015; 8:564-574.

A New Bifurcation Model to Quantify Stenosis Severity

FIGURE 1 A New Quantitative Model for Assessing Bifurcation Lesions



Tu et al. J Am Coll Cardiol Interv 2015; 8:564-574.

Anatomical and Functional Discrepancy

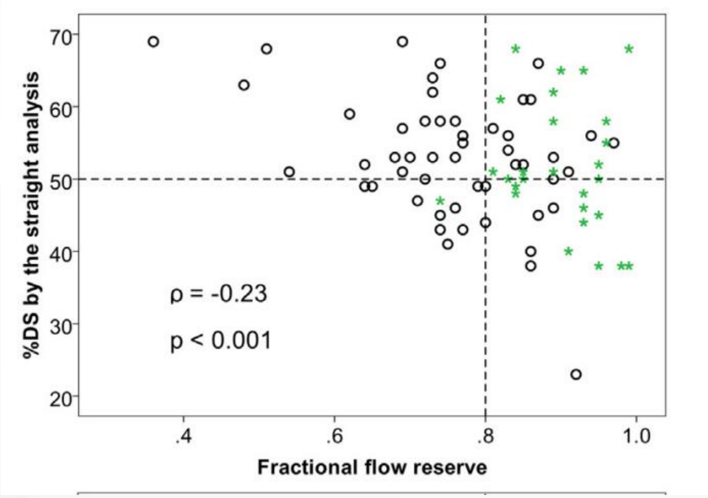
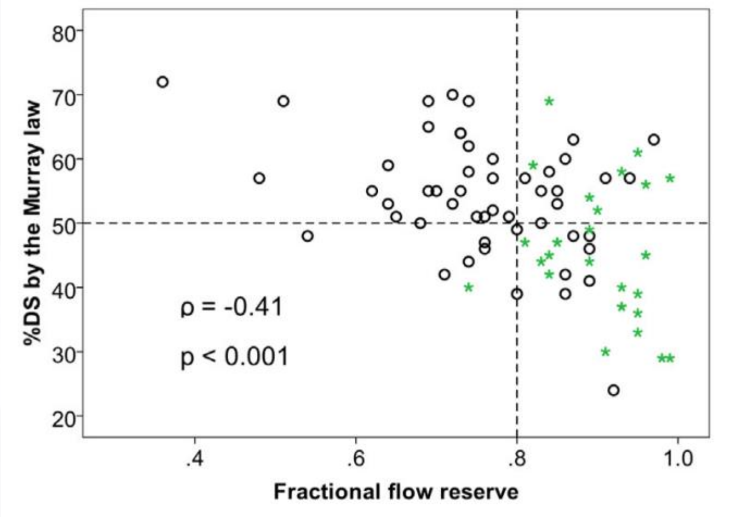
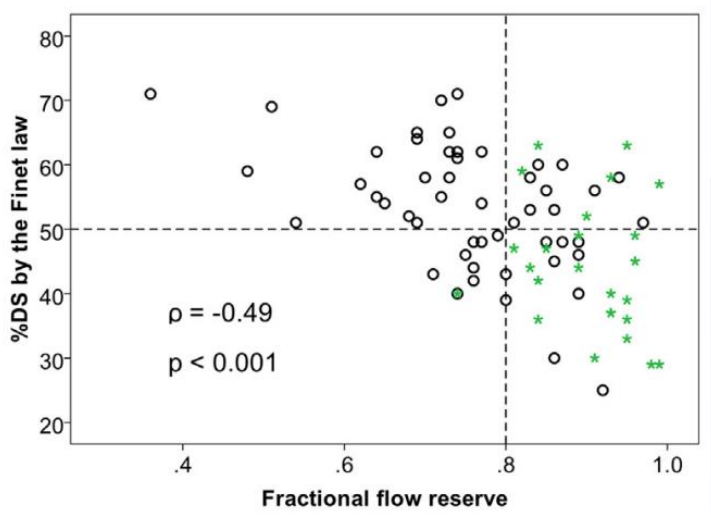
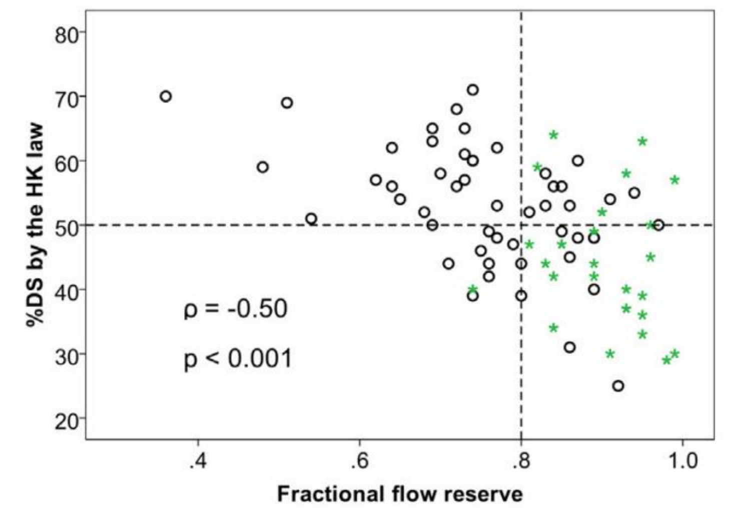


TABLE 5 Diagnostic Performance of 3-Dimensional Quantitative Coronary Angiography

	DS%HK ≥50%	DS%HK ≥56%	MLD ≤1.35 mm	MLA ≤1.70 mm^2
Accuracy	64 (53-75)	68 (57-79)	62 (50-73)	67 (56-77)
Sensitivity	68 (50-83)	53 (35-80)	79 (62-91)	76 (59-89)
Specificity	61 (46-76)	80 (65-90)	48 (33-63)	59 (43-74)
PPV	58 (41-73)	67 (46-84)	54 (39-68)	59 (43-74)
NPV	71 (54-83)	69 (54-81)	75 (55-89)	77 (59-89)



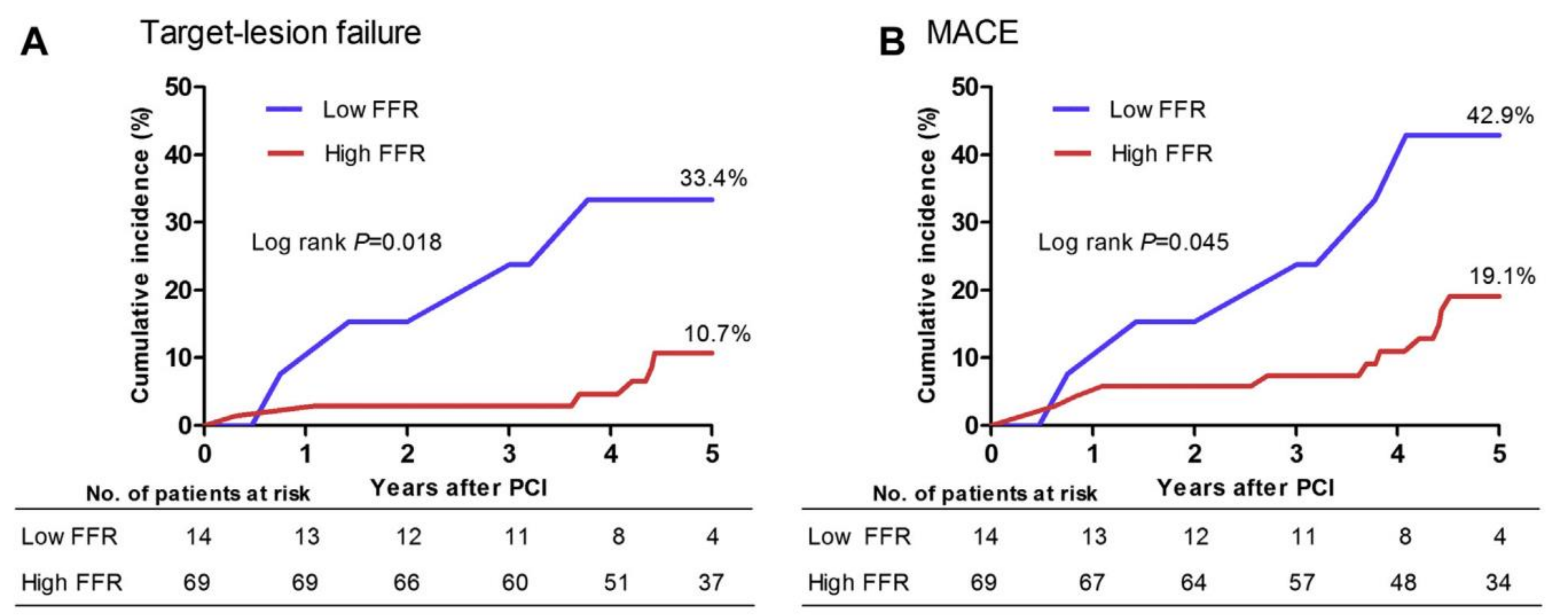




Tu et al. J Am Coll Cardiol Interv 2015; 8:564-574.

FFR in Bifurcation Lesions: A Matter of Gain and Risk

- Final jailed SB FFR is associated long-term clinical outcomes



Unadjusted 5-year event rate according to FFR in LCx after LM simple crossover stenting

