

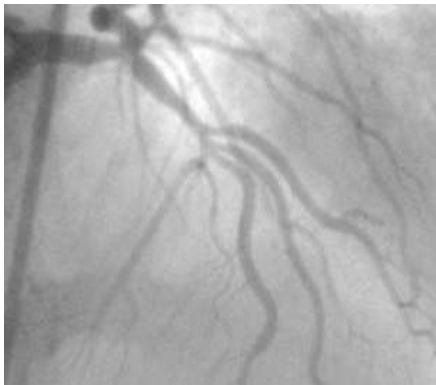
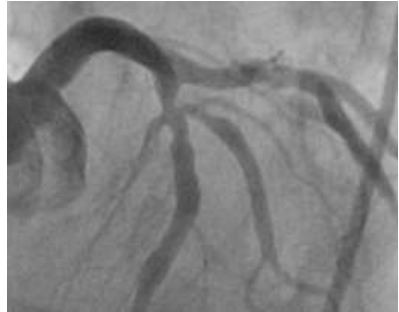
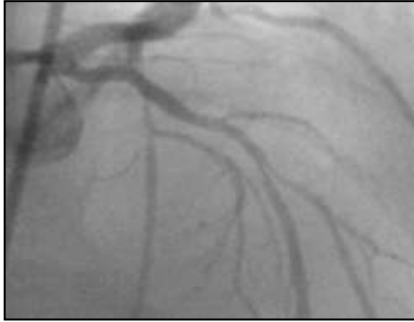
Imaging and Physiologic Assessment for Bifurcation Lesions

Bon-Kwon Koo, MD, PhD

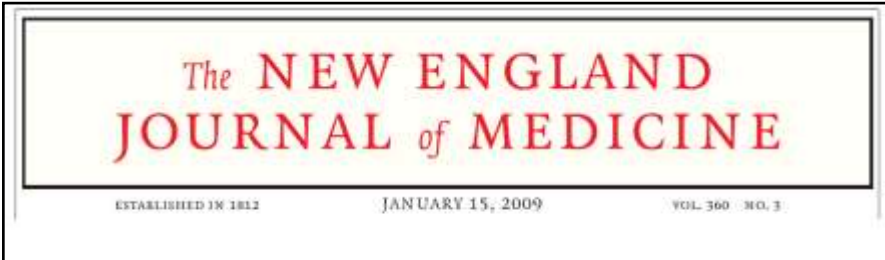
Seoul National University Hospital, Seoul, Korea



Bifurcations are complex!



FFR/IVUS-guided PCI can improve outcomes!



Impact of intravascular ultrasound guidance on long-term clinical outcomes in patients treated with drug-eluting stent for bifurcation lesions: data from a Korean multicenter bifurcation registry.

Abstract
BACKGROUND: although intravascular ultrasound (IVUS) has been widely used for complex lesions during coronary intervention, IVUS for stenting of bifurcation lesions has not been sufficiently assessed. The aim of this study was to investigate the impact of IVUS guidance on long-term clinical outcomes during drug-eluting stent (DES) implantation for bifurcation lesions.

METHODS: the Korean multicenter bifurcation registry listed 1,600 patients with non-left main de novo bifurcation lesions who underwent DES implantation between January 2004 and February 2006. We compared the adverse outcomes in patients with IVUS-guidance and 467 patients without IVUS-guidance.

RESULTS: baseline clinical and angiographic characteristics and final kissing balloon dilatation technique and final kissing balloon dilatation (FKBD) (the main vessel and the side branch stents) was frequently observed in the IVUS-guided group compared to the angio-guided group (P = .04).

CONCLUSIONS: intravascular ultrasound guidance significantly reduced the long-term all-cause mortality in patients receiving drug-eluting stents (DESs) (HR 0.24, 95% CI 0.06 to 0.86, p = 0.03), but not in the patients receiving bare metal stents (HR 0.41, 95% CI 0.13 to 1.26, p = 0.12). IVUS-guided stenting had no effect on the rate of stent thrombosis (HR 0.48, 95% CI 0.16 to 1.43, p = 0.19) or target lesion revascularization (HR 1.47, 95% CI 0.79 to 2.71, p = 0.21). In patients receiving DESs, however, IVUS guidance reduced the development of very late stent thrombosis (0.4% vs 2.8%, p = 0.03, log-rank test). In conclusion, in patients receiving DESs, IVUS-guided stenting for treatment of bifurcation lesions significantly reduced the 4-year mortality compared to conventional angiographically guided stenting. In addition, IVUS guidance reduced the development of very late stent thrombosis in patients receiving DESs. © 2010 Elsevier Inc. All rights reserved. (Am J Cardiol 2010;106:612-618)

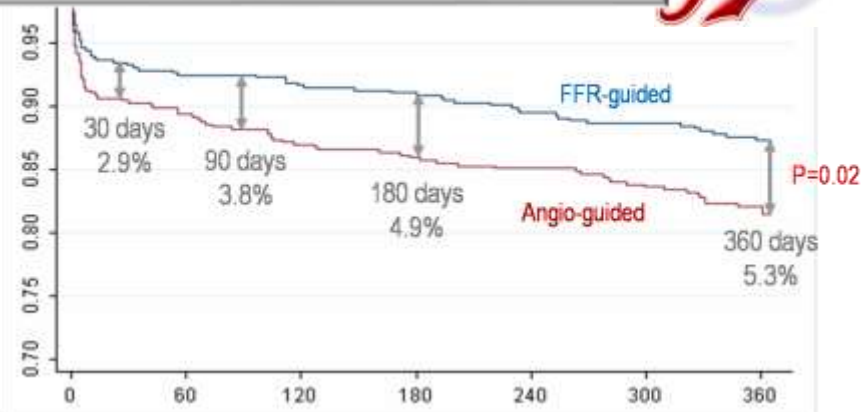
FFR and IVUS for bifurcation lesions

When and How?

Long-Term Outcomes

Sung-Hwan Park, MD, PhD, Duk-Woo Park, MD, PhD, Myeong-Ki Hong, MD, PhD, Sung-Gig Cho, MD, PhD, Joo-Young Kim, MD, PhD, Seong-Wook Park, MD, PhD*, and Seung-Jung Park, MD, PhD**

Stenting for bifurcation lesions is still challenging, and the effect of intravascular ultrasound (IVUS) guidance on long-term outcomes has not been evaluated. We assessed the long-term outcomes of IVUS-guided stenting in bifurcation lesions. We evaluated 758 patients with de novo nonleft main coronary bifurcation lesions who underwent stent implantation from January 1998 to February 2006. We compared the adverse outcomes (i.e., death, stent thrombosis, and target lesion revascularization) within 4 years, after adjustment using a multivariate Cox proportional hazard model and propensity scoring. IVUS-guided stenting significantly reduced the long-term all-cause mortality (hazard ratio [HR] 0.31, 95% confidence interval [CI] 0.13 to 0.74, p = 0.008) in the total population and in the patients receiving drug-eluting stents (DESs) (HR 0.24, 95% CI 0.06 to 0.86, p = 0.03), but not in the patients receiving bare metal stents (HR 0.41, 95% CI 0.13 to 1.26, p = 0.12). IVUS-guided stenting had no effect on the rate of stent thrombosis (HR 0.48, 95% CI 0.16 to 1.43, p = 0.19) or target lesion revascularization (HR 1.47, 95% CI 0.79 to 2.71, p = 0.21). In patients receiving DESs, however, IVUS guidance reduced the development of very late stent thrombosis (0.4% vs 2.8%, p = 0.03, log-rank test). In conclusion, in patients receiving DESs, IVUS-guided stenting for treatment of bifurcation lesions significantly reduced the 4-year mortality compared to conventional angiographically guided stenting. In addition, IVUS guidance reduced the development of very late stent thrombosis in patients receiving DESs. © 2010 Elsevier Inc. All rights reserved. (Am J Cardiol 2010;106:612-618)



Which is the most useful tool for jailed side branch assessment ?

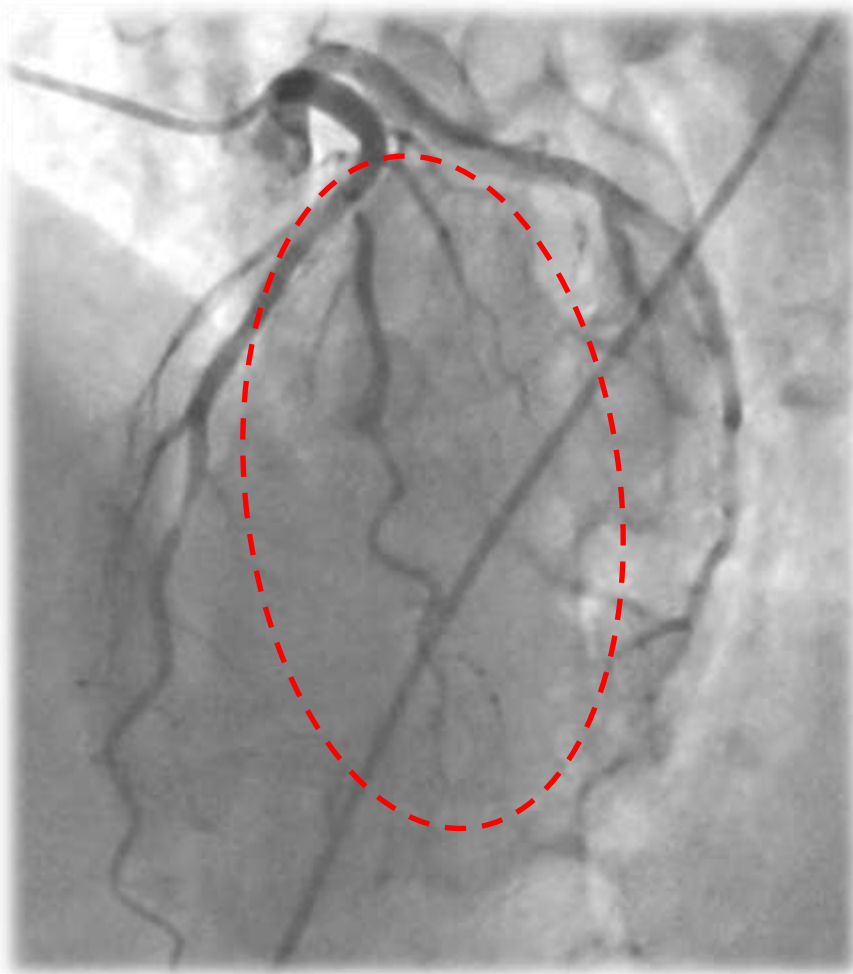


Jailed diagonal branch after LAD stenting

1. Angiography
2. IVUS
3. OCT
4. FFR

Answer) 1. Angiography

Evaluation for jailed side branch: 1st step should be....

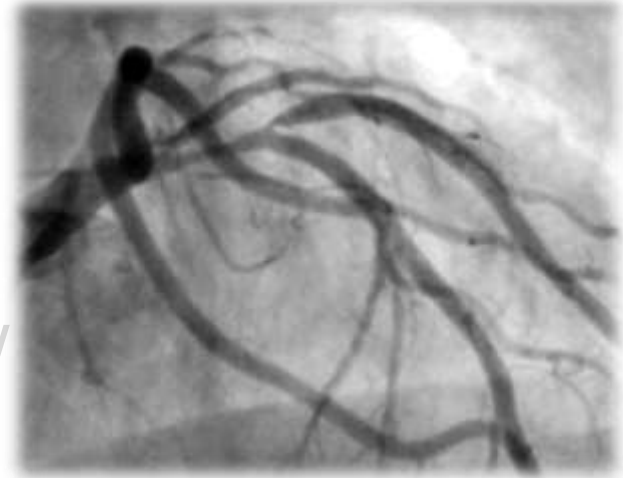


Assess the amount of myocardial territory supplied by the jailed branch rather than the lesion severity!