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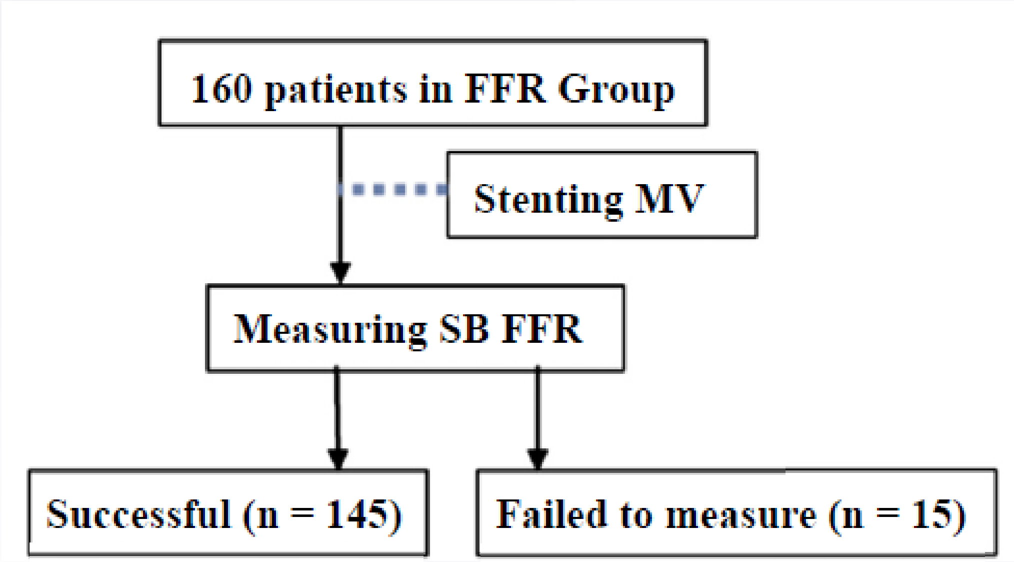
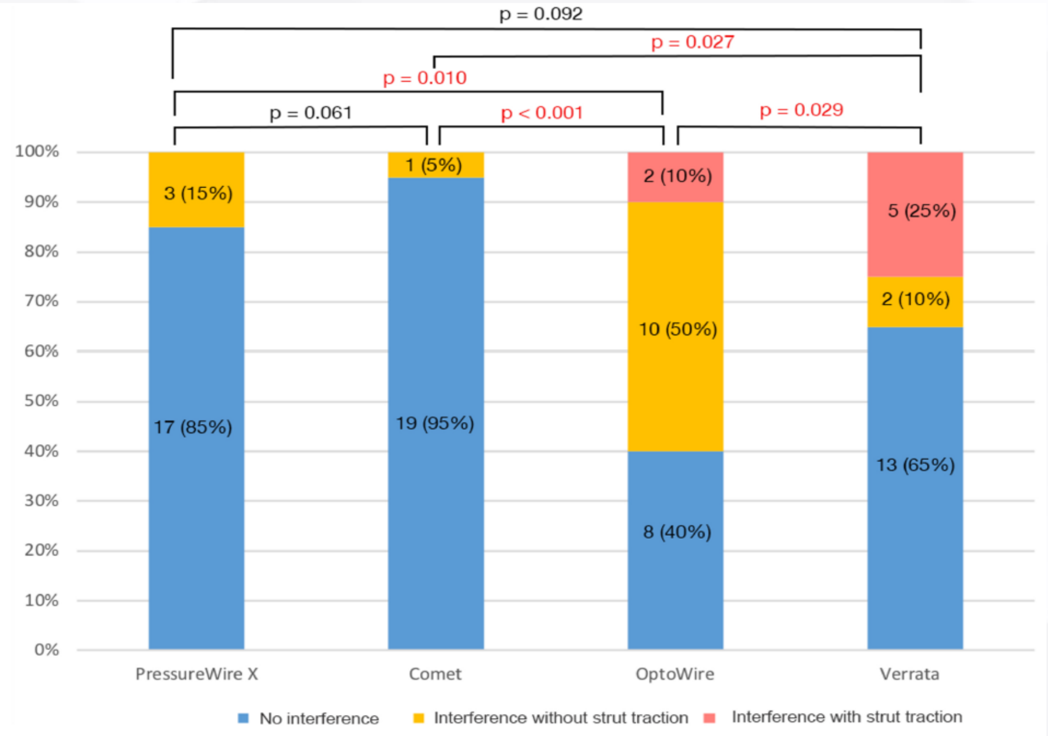
Lee et al., JACC Cardiovasc Interv 2019;12:847-855

FFR in Bifurcation Lesions: A Matter of Gain and Risk

- **Technically difficult** for jailed SB FFR assessment after MV crossover stenting
- **Safety concern** (potential damage in both pressure wire and stent strut)



SB FFR in up to 9.4% lesions could not be measured despite KBI using a 1.2-mm SB balloon

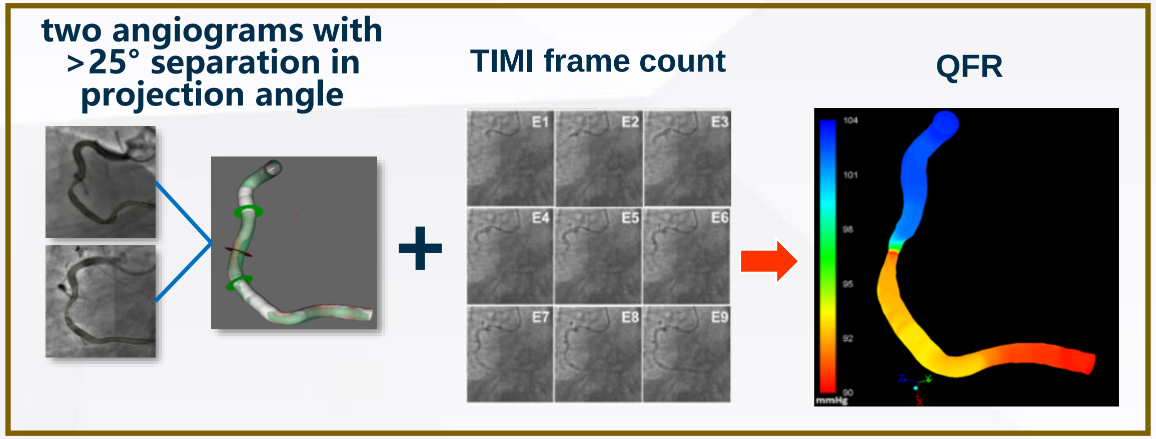


Differences in interference with pressure-wires between stent strut

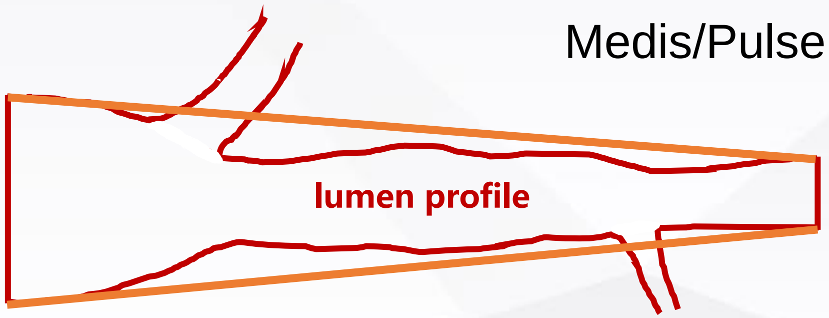
Chen et al., JACC Cardiovasc Interv 2015;8(4):536-546
Warisawa et al., Cardiovasc Revasc Med 2020;21(6):765-770

Angiography-Derived Quantitative Flow Ratio（QFR)

First generation QFR

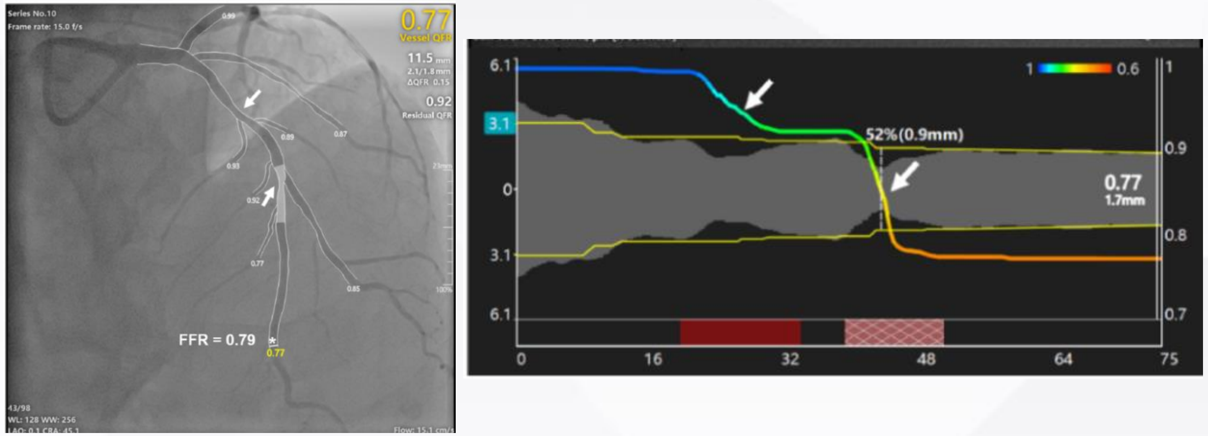


Medis/Pulse Medical

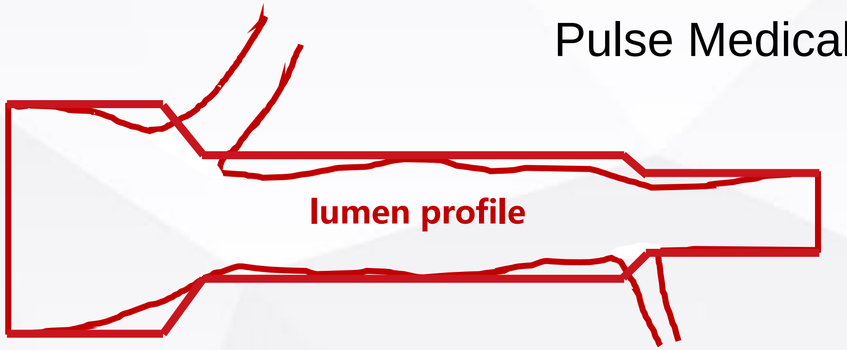


Tapering reference lumen

Second generation μQFR/μFR



Pulse Medical

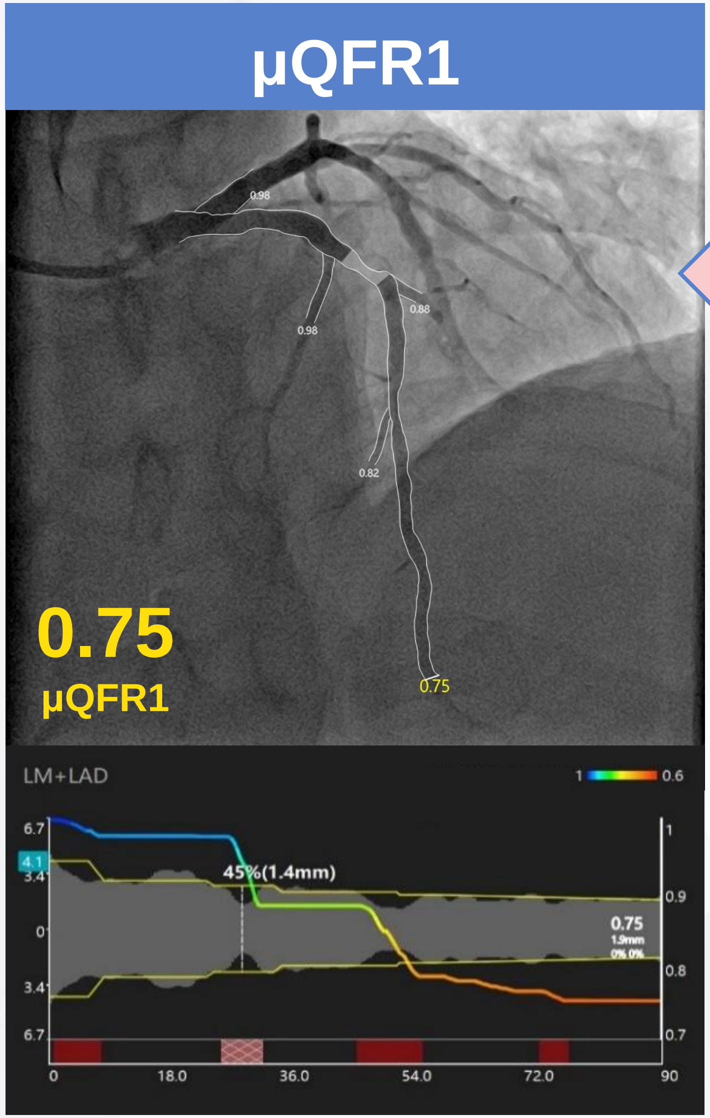


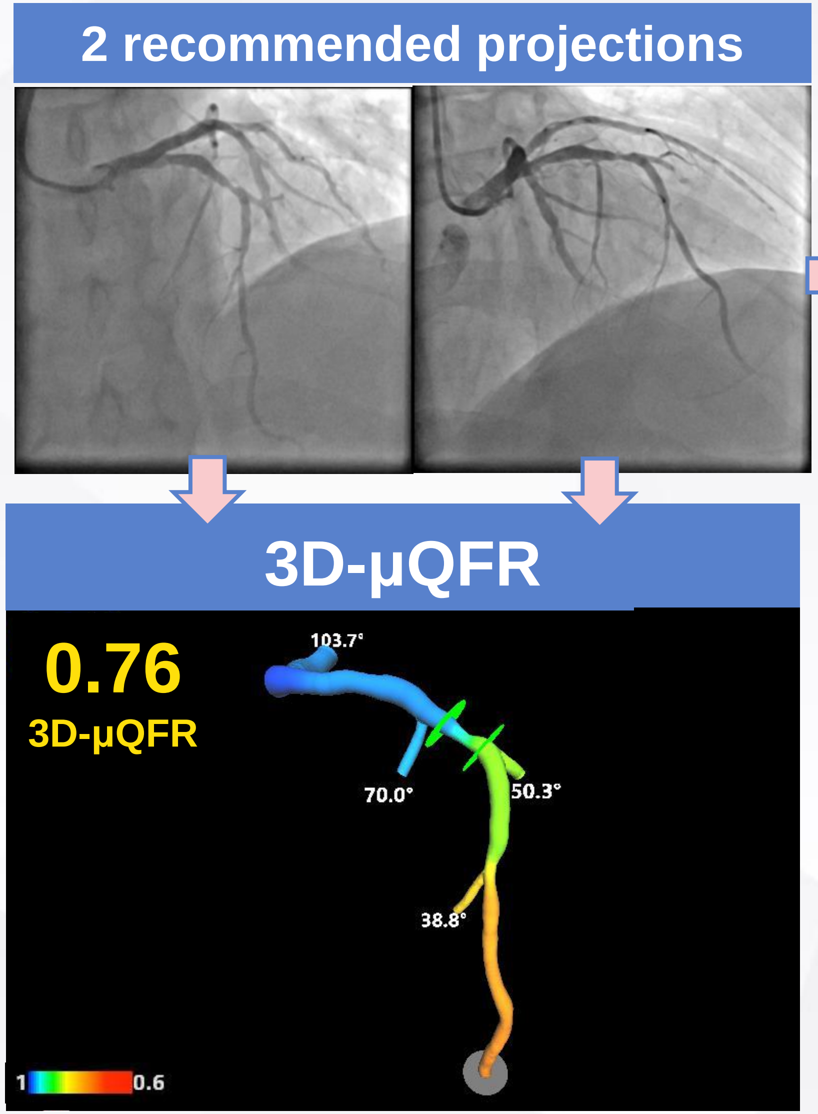
Reference lumen with step-down across bifurcations

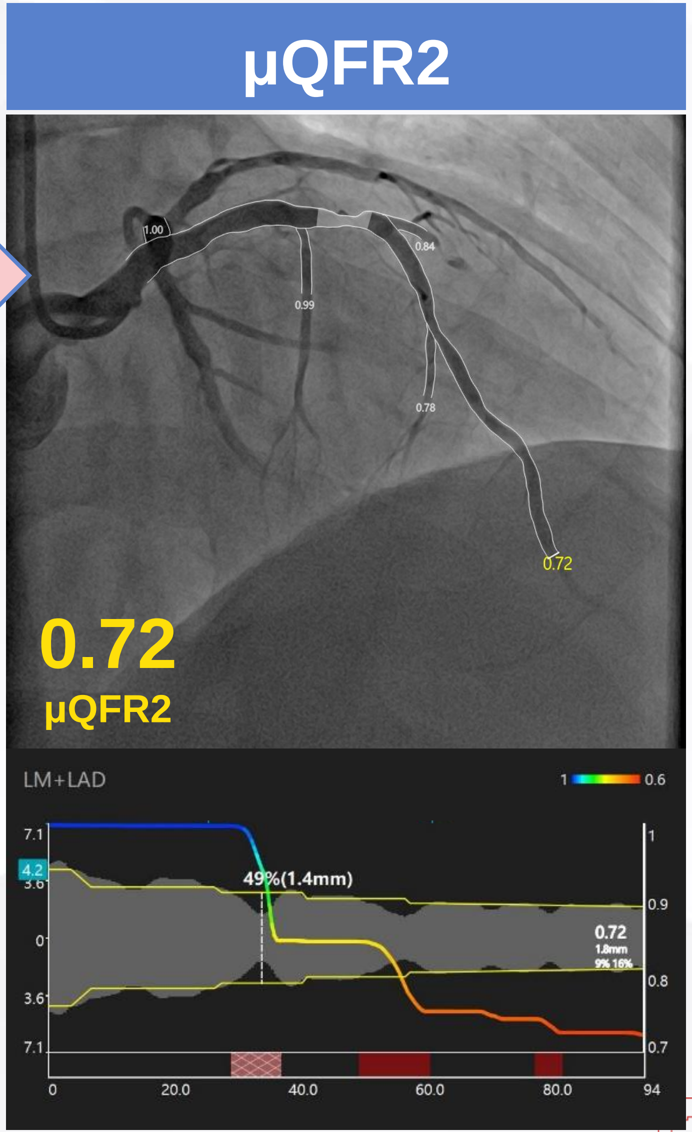
Tu S, et al. JACC Cardiovasc Interv. 2016;9:2024-35

Tu S, et al. Catheter Cardiovasc Interv 2021;97(2):1040-1047

2D μQFR vs. 3D μQFR

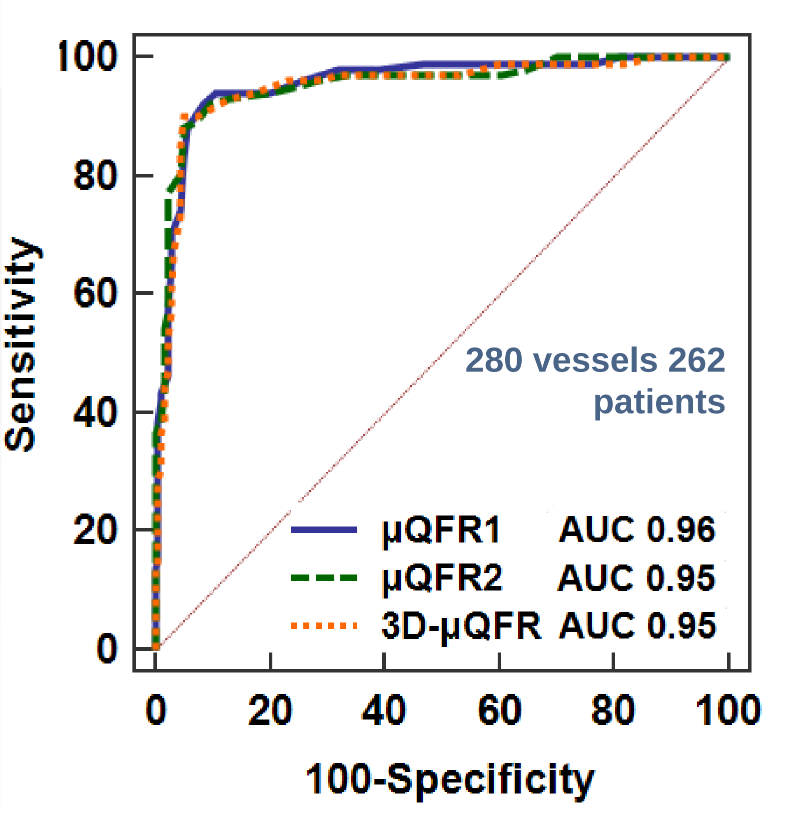






Ding, Tu, Wijns et al. *JSCAI* 2022; 1: 100399

2D μQFR vs. 3D μQFR



FFR ≤0.80 as reference

	μQFR1 ≤0.80	μQFR2 ≤0.80	3D-μQFR ≤0.80
Accuracy %	**92.1 (89.0, 95.3)**	**92.5 (89.4, 95.6)**	**93.2 (90.3, 96.2)**
Sensitivity %	88.1 (80.2, 93.7)	88.1 (80.2, 93.7)	90.1 (82.5, 93.7)
Specificity %	94.4 (90.0, 97.3)	95.0 (90.7, 97.7)	95.0 (90.7, 97.7)
PPV %	89.9 (82.2, 95.0)	90.8 (83.3, 95.7)	91.0 (83.6, 95.8)
NPV %	93.4 (88.7, 96.5)	93.4 (88.8, 96.5)	94.4 (90.0, 97.3)
+LR	15.8 (8.6, 28.9)	17.5 (9.2, 33.3)	17.9 (9.4, 34.0)
-LR	0.13 (0.07, 0.2)	0.13 (0.07, 0.2)	0.10 (0.06, 0.2)
AUC	0.96 (0.93, 0.98)	0.95 (0.92, 0.98)	0.95 (0.92, 0.97)