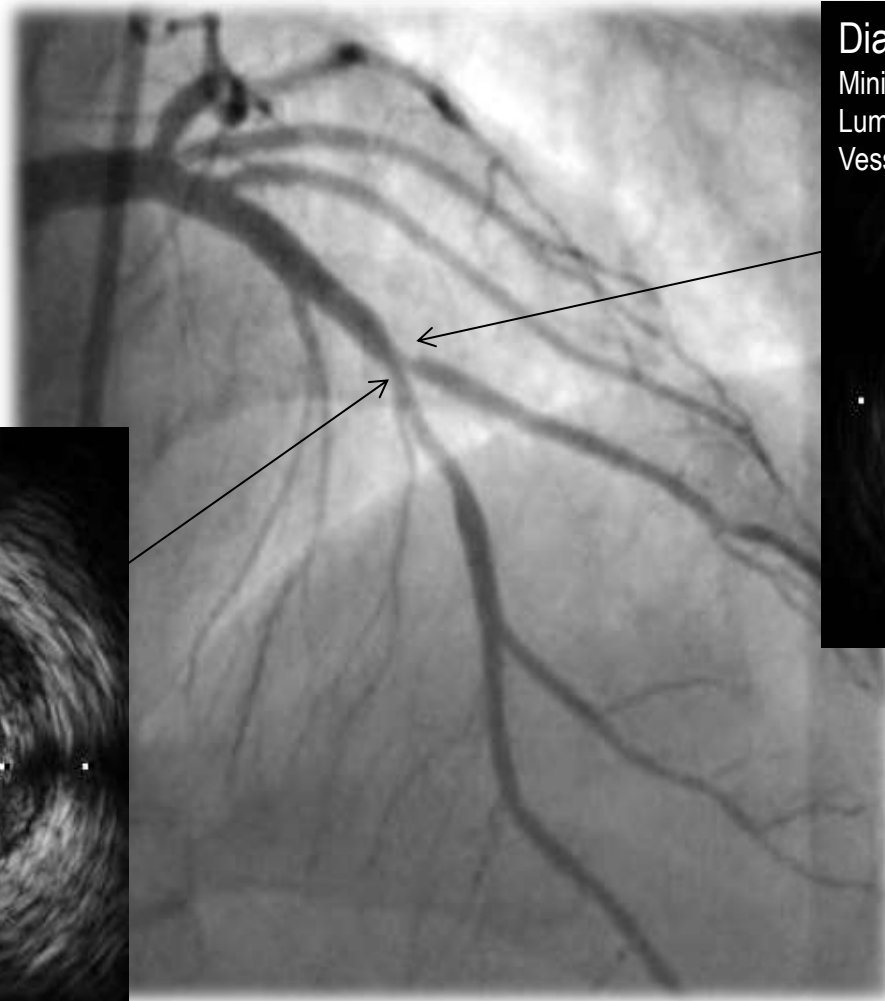
Only the branch supplies large amount of myocardium deserves any further assessment and intervention.

Integrated use of IVUS and FFR in non-LM bifurcation PCI

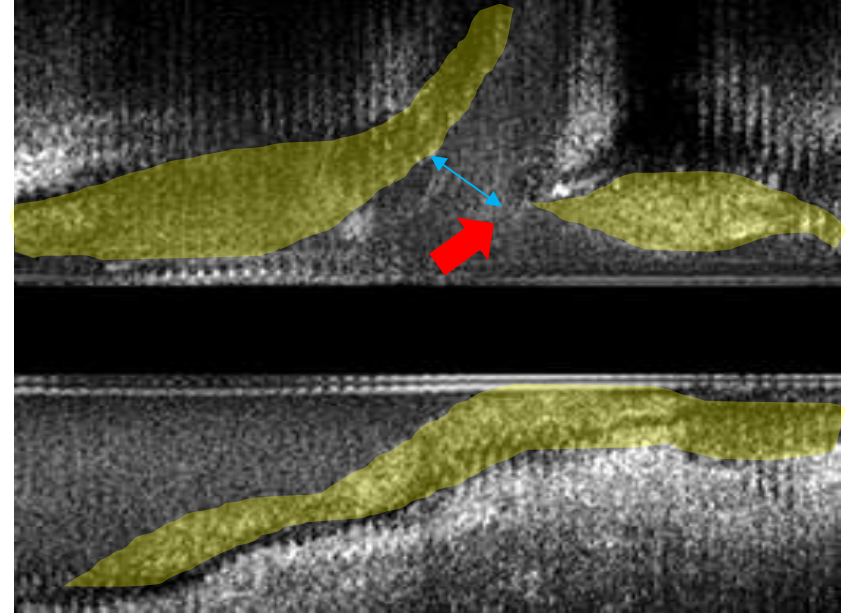
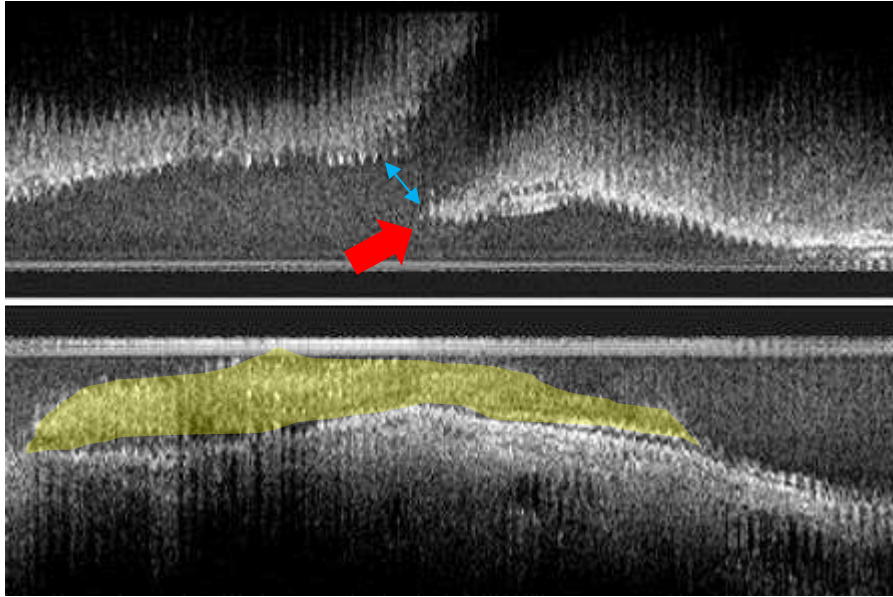
- Pre-intervention
- After main branch stent implantation
- After side branch balloon angioplasty
- After side branch stenting



Precise anatomical assessment

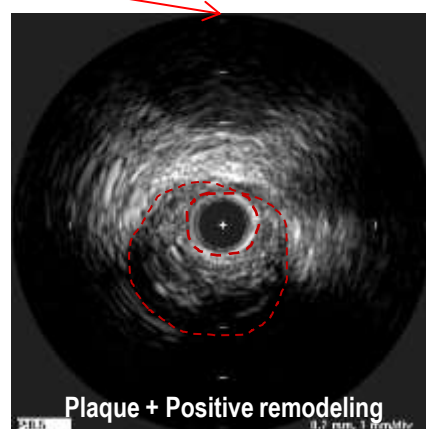
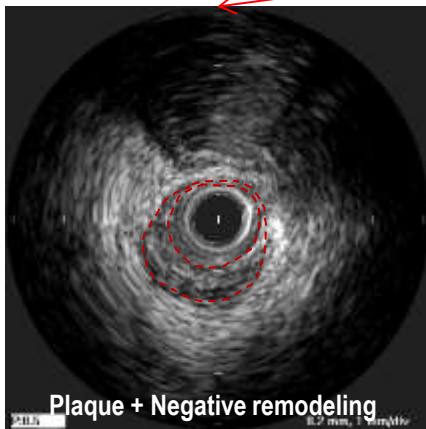
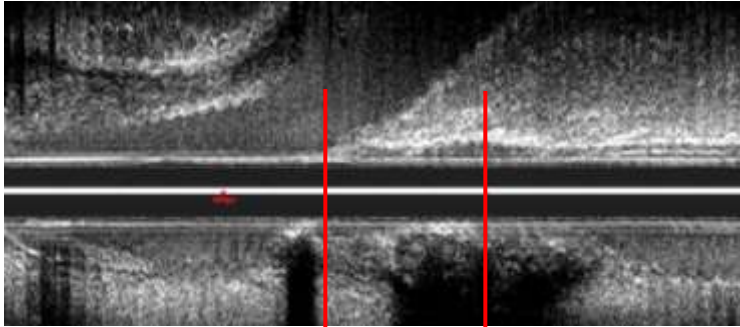
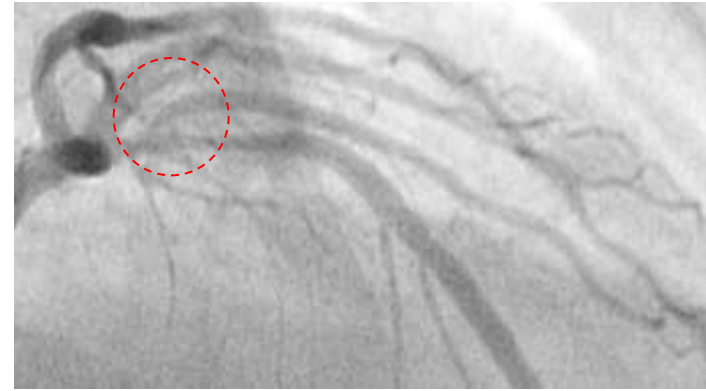
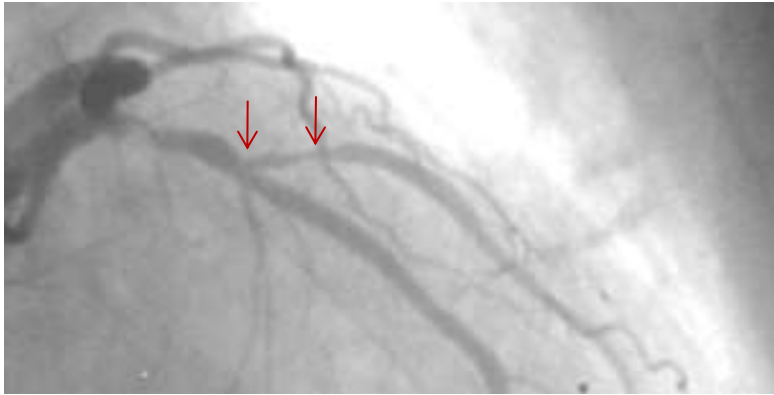