Single-view μQFR and two-view 3D-μQFR had comparable accuracy

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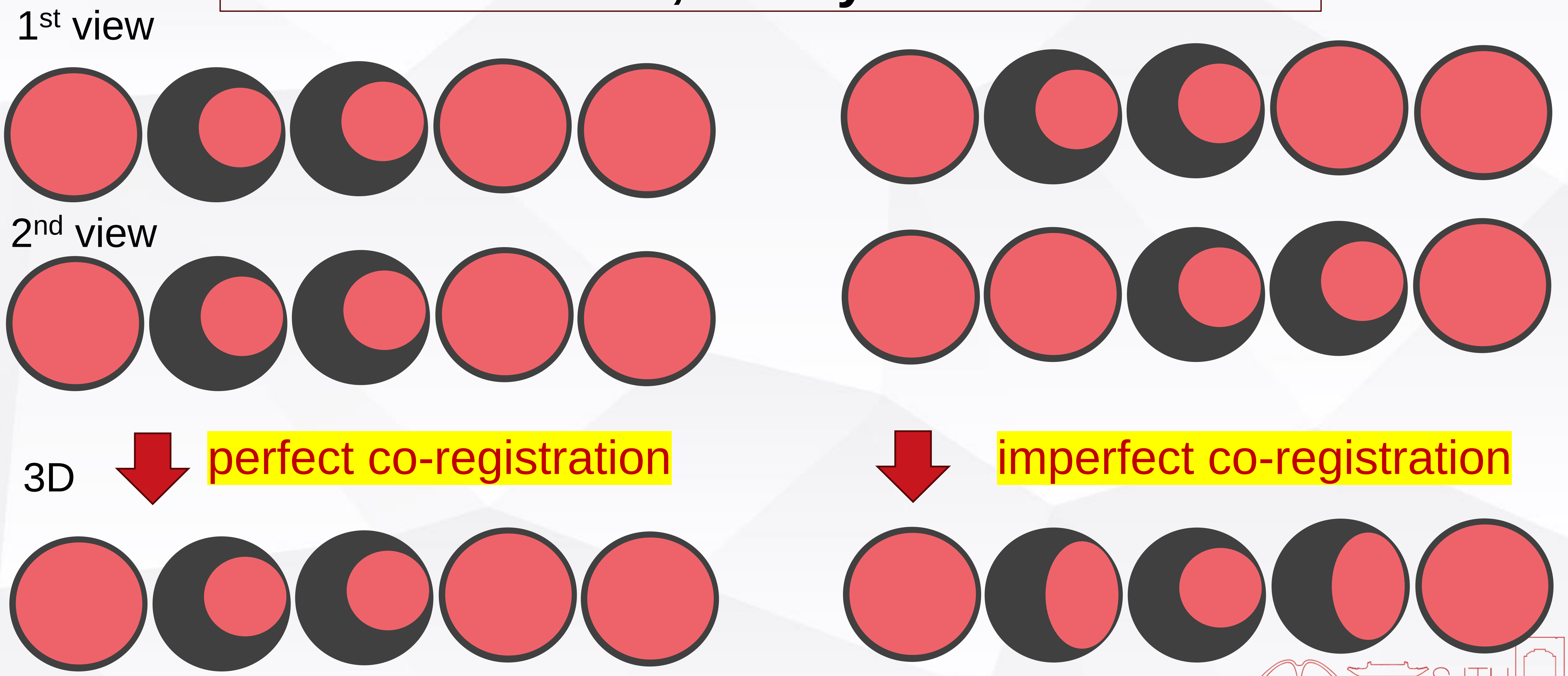
Ding, Tu, Wijns et al. *JSCAI* 2022; 1: 100399

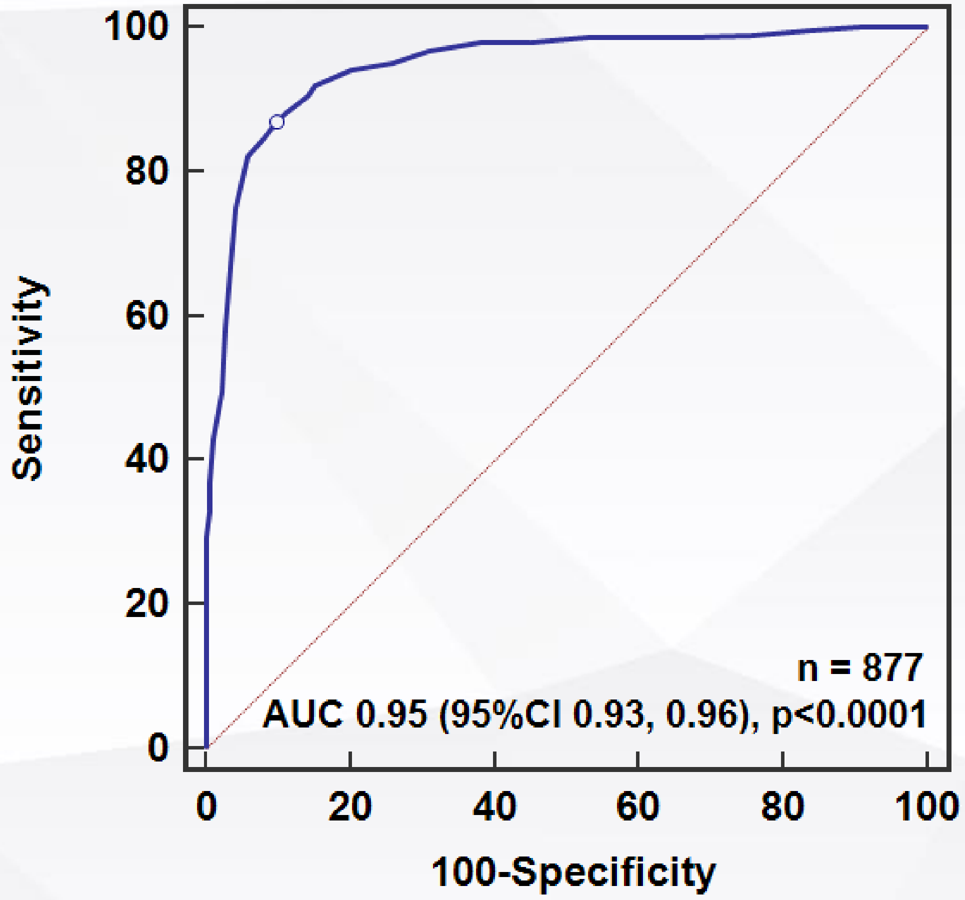
Two Views Is Not Always Better

Eccentric Lesion, but Symmetric Lumen



Diagnostic Performance of μQFR

797 patients, 877 vessels (feasibility 95.4%) with paired μQFR and FFR core lab, blinded analysis using the FLAVOUR* study population



	Pre-PCI μQFR ≤0.80
Accuracy %	90 (88, 92)
Sensitivity %	82 (77, 86)
Specificity %	94 (92, 96)
PPV %	87 (83, 91)
NPV %	92 (89, 94)
+LR	14.3 (10.3, 19.9)
-LR	0.19 (0.1, 0.2)
AUC	0.95 (0.93, 0.96)

Pre-PCI FFR ≤0.80 as reference

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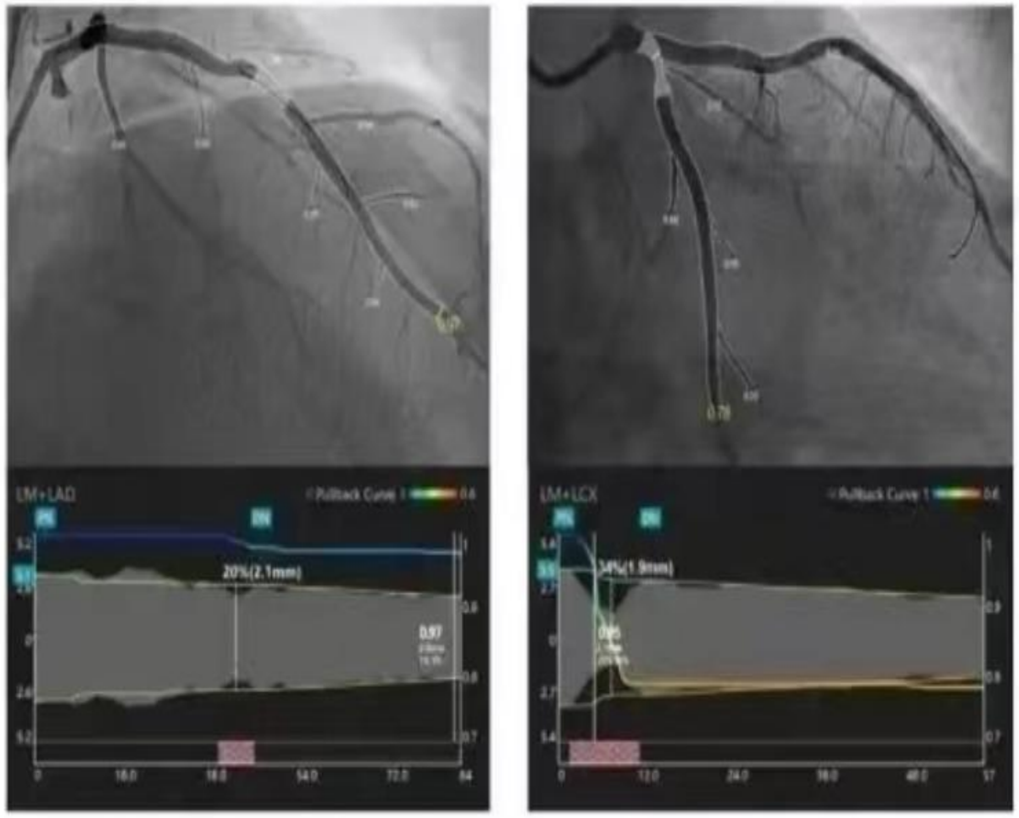
* Koo et al. N Engl J Med 2022;387:779-89