Important anatomical information

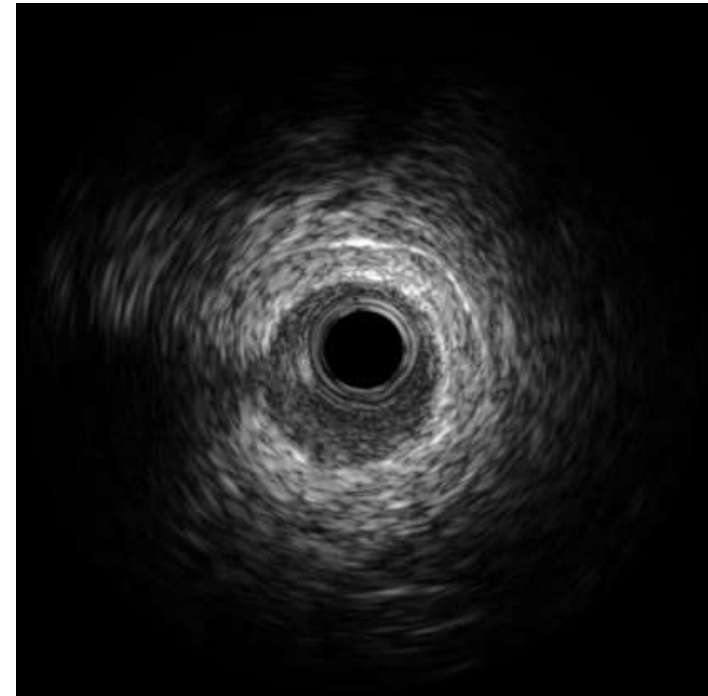
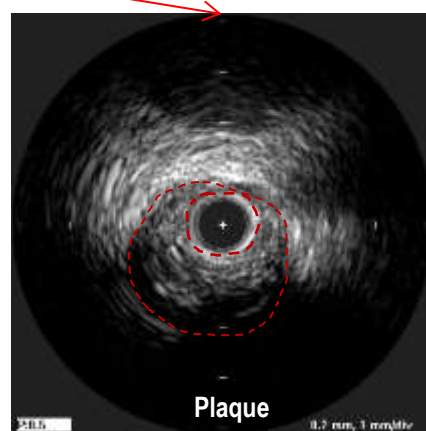
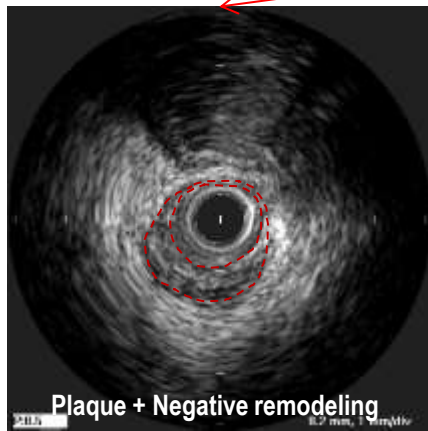
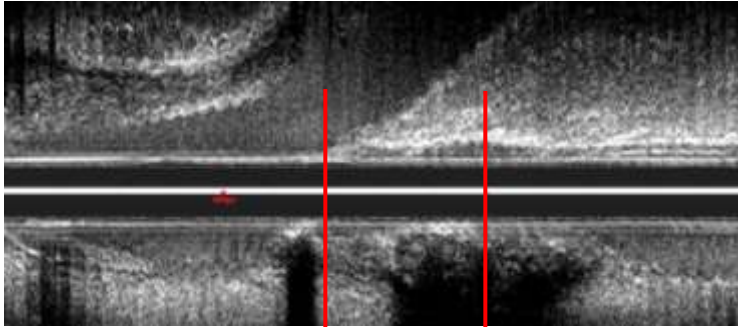
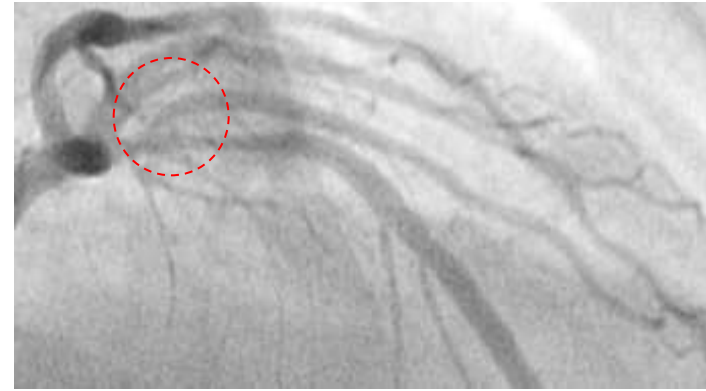
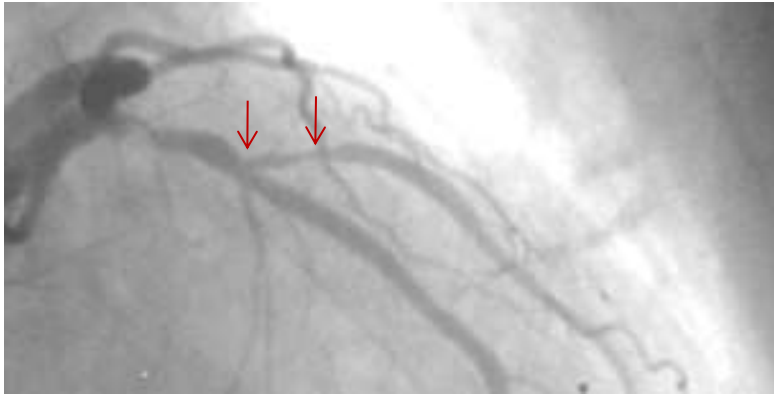


- Geometry of bifurcation lesion
- Amount, character and distribution of plaque
- Location, length of carina
- Distance between carina and outer lumen of a side branch

Mechanism of side branch stenosis



Mechanism of side branch stenosis



Side branch ostium is different!

Catheterization and Cardiovascular Interventions 81:1150-1155 (2013)

Vascular Remodeling at Both Branch Ostia in Bifurcation Disease Assessed by Intravascular Ultrasound

Soo-Jin Kang,¹ MD, PhD, Won-Jang Kim,¹ MD, Sung-Cheol Yun,² PhD, Duk-Woo Park,¹ MD, PhD, Seung-Wan Lee,¹ MD, PhD, Young-Hak Kim,¹ MD, PhD, Cheol Whan Lee,¹ MD, PhD, Seong-Wook Park,¹ MD, PhD, Gary S. Mintz,³ MD, and Seung-Jung Park,^{1*} MD, PhD

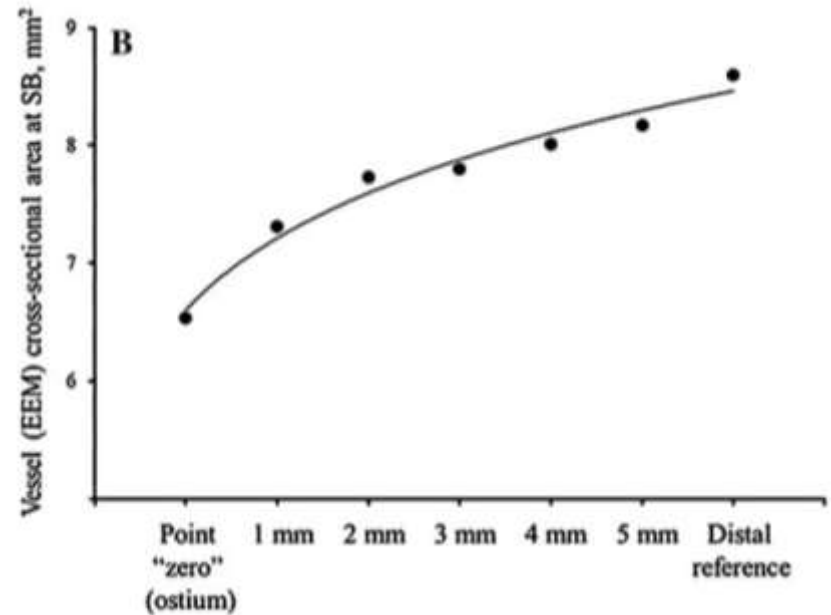
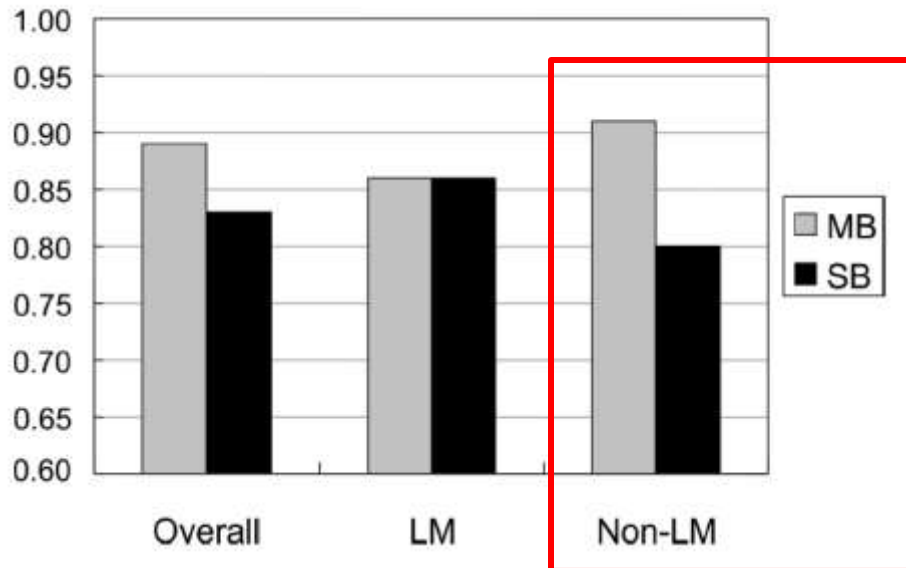
Int J Cardiovasc Imaging
DOI 10.1007/s10554-013-0263-1

ORIGINAL PAPER

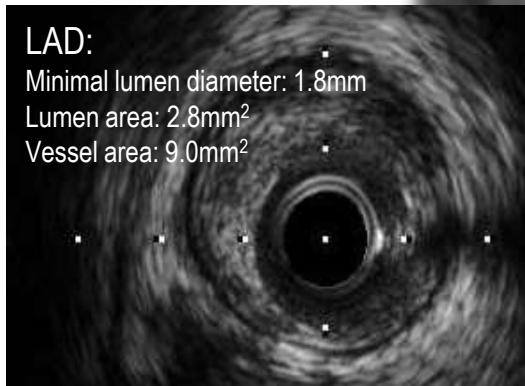
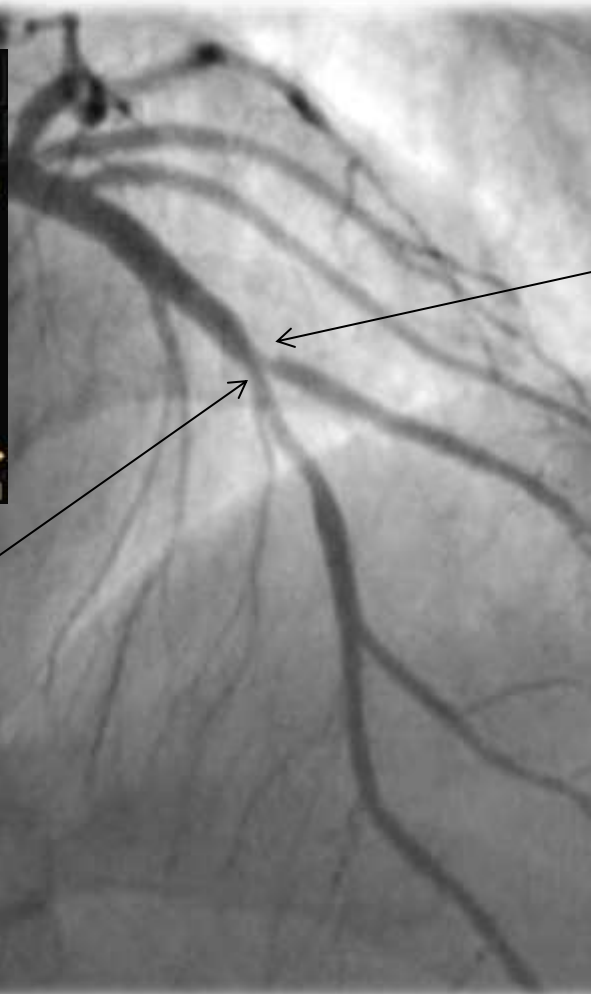
Vessel remodeling and plaque distribution in side branch of complex coronary bifurcation lesions: a grayscale intravascular ultrasound study

Ricardo A. Costa · Fausto Feres · Rodolfo Staico · Alexandre Abizaid · J. Ribamar Costa Jr. · Dimytri Siqueira · Luiz F. Tanajura · Lucas P. Damiani · Amanda Sousa · J. Eduardo Sousa · Antonio Colombo