Ding et al, Manuscript under review

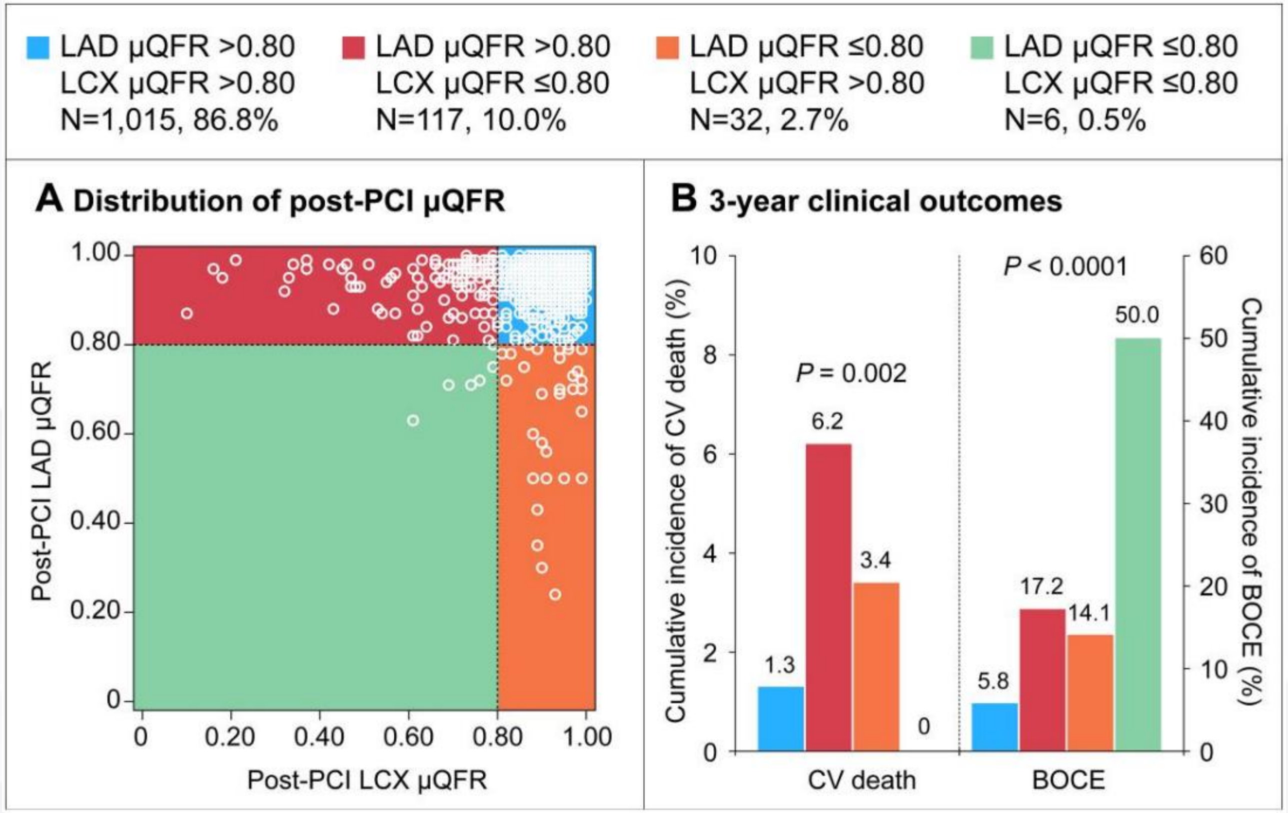
Post-PCI μQFR Predicts 3-Year Outcome

Offline post-PCI μQFR assessment

Post-PCI LAD μQFR | Post-PCI LCx μQFR



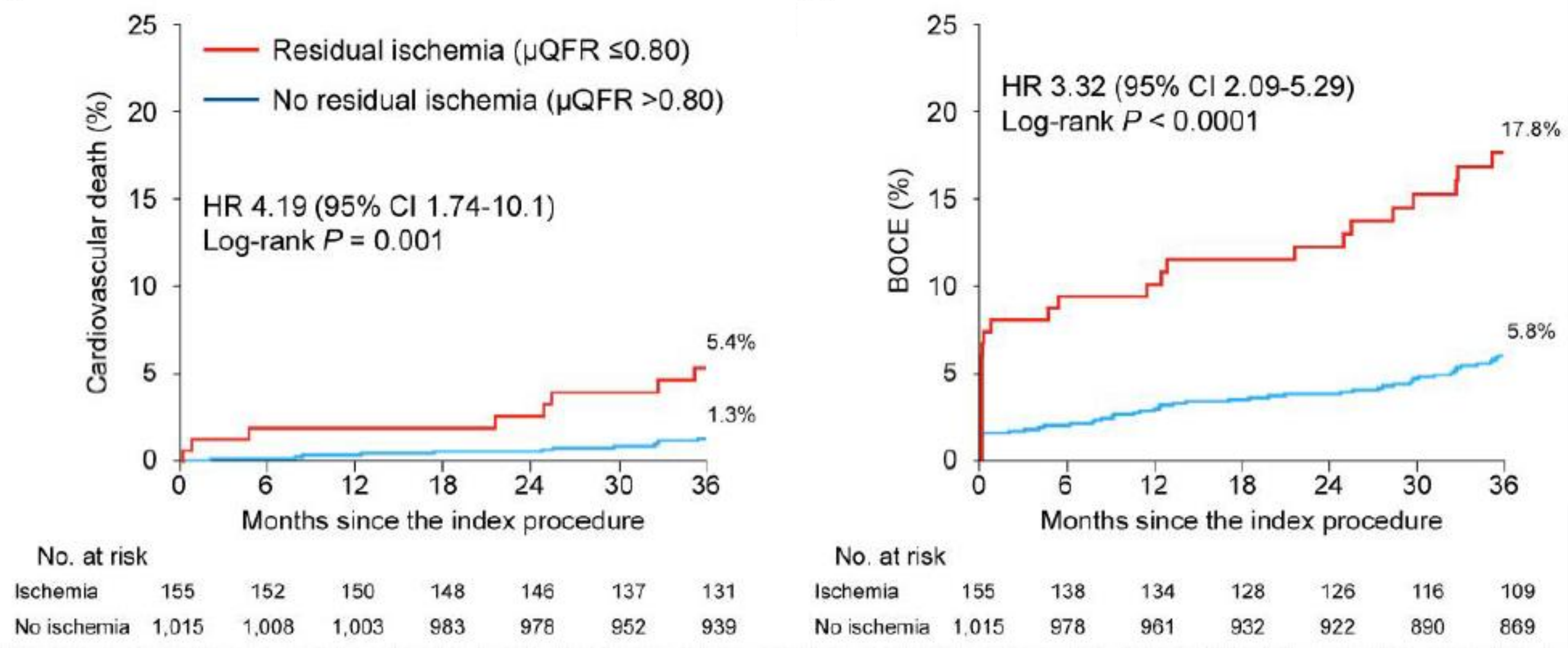
Post-PCI residual ischemia was detected in 155 (13.2%) patients after LMB PCI



Wang, Tu, Wijns, Xu, et al. Eur Heart J 2023; doi: 10.1093/eurheartj/ehad318

Post-PCI μQFR Predicts 3-Year Outcome

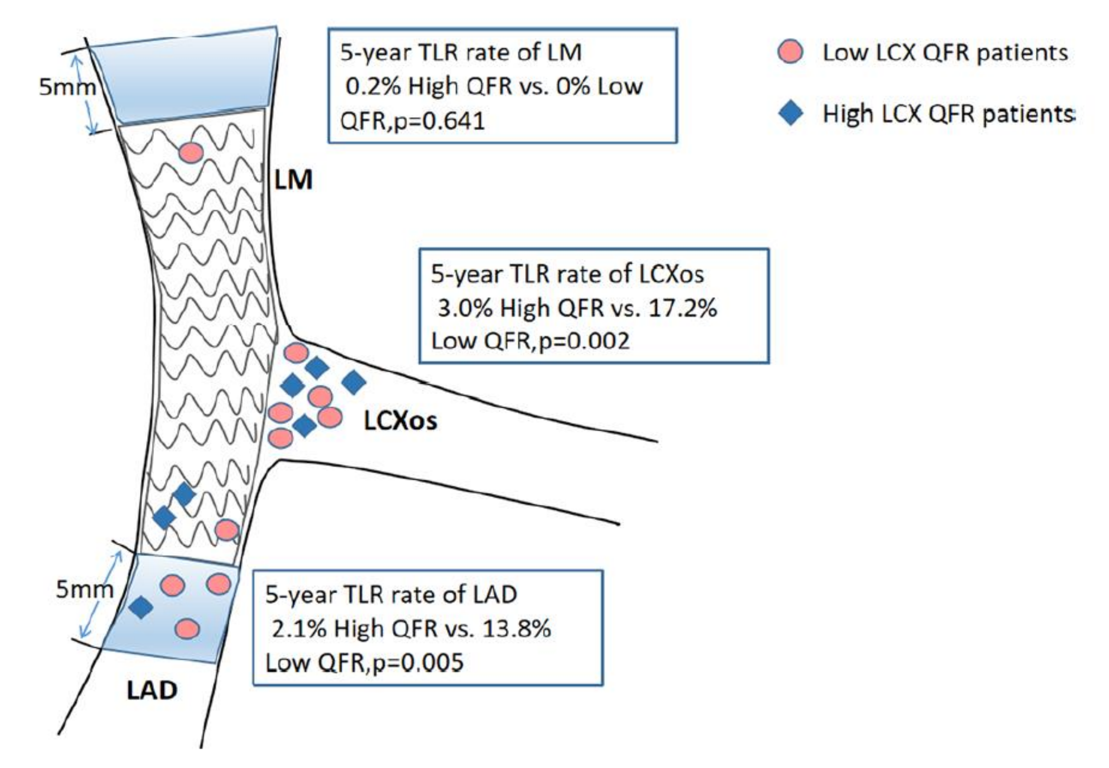
Time-To-Event Curves For 3-Year Clinical Outcomes