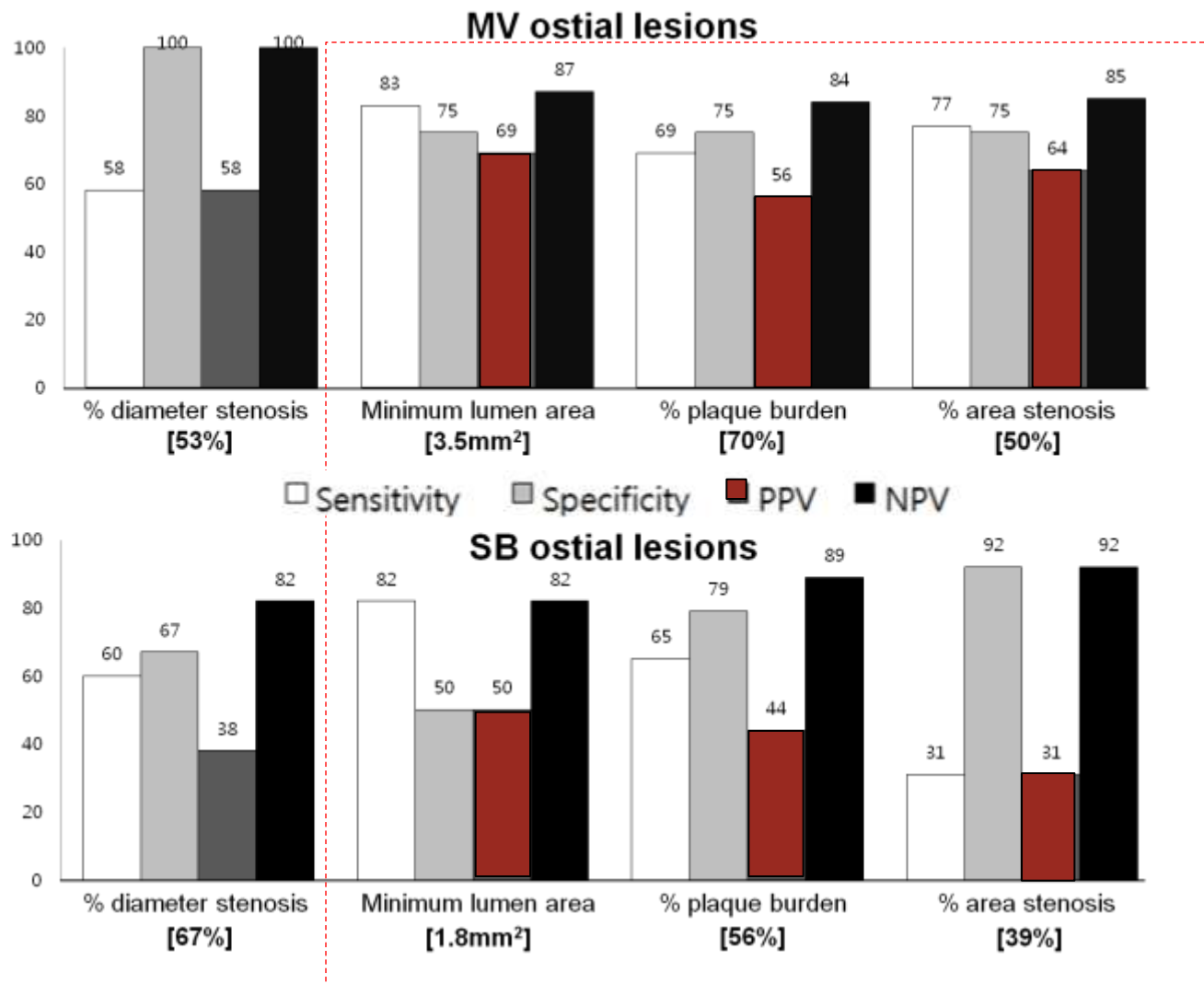
Remodeling index at main branch (MB)
and side branch (SB) ostium



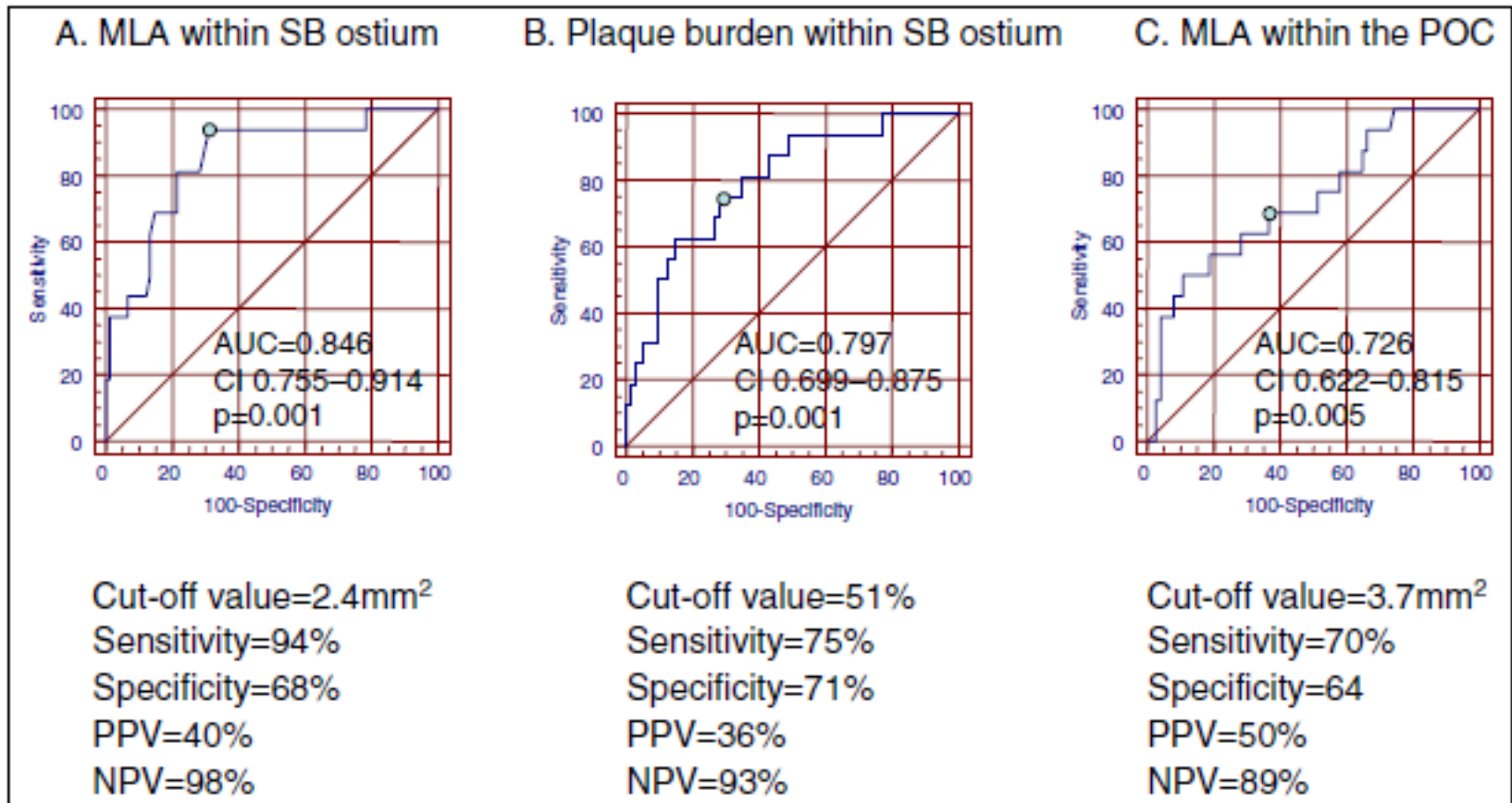
Anatomical information, is it enough?



Diagnostic accuracy of IVUS parameters in pure ostial lesions



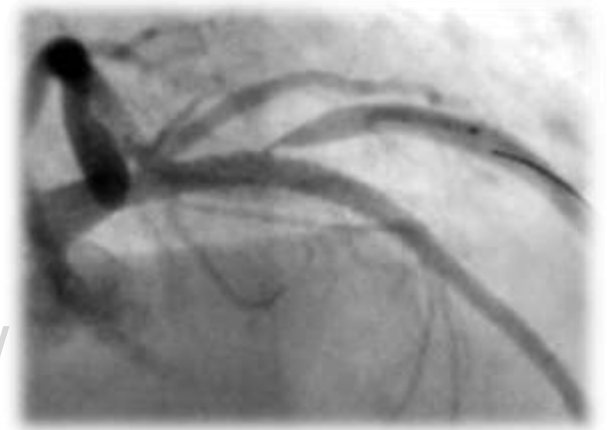
Prediction of functionally significant jailing using pre-intervention IVUS



In conclusion, there do not appear to be reliable IVUS predictors of functional SB compromise after crossover stenting.

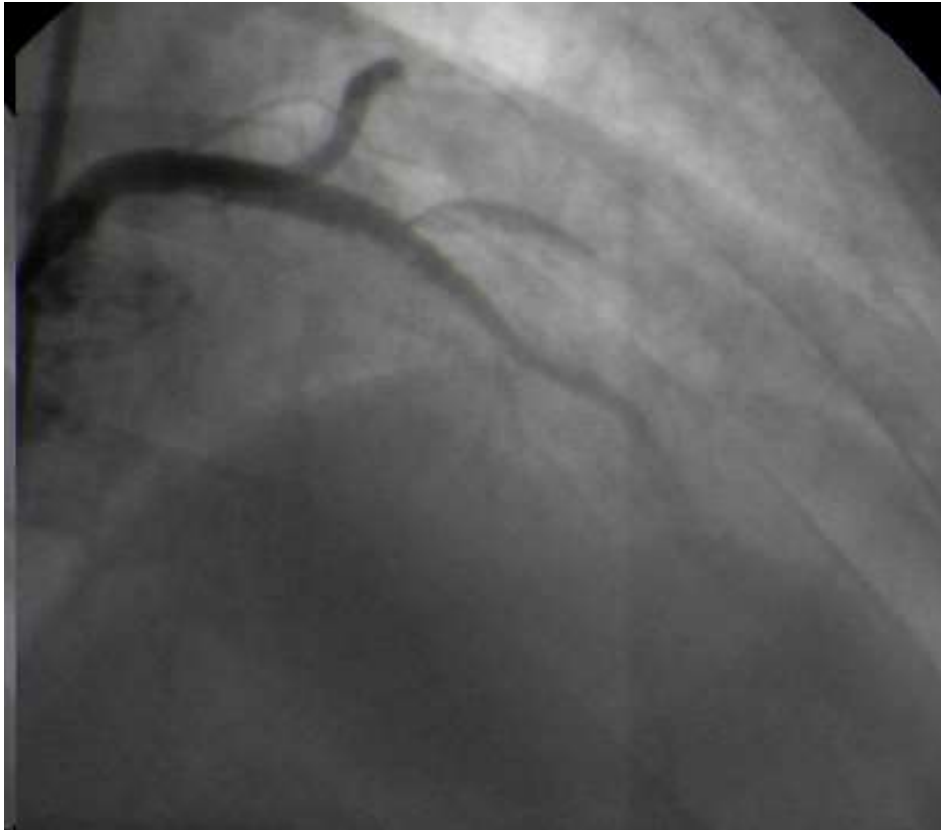
Integrated use of IVUS and FFR in non-LM bifurcation PCI

- Pre-intervention
- After main branch stent implantation
- After side branch balloon angioplasty
- After side branch stenting

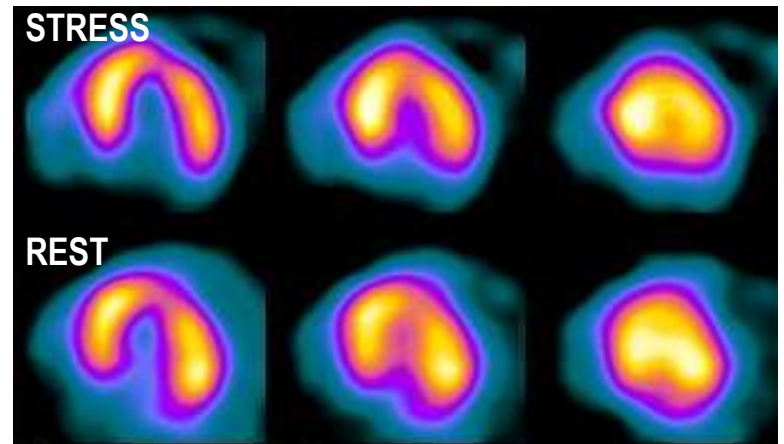
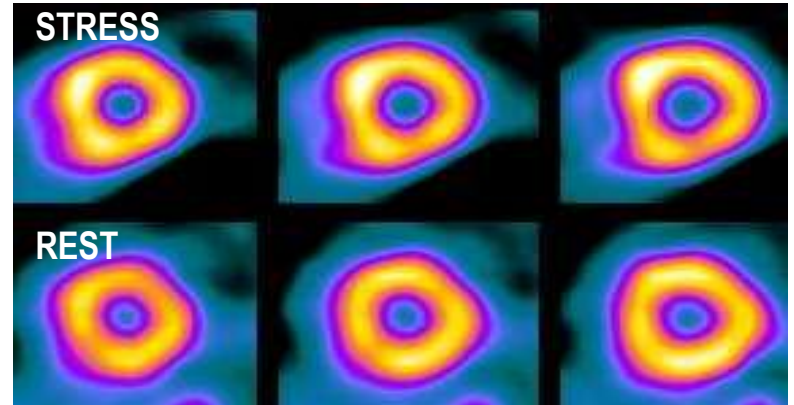


Jailed Side Branches

Angiographic severity \neq Functional significance



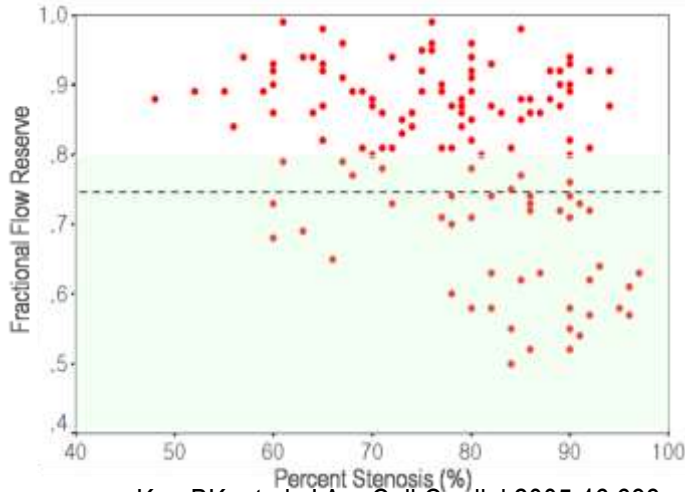
FFR >0.80



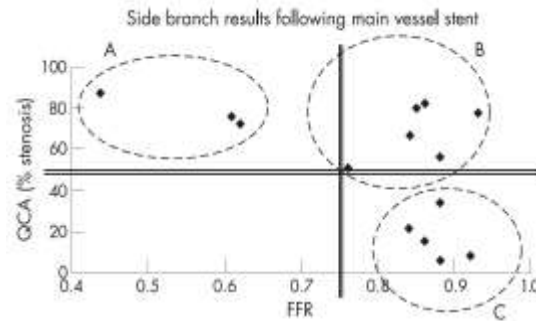
Severe stenosis, but no perfusion defect!

Can anatomical severity predict the functional significance?

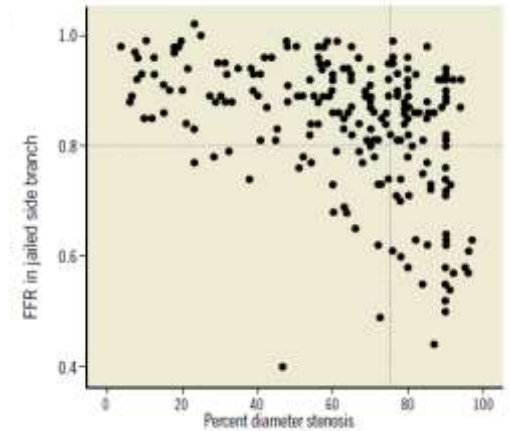
FFR vs. anatomical stenosis in Jailed side branches



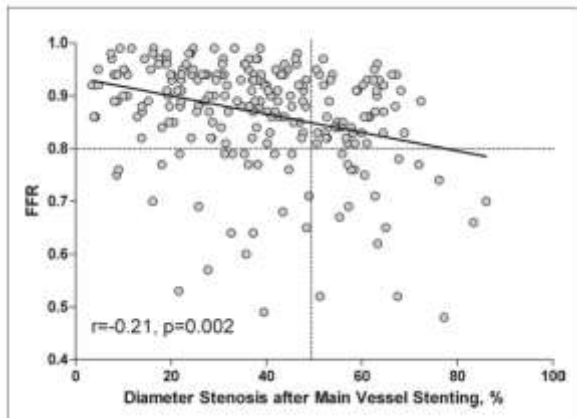
Koo BK, et al. J Am Coll Cardiol 2005;46:633
Park SH & Koo BK J Geriatr Cardiol 2012;9:278



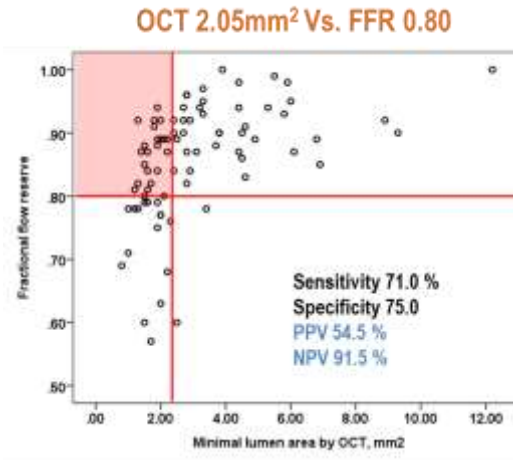
Bellenger, et al. Heart 2007



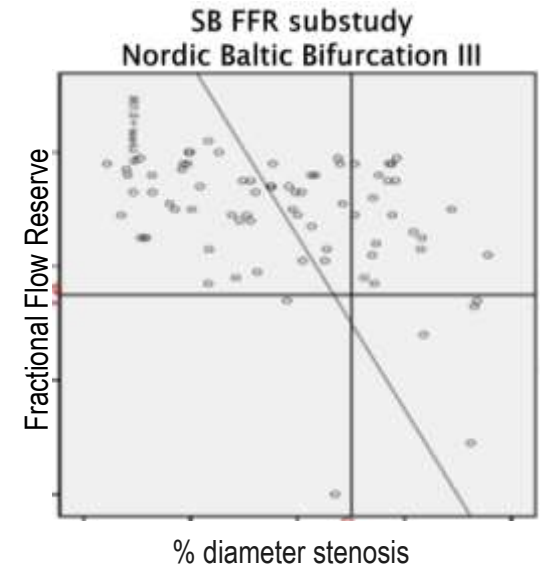
Lee JM, et al. Eurointervention 2015;11:V59



Ahn JM, et al. JACC interv 2012



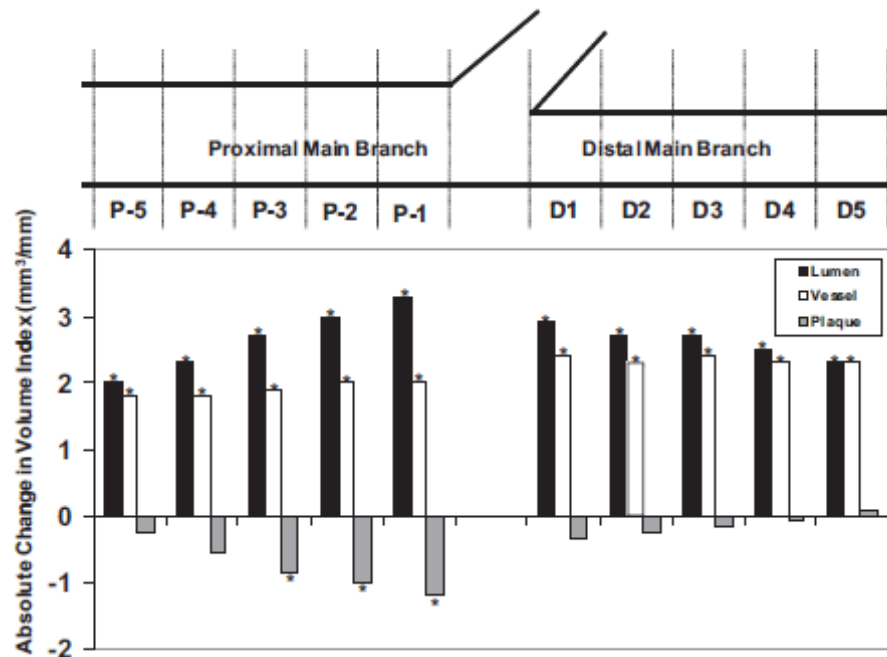
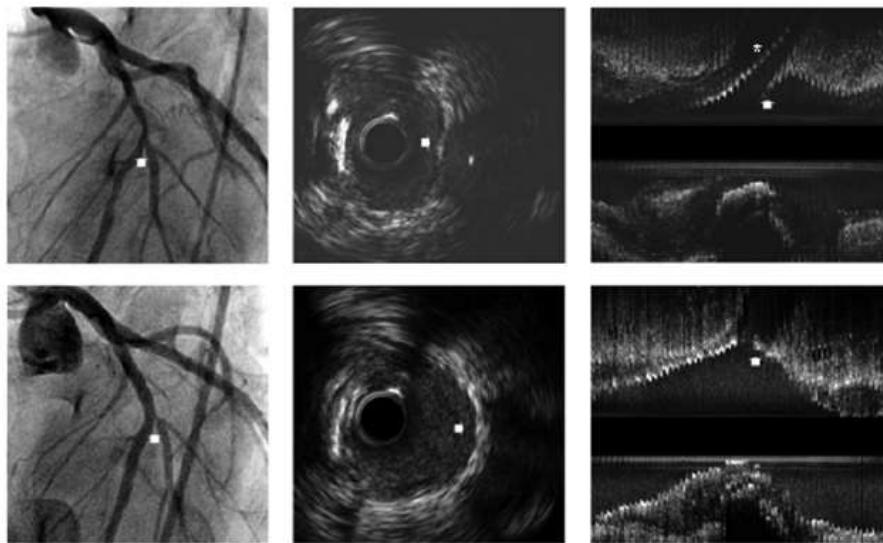
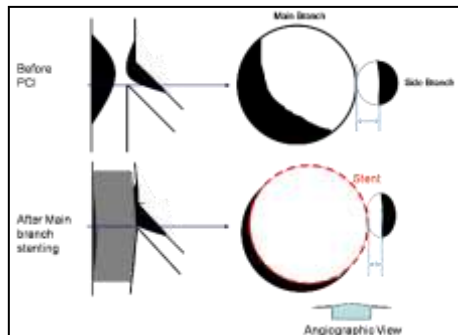
Ha J, et al JACC Imag 2013



Kumsars I, et al. Eurointervention 2011

Why discrepancy between angiographic lesion severity and jailed SB FFR?