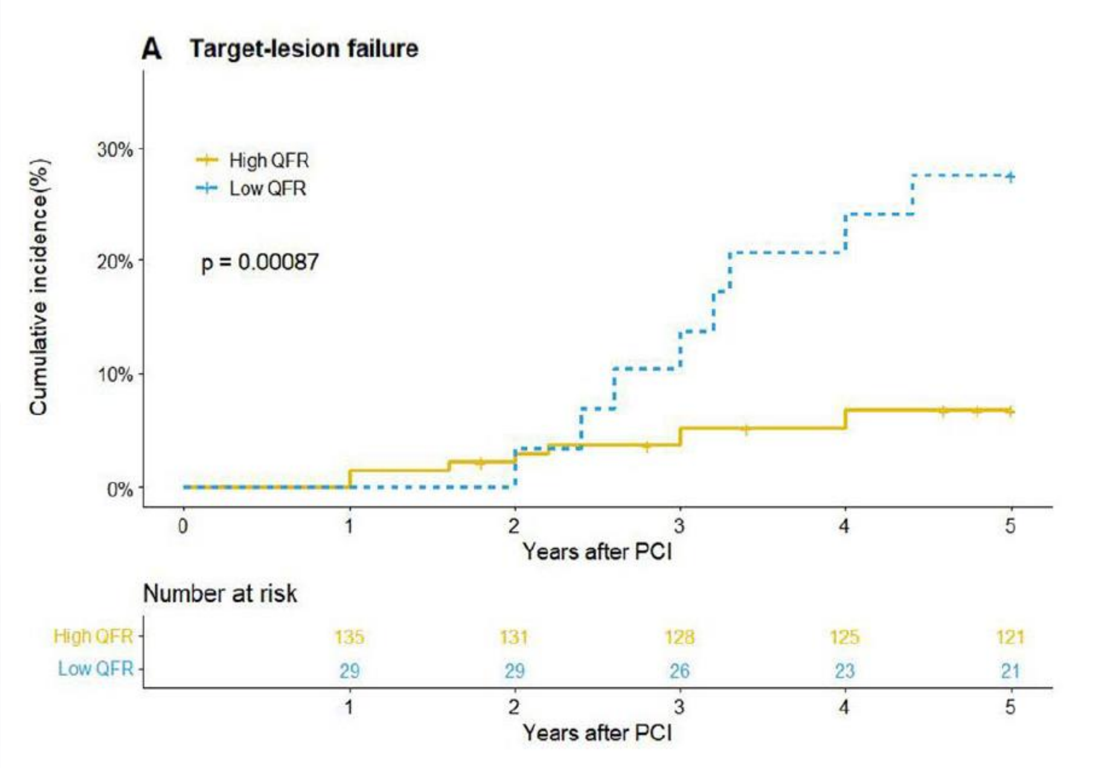


Wang, Tu, Wijns, Xu, et al. Eur Heart J 2023; doi: 10.1093/eurheartj/ehad318

Post-PCI Jailed LCx μQFR Predicts 5-Year TLF

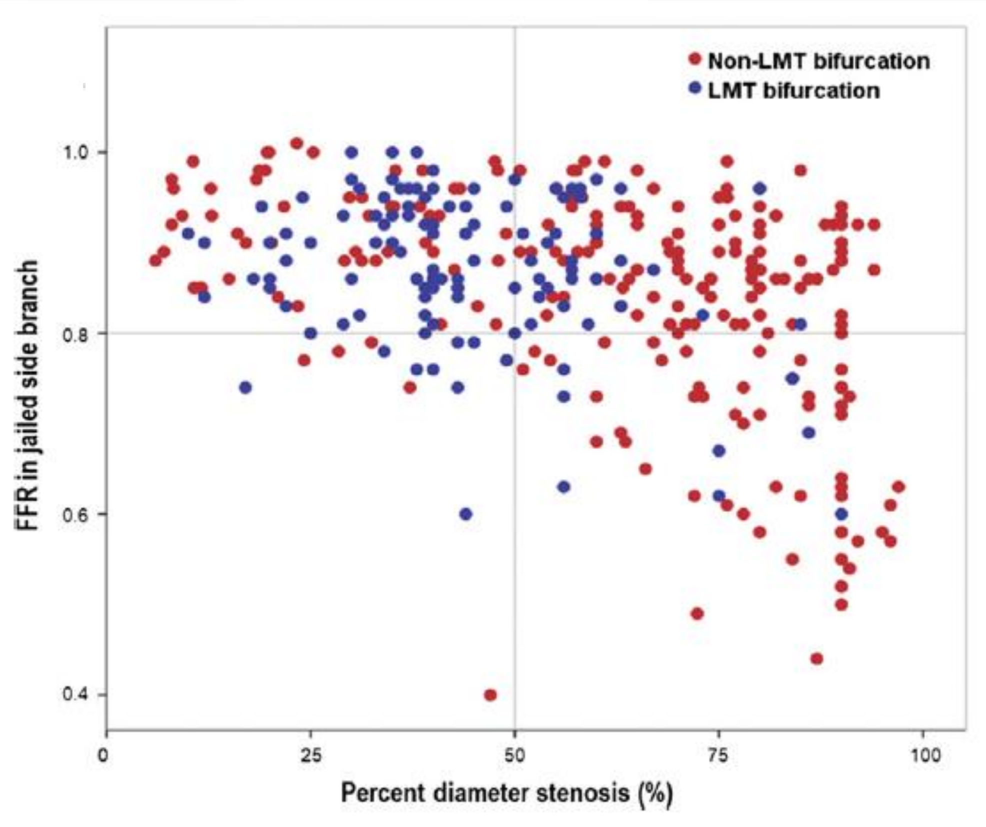
- LMB lesions receiving LM-LAD crossover stenting
- Post-PCI low QFR was defined as μQFR <0.80 and the primary endpoint was 5-year TLF



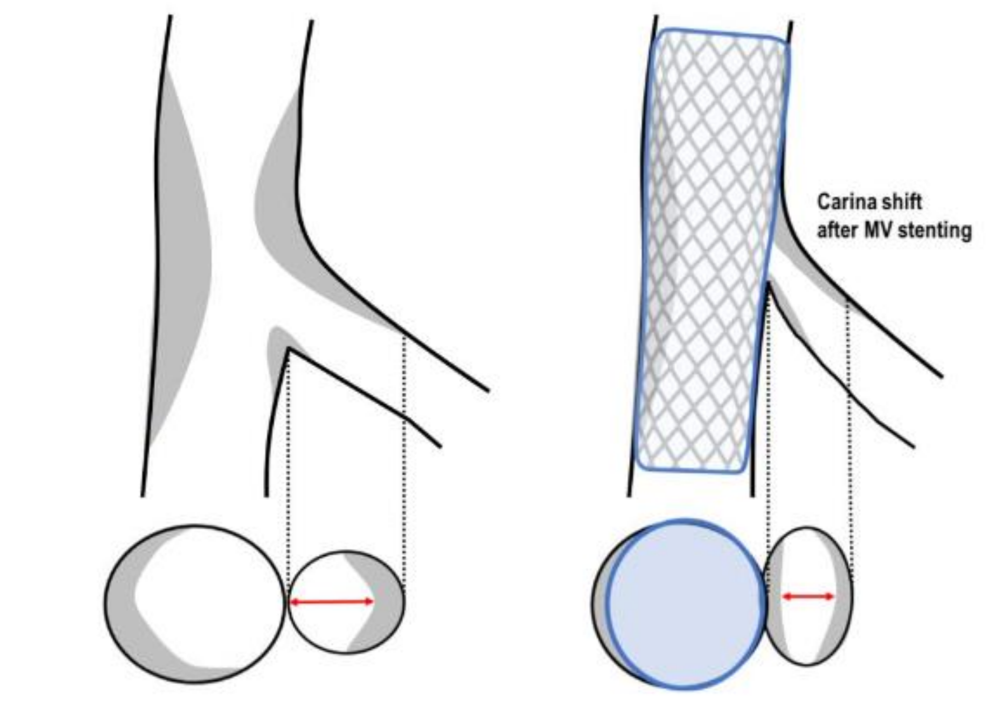


Li, Chen, Fan, et al. Sci Rep 2023;13(1):4391

Limitations of Agiongraphy-Based Lumen Assessment



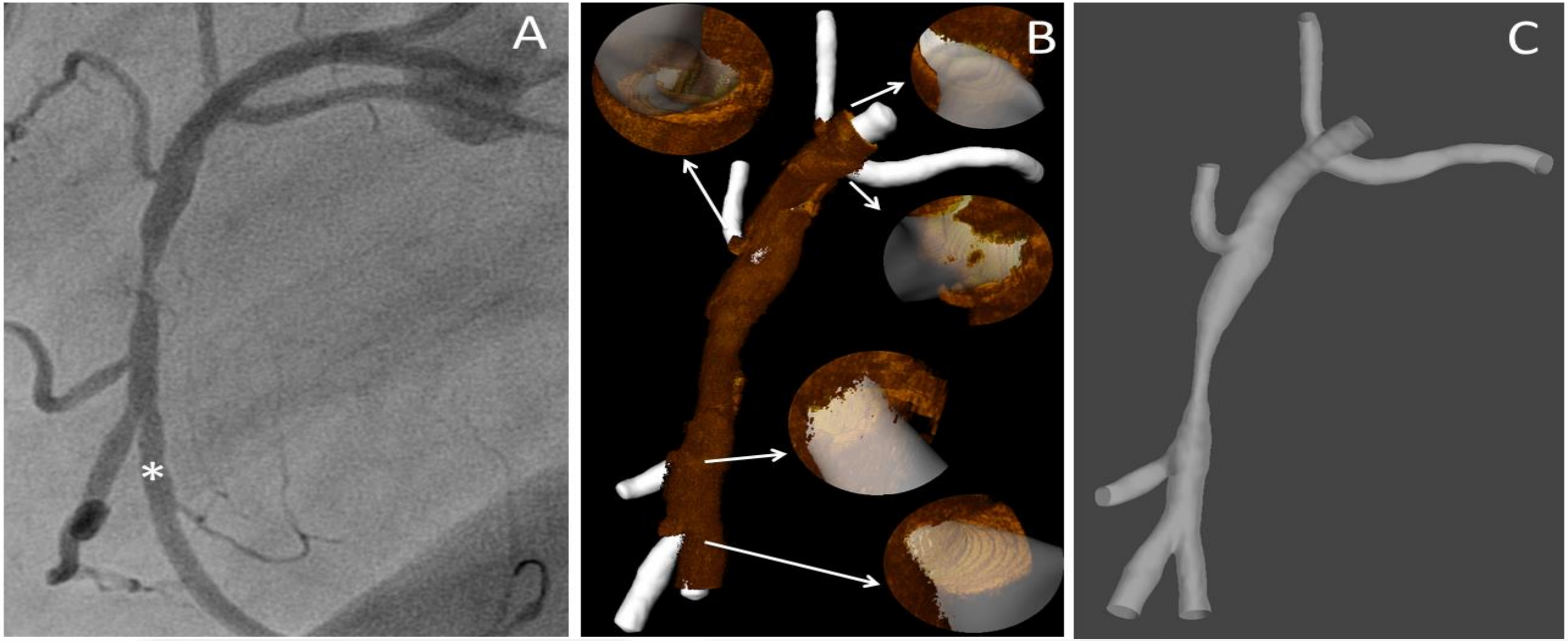
Discordance between angiographic DS% and FFR in jailed SB



The major mechanism could be **carina shift**; other mechanisms included plaque shift and suboptimal angiographic imaging.

Lee, et al. JACC Cardiovasc Interv 2022;15:1297-1309

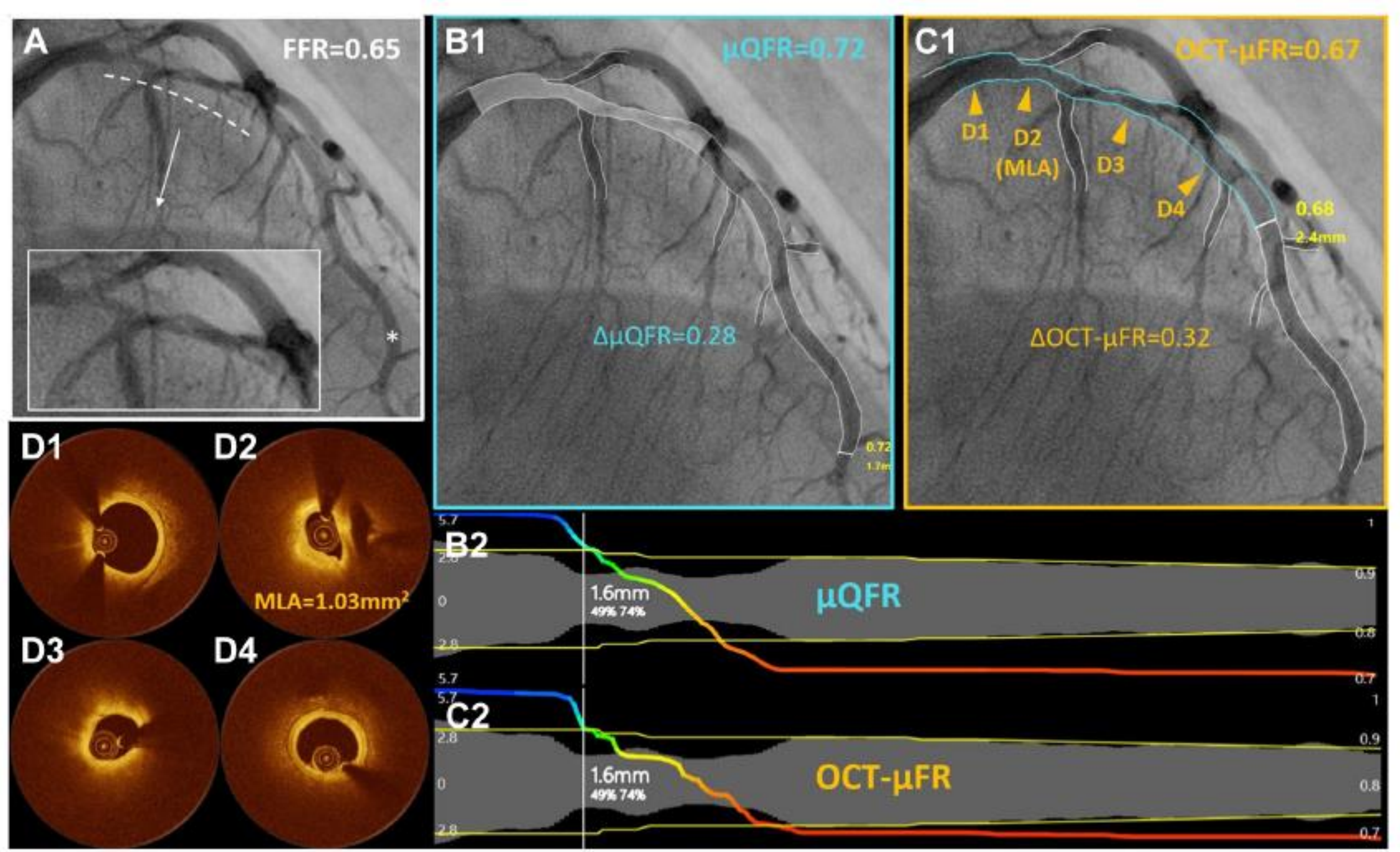
Coronary Tree Reconstruction



3D QCA (side branches) + OCT (main vessel) = Tree Model

Li,Tu, et al. JACC 2015

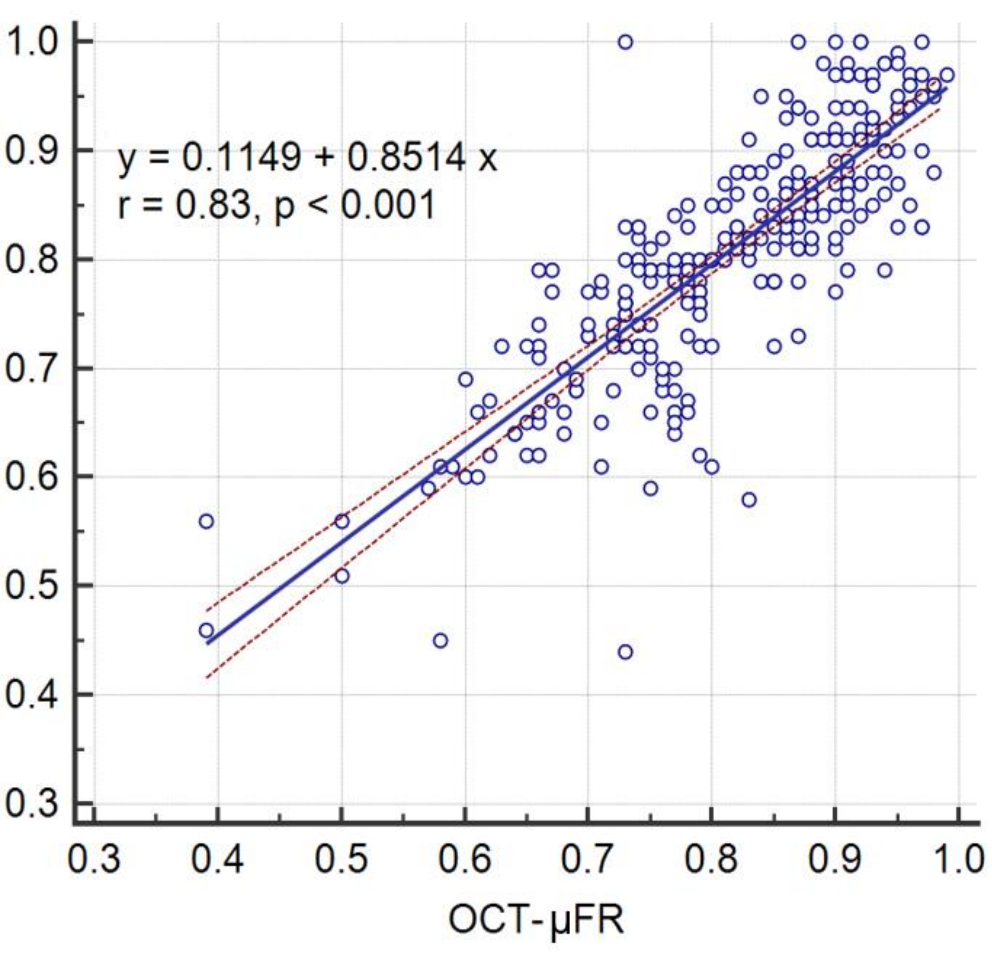
OCT-Modulated μQFR (OCT-μFR) from Co-registered Data

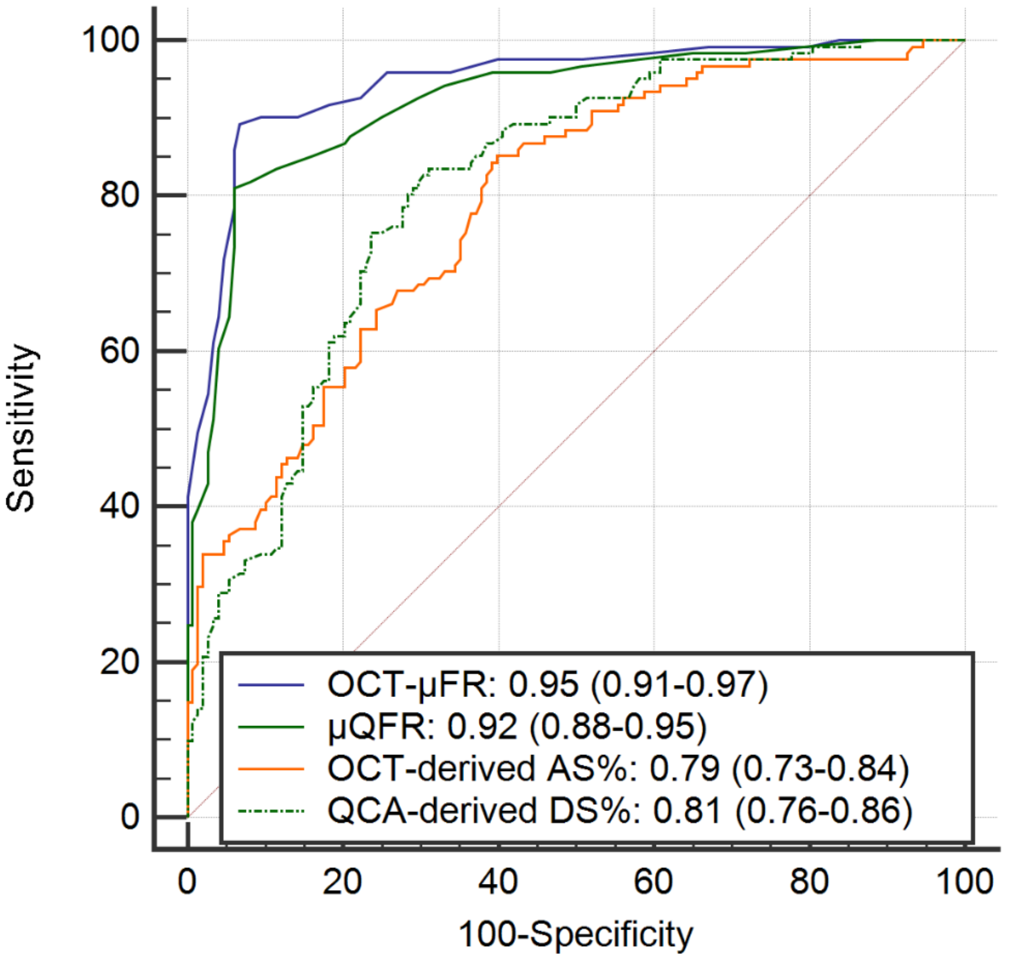


Xu,Tu, et al. JSCAI 2023; https://doi.org/10.1016/j.jscai.2023.101043

Validation of OCT-μFR in Main Vessels

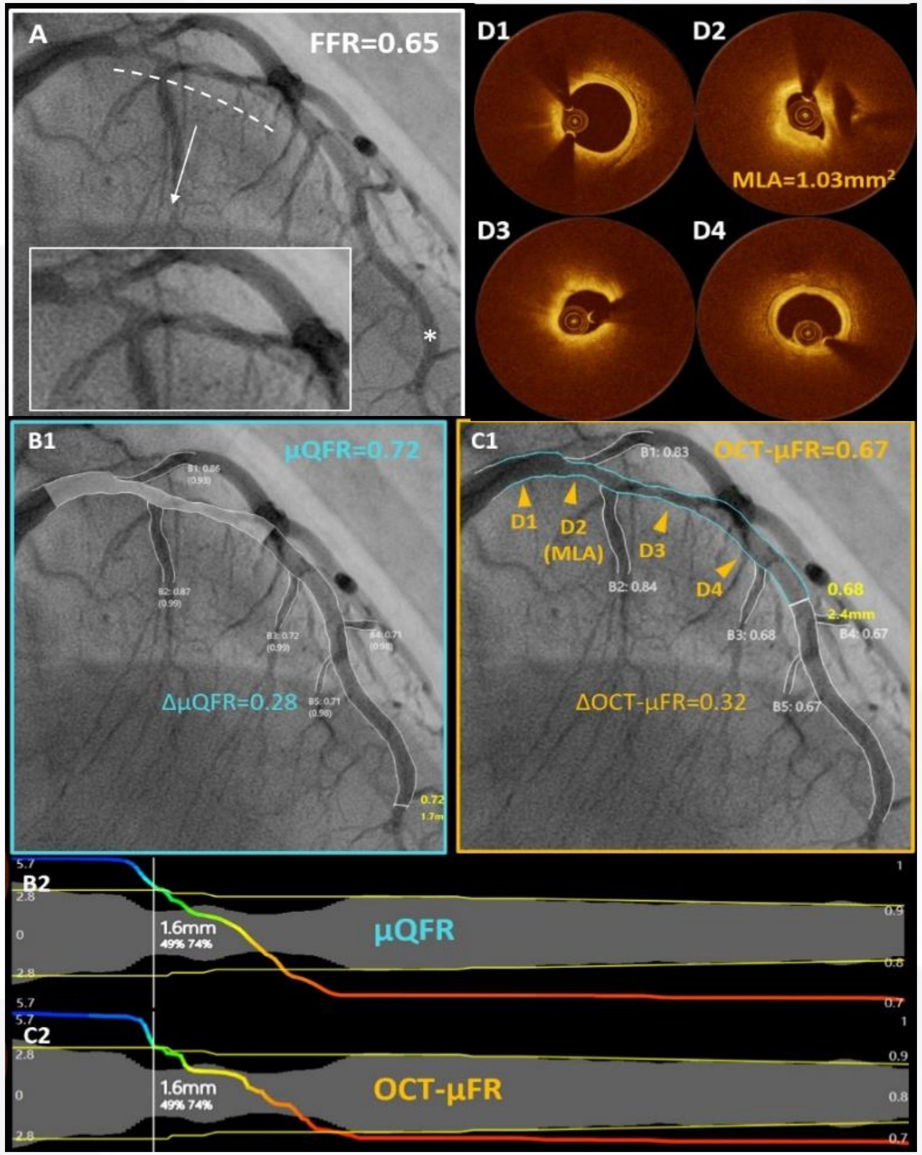
n = 269 vessels





Xu,Tu, et al. JSCAI 2023; https://doi.org/10.1016/j.jscai.2023.101043

Validation of OCT-μFR in Main Vessels



Suboptimal angiographic image quality (109 vessels)