'Carina' shift: Lumen area loss << Angiographic diameter loss



Mechanism of SB jail

: Plaque shift from proximal MB + **Carina shift**

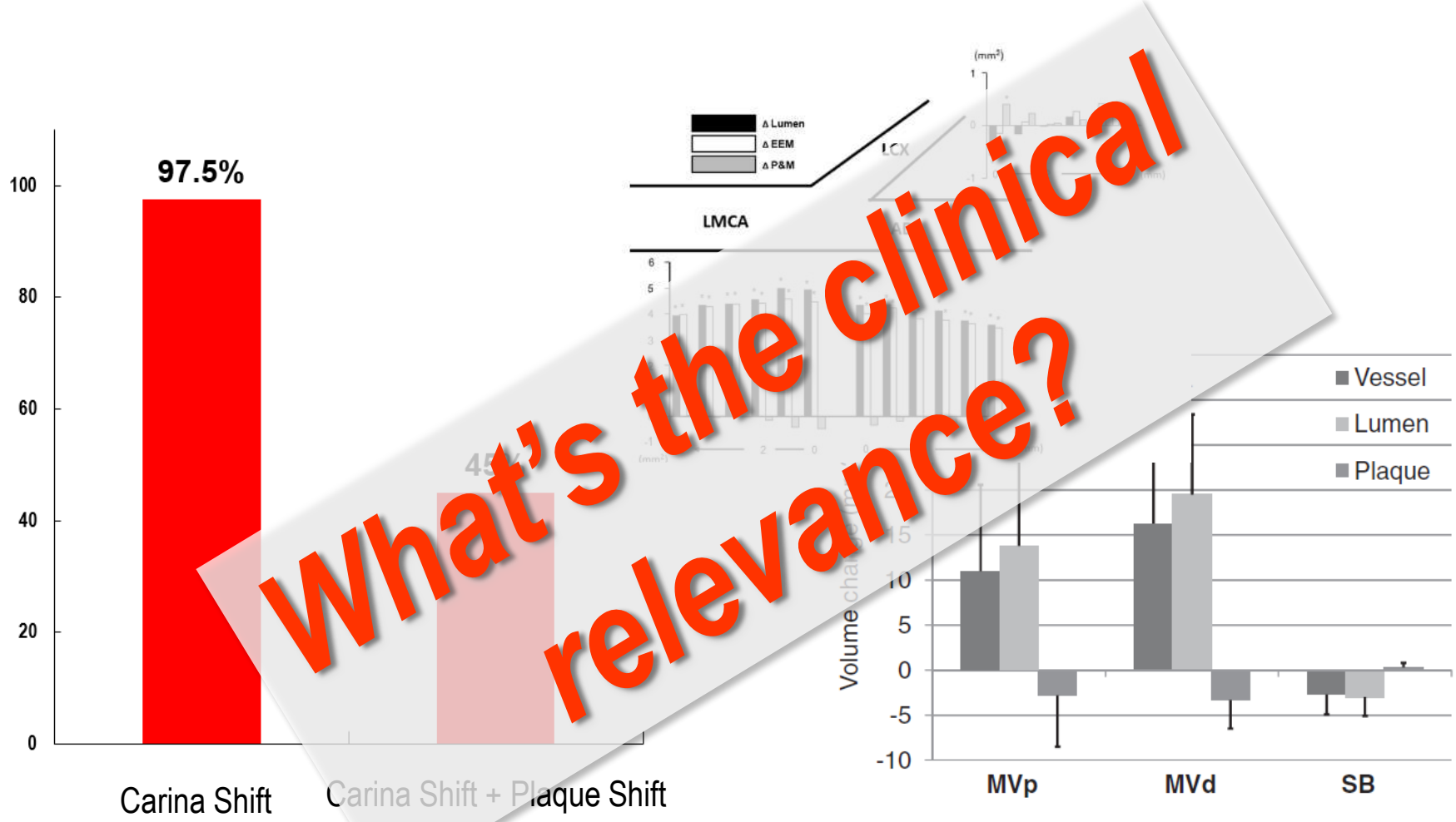
Carina shift accentuates lumen eccentricity and results in more angiographic diameter loss than lumen area loss.

Koo BK. EBC 2008

Koo BK, et al. Circ Cardiovasc Interv 2010;3:113

Why discrepancy between angiographic lesion severity and jailed SB FFR?

'Carina' shift: Lumen area loss << Angiographic diameter loss



What's the clinical relevance?

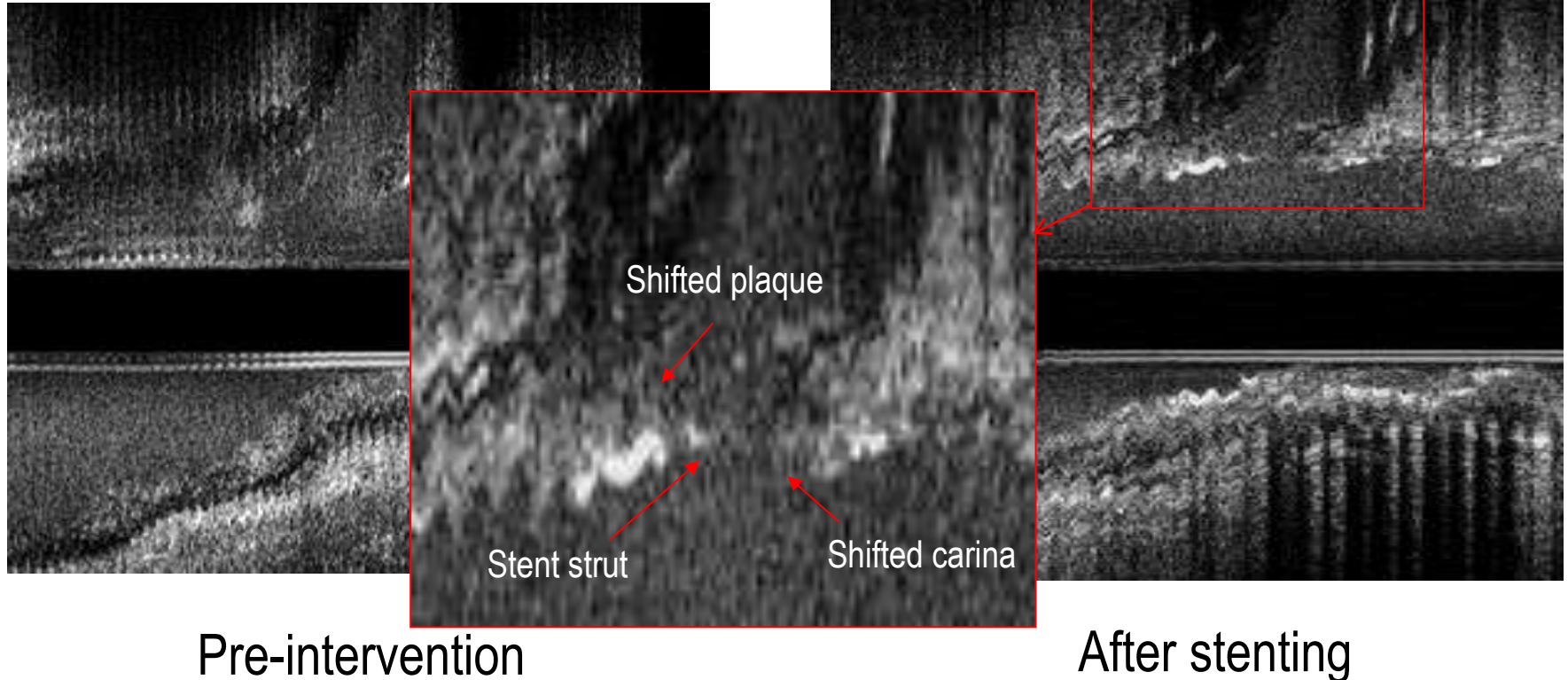
Kang SJ, et al. Circ Cardiovasc Interv 2011;4:355-61
 Kang SJ, et al. Cath Cardiovasc Interv 2013;82:1075-82

Xu J, et al. Circ Cardiovasc Interv 2012;5:657-62
 Xiu J and Choi S-Y, et al. Cath Cardiovasc Interv 2013;81:1142-49

Practical aspect of “Carina shift”

In case of pure carina shift, functionally significant jailing is infrequent .
IVUS assessment can be helpful in selection of treatment strategy.

IVUS for Mechanism of SB jailing



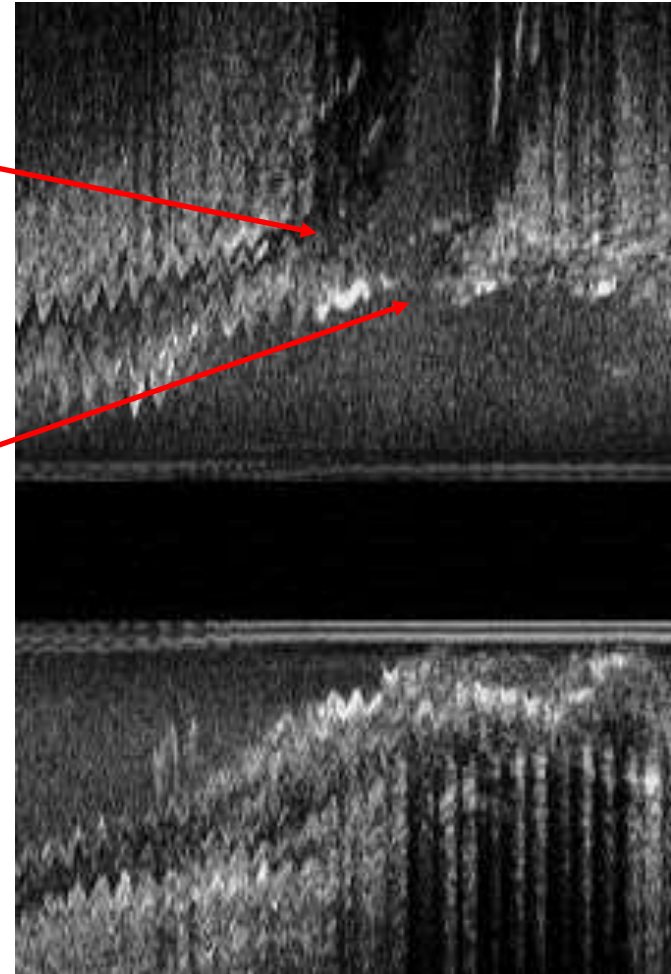
Pre-intervention

After stenting

Koo BK, TCT 2008

IVUS for selection of a treatment target

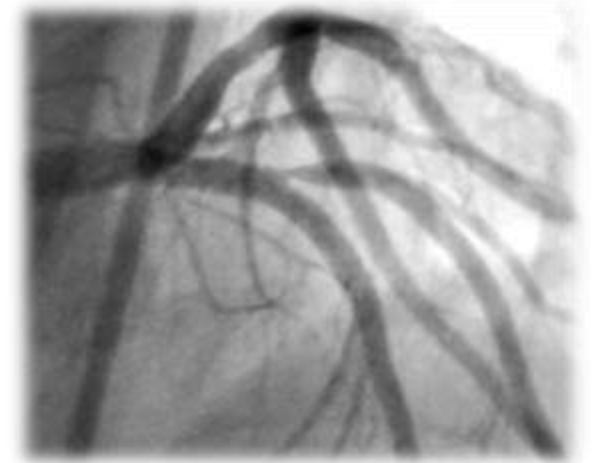
- **Target: SB plaque**
 - Large balloon, high pressure
 - More injury, more dissection
 - Higher chance of SB stenting
 - More late loss
- **Target: Shifted carina**
 - Relatively small balloon, low pressure
 - Less injury, less dissection
 - Less chance of SB stenting
 - Less late loss



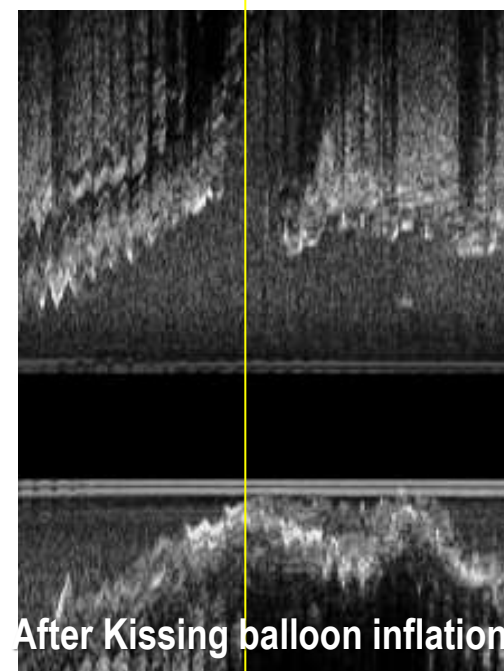
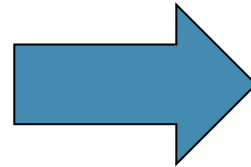
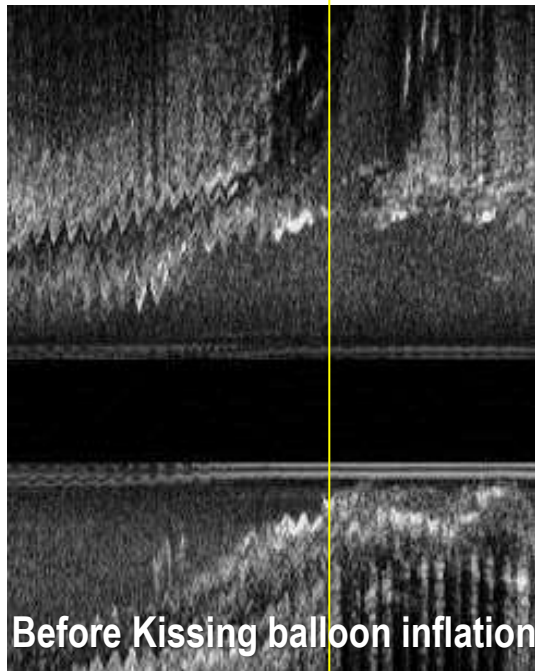
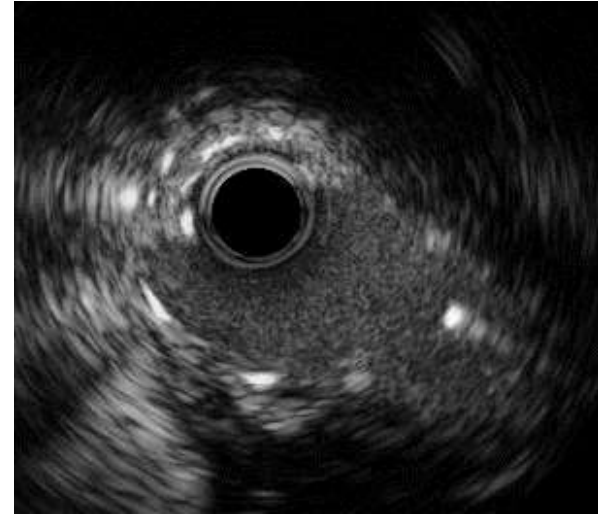
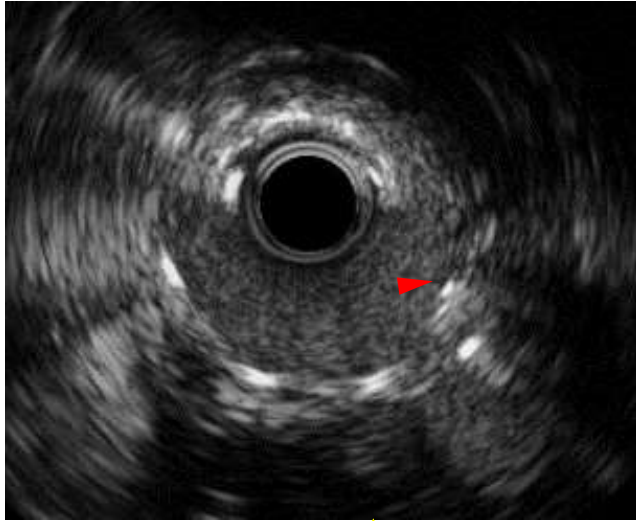
Koo BK, EBC 2008