	OCT-μQFR ≤ 0.80	μQFR ≤ 0.80	p
AUC	**0.93**	**0.87**	**0.028**
Accuracy	90%	81%	0.056

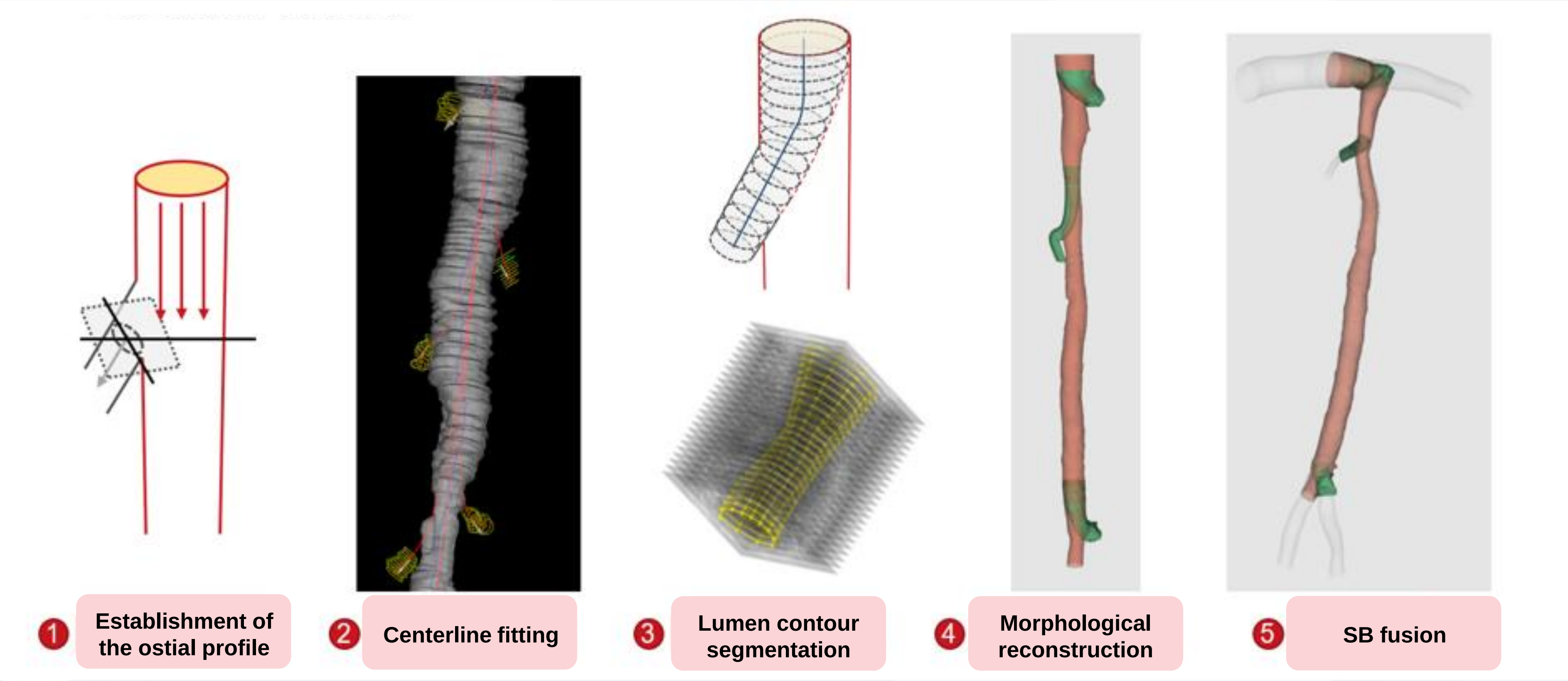
Optimal angiographic image quality (160 vessels)

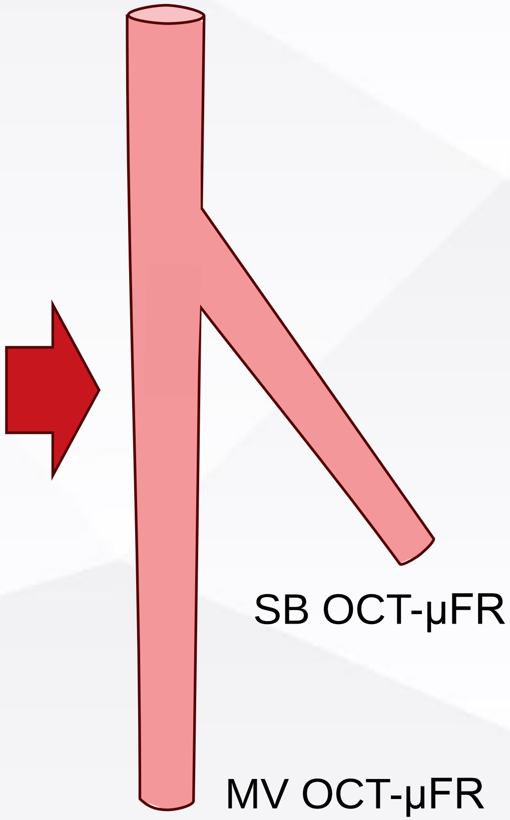
	OCT-μQFR ≤ 0.80	μQFR ≤ 0.80	p
AUC	0.94	0.94	0.879
Accuracy	93%	93%	0.828

Xu,Tu, et al. JSCAI 2023; https://doi.org/10.1016/j.jscai.2023.101043

Methodology: OCT-μFR for SB Functional Assessment

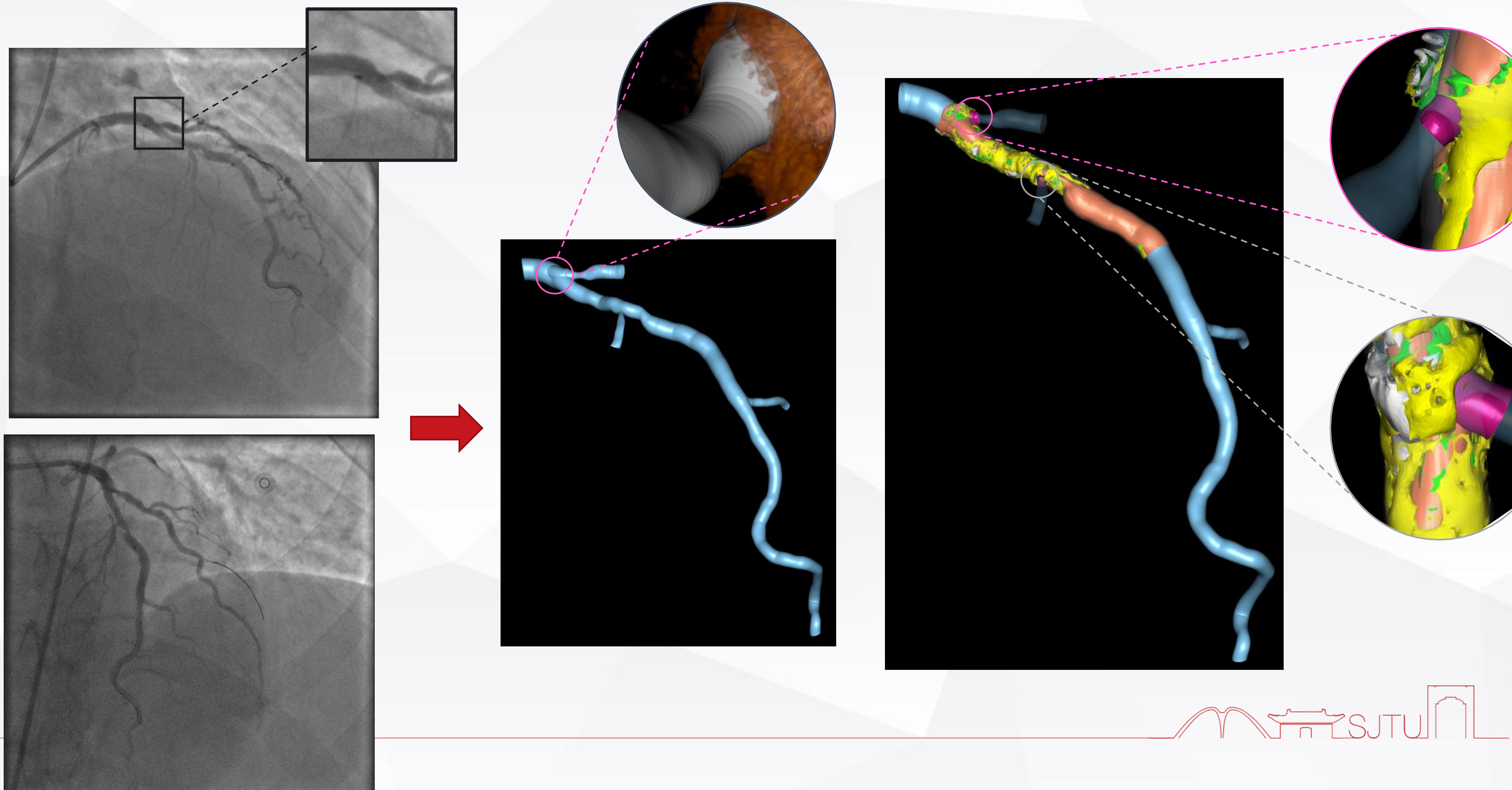
Angiography-OCT Fusion for Physiological Assessment





Xu,Tu, et al. JSCAI 2023; https://doi.org/10.1016/j.jscai.2023.101043

Fusion of OCT and Angiography in LMB



Summary

- Angiography-derived physiology provided significant prognostic value in patients undergoing LMB

- **Future directions**:

(1) To investigate whether the fusion with intracoronary imaging could improve the accuracy of angiography-derived SB physiological assessment in bifurcation lesions

(2) To investigate the performance of OCT/IVUS-μFR for guiding SB treatment after MV crossover stenting

(3) Comprehensive assessment of anatomy, physiology, and biomechanics for optimal management of coronary bifurcation lesions