Integrated use of IVUS and FFR in non-LM bifurcation PCI

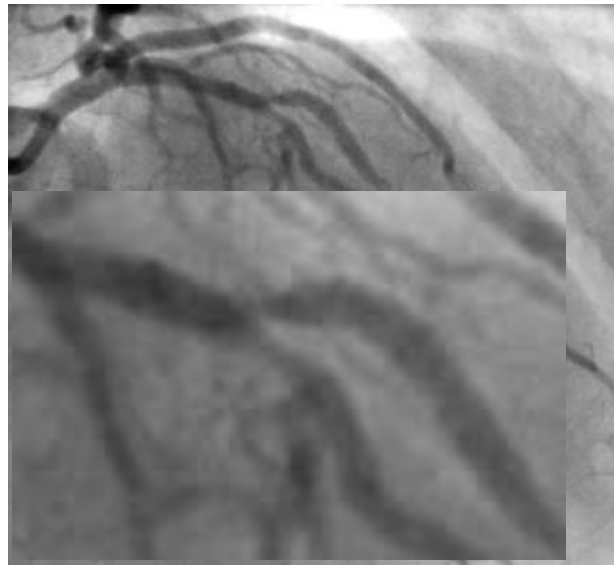
- Pre-intervention
- After main branch stent implantation
- After side branch balloon angioplasty
- After side branch stenting



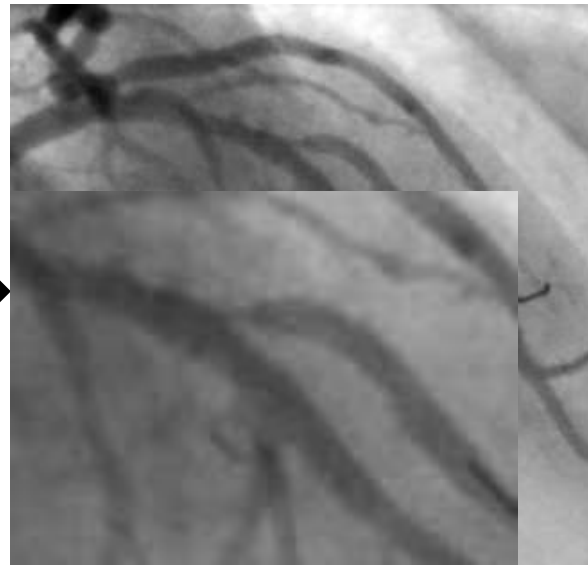
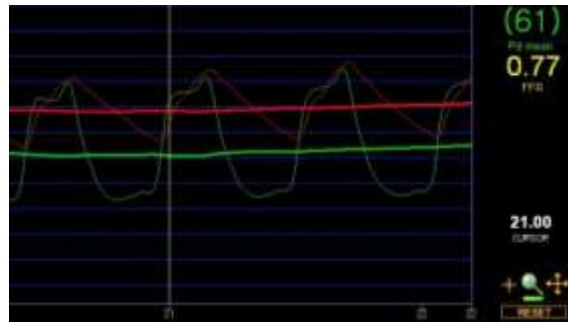
Assessment of procedural results: IVUS



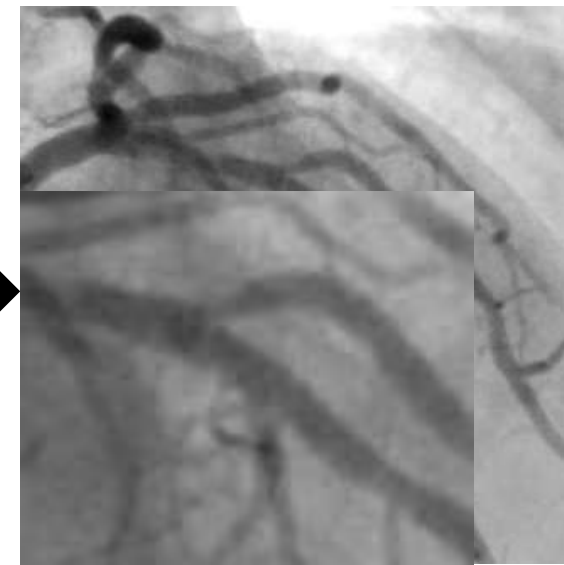
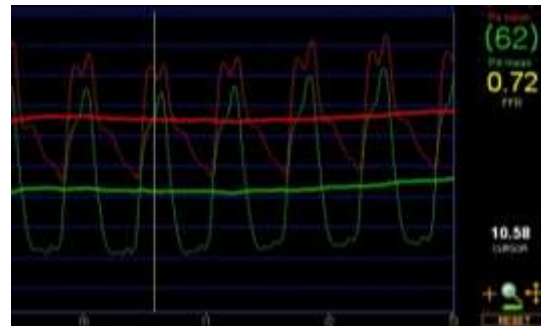
Assessment of procedural results: FFR



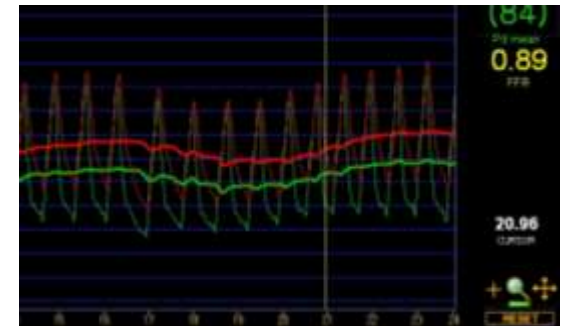
Before PCI



After MB stenting

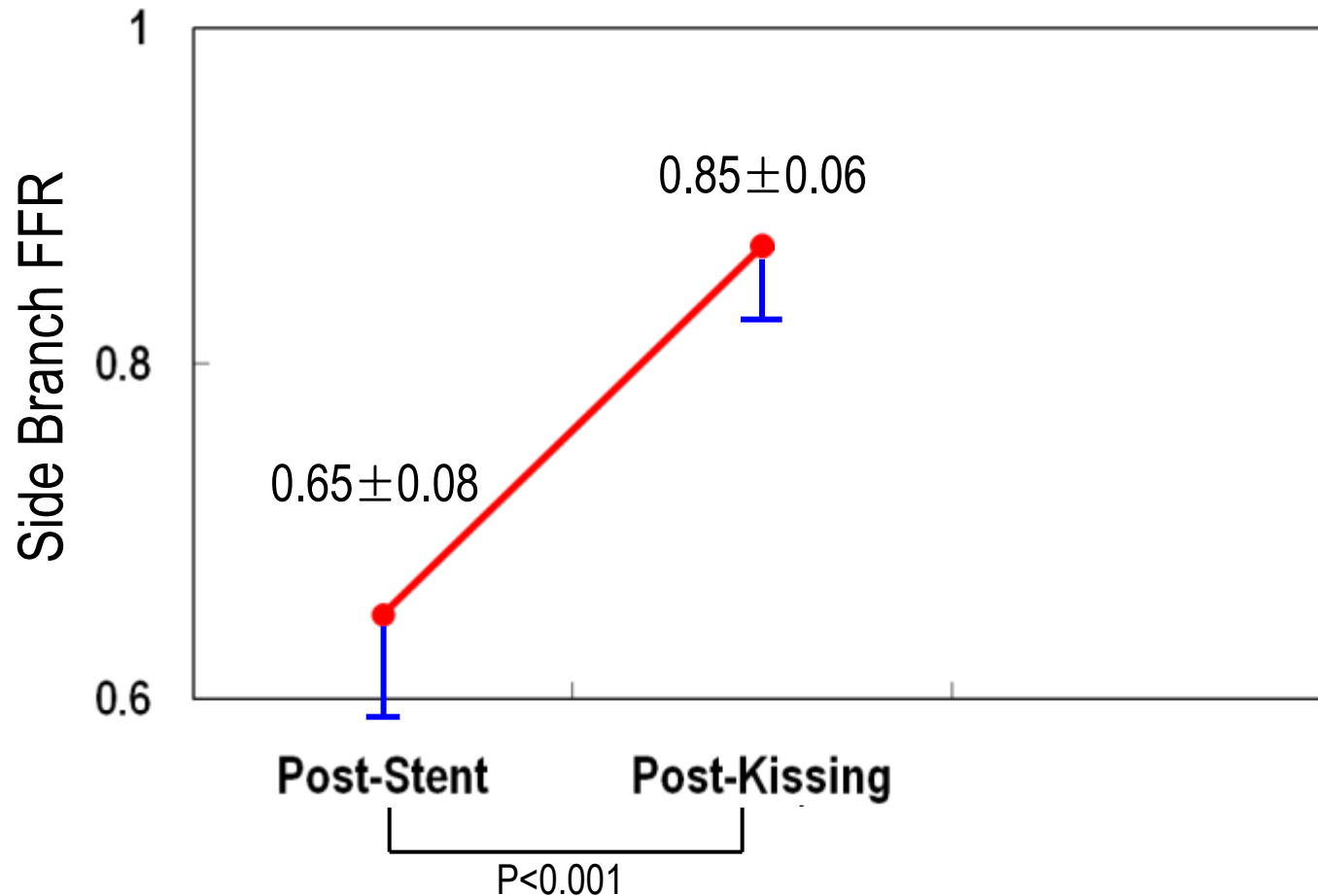


After kissing balloon

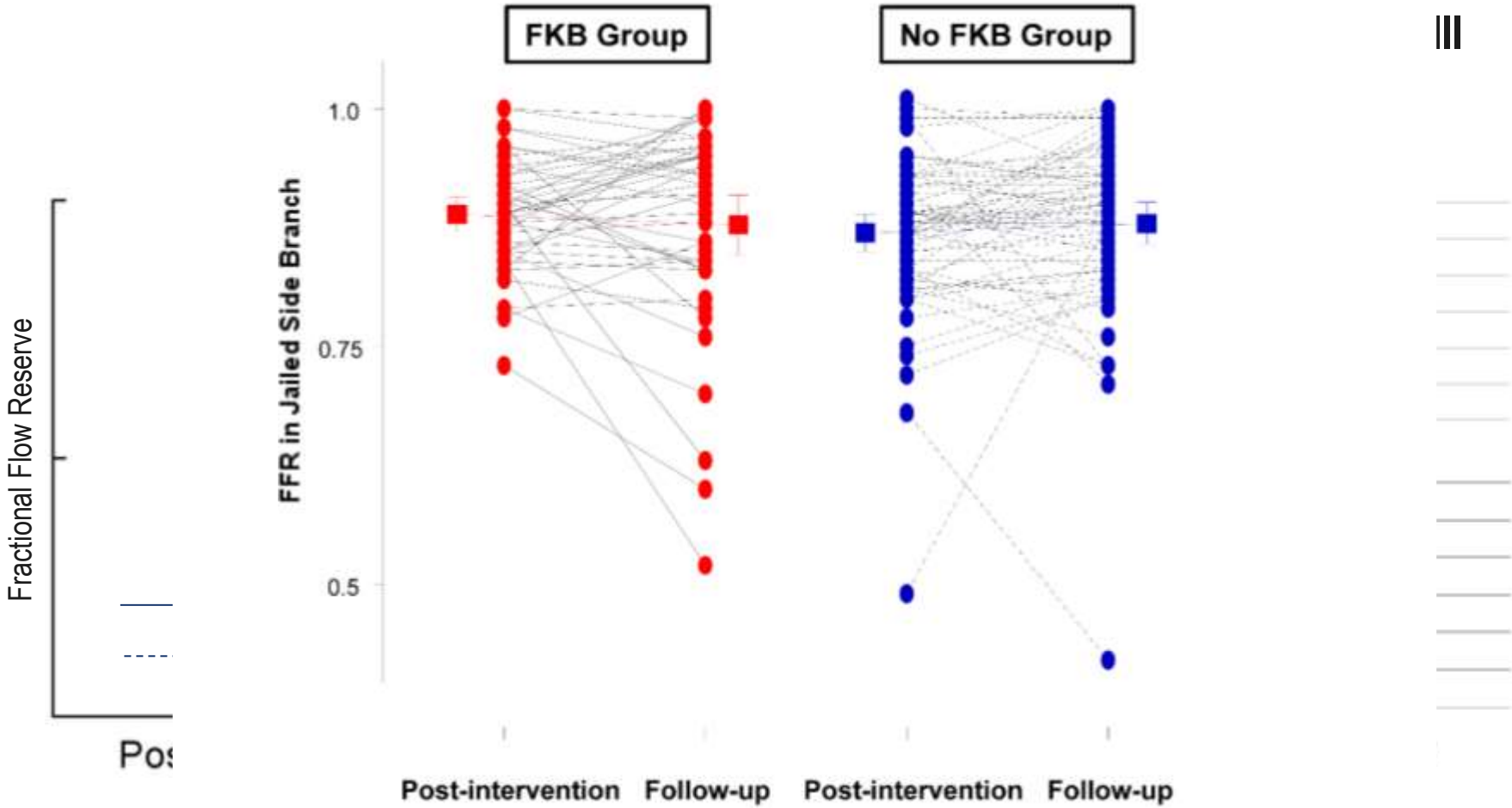


Changes of side branch FFR after “gentle” kissing balloon

(Side branch balloon/artery ratio: 0.9 ± 0.1)



Functional outcome of Jailed side branches



Lee JM..... Koo BK, Eurointervention 2015

© 2011

Assessment of procedural results after 2 stenting

Angiographically excellent, but.....

604 Costa et al.
Crush Stenting for Bifurcation Lesions

JACC Vol. 46, No. 4, 2005
August 16, 2005:599-605

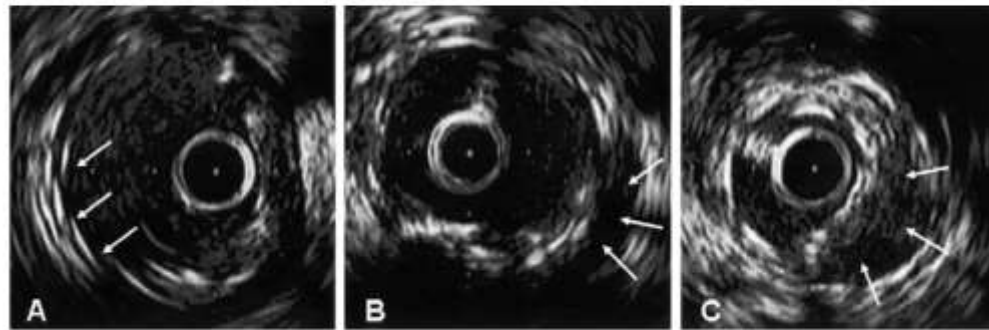
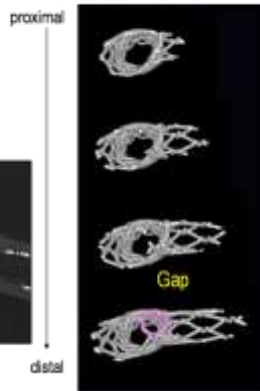


Figure 4. (A) Intravascular ultrasound image showing complete crush (apposition) of the side branch (SB) stent; **arrows** indicate the three layers of stent struts. (B, C) Intravascular ultrasound images showing incomplete crush (apposition) of the SB stent struts (**arrows**).

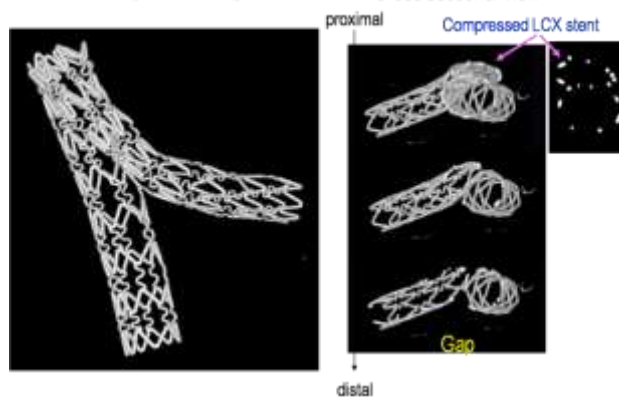
Modified T-stenting

Cross sectional view



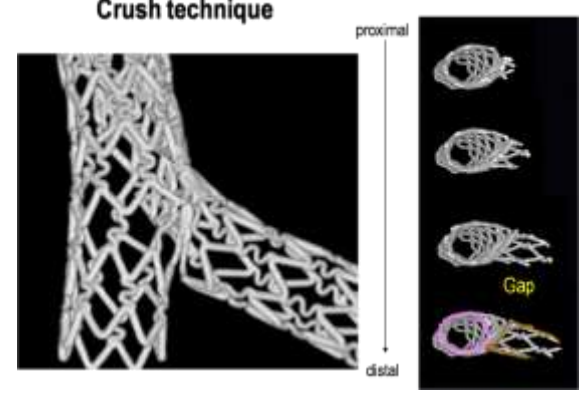
Kissing stenting

Cross sectional view



Crush technique

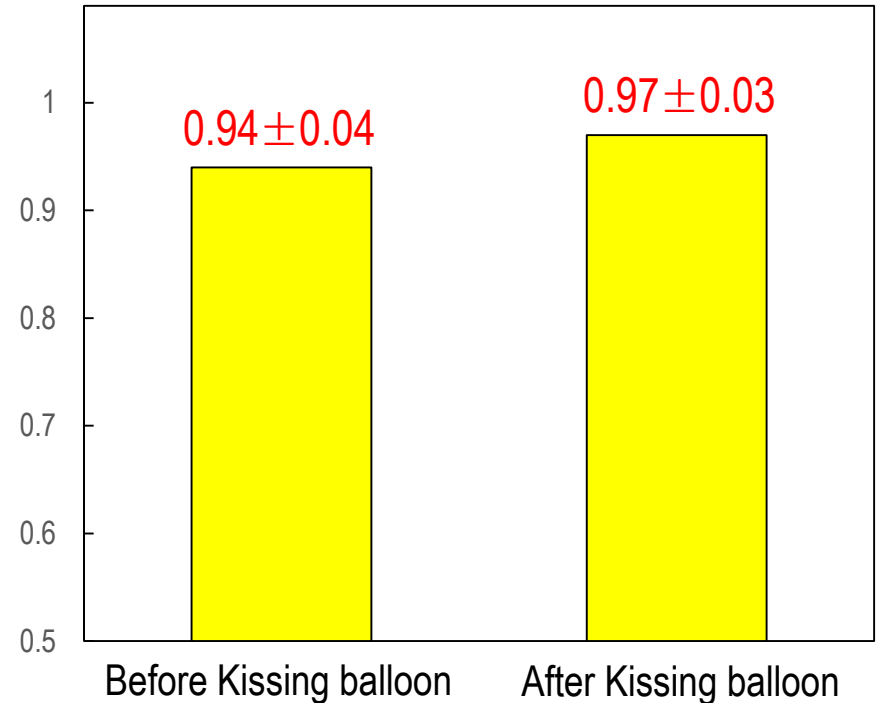
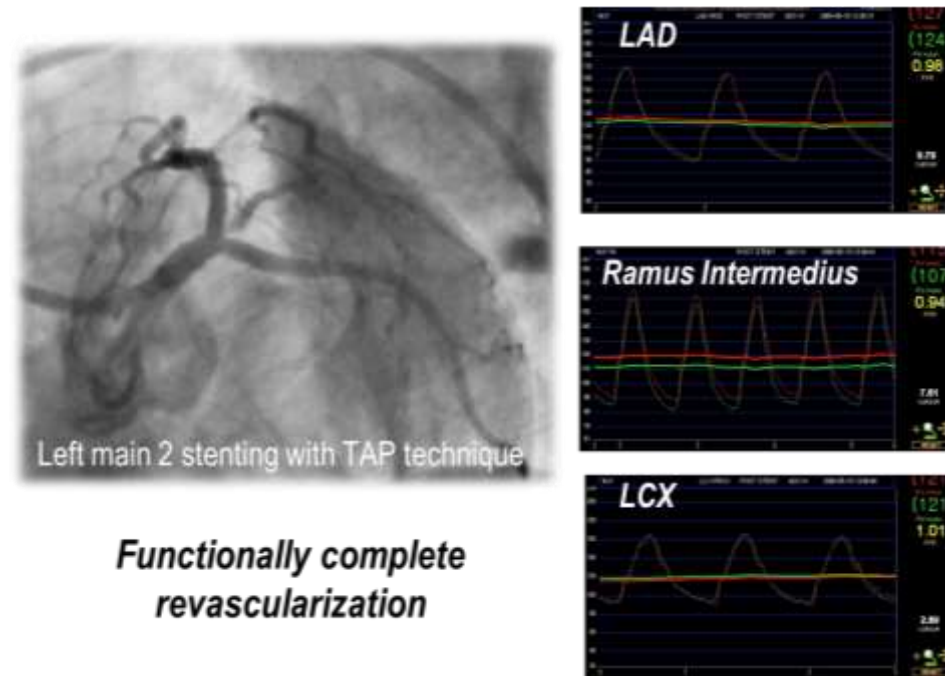
Cross sectional view



Courtesy of Dr. Murasato

FFR and IVUS after 2 stenting

SB FFR after Crush stenting



Lee BK, et al. Clinical Cardiol 2010

- After 2 stenting, high FFR does not guarantee the procedural success. Therefore, IVUS is recommended more than FFR in case of 2 stenting.

IVUS and FFR in non-LM bifurcation PCI

- Use of IVUS and/or FFR is feasible and helpful at each step of bifurcation PCI.
- However, adequate knowledge on coronary anatomy/physiology and pitfalls of IVUS/FFR is essential to properly use IVUS/FFR at each step of bifurcation PCI.

	FFR	IVUS
<i>Pre-intervention</i>		
Main branch ischemia	+++	+
Side branch ischemia	++	+
Planning the procedure	+	+++
<i>After main branch stenting</i>		
Mechanism of side branch jailing	-	+++
Jailed side branch ischemia	+++	+
<i>After side branch intervention</i>		
Residual ischemia	+++	+
Procedural success after 2 stenting	+	+++