

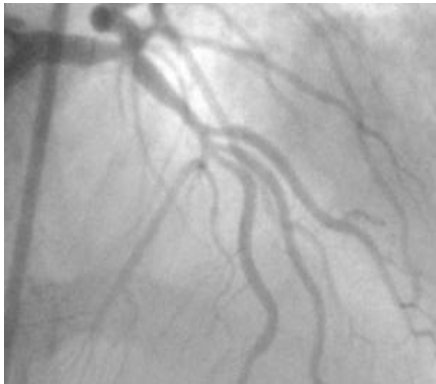
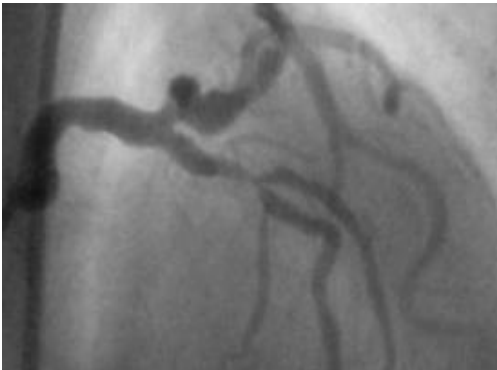
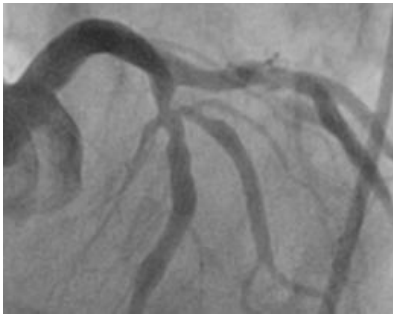
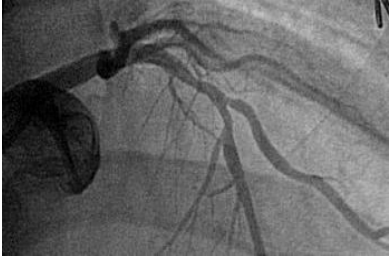
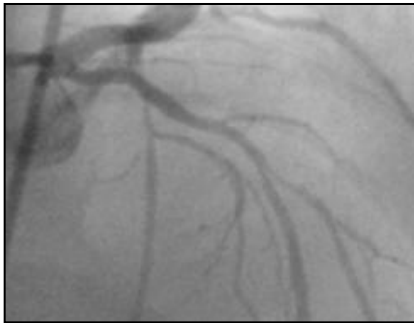
# Clinical Application of Integrated Use of FFR and IVUS : Non-LM bifurcation PCI

**Bon-Kwon Koo, MD, PhD**

Seoul National University Hospital, Seoul, Korea



# Bifurcations are complex!



# Integrated use of IVUS and FFR

FFR/IVUS-guided PCI for complex lesions can improve outcomes!

Am Heart J. 2011 Jan;161(1):180-7.

## 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.

Kim JS, Hong MK, Ko YG, Choi D, Yoon JH, Choi SH, Hahn JY, Gwon HC, Jeong MH, Kim HS, Seong IW, Yang JY, Rha SW, Tahk SJ, Seung KB, Park SJ, Jang Y.

Division of Cardiology, Severance Cardiovascular Hospital, Yonsei University College of Medicine, Seoul, Korea.

### Abstract

**BACKGROUND:** although intravascular ultrasound (IVUS) has been widely used for complex lesions during coronary intervention, IVUS for stenting at 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 1,668 patients with non-left main de novo bifurcation lesions who underwent DES implantation between January 2004 and June 2006. Using propensity score matching with clinical and angiographic characteristics, 487 patients with IVUS guidance and 487 patients with angiography guidance were selected. The long-term clinical outcomes were compared between the 2 groups.

**RESULTS:** baseline clinical and angiographic characteristics were well matched and showed no significant differences between the 2 groups. Two-stent technique and final kissing ballooning angioplasty were more frequently performed in the IVUS-guided group. Maximal stent diameters at both the main vessel and the side branch were larger in the IVUS-guided group. Periprocedural creatine kinase-MB elevation (>3 times of upper normal limits) was frequently observed in the angiography-guided group. The incidence of death or myocardial infarction was significantly lower in the IVUS-guided group compared to the angiography-guided group (3.8% vs 7.8%, log rank test  $P = .03$ , hazard ratio 0.44, 95% CI 0.12-0.96, Cox model  $P = .04$ ).

**CONCLUSIONS:** intravascular ultrasound guidance during DES implantation at bifurcation lesions may be helpful to improve long-term clinical outcomes by reducing the occurrence of death or myocardial infarction.

## Long-Term Outcomes of Intravascular Ultrasound-Guided Stenting in Coronary Bifurcation Lesions

Sung-Hwan Kim, MD<sup>a</sup>, Young-Hak Kim, MD, PhD<sup>a</sup>, Soo-Jin Kang, MD, PhD<sup>a</sup>, Duk-Woo Park, MD, PhD<sup>a</sup>, Seung-Whan Lee, MD, PhD<sup>a</sup>, Cheol Whan Lee, MD, PhD<sup>a</sup>, Myeong-Ki Hong, MD, PhD<sup>a</sup>, Sang-Sig Cheong, MD, PhD<sup>a</sup>, Jae-Joong Kim, MD, PhD<sup>a</sup>, Seong-Wook Park, MD, PhD<sup>a</sup>, and Seung-Jung Park, MD, PhD<sup>a,\*</sup>

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)

Seoul National University Hospital  
Cardiovascular Center

## The NEW ENGLAND JOURNAL of MEDICINE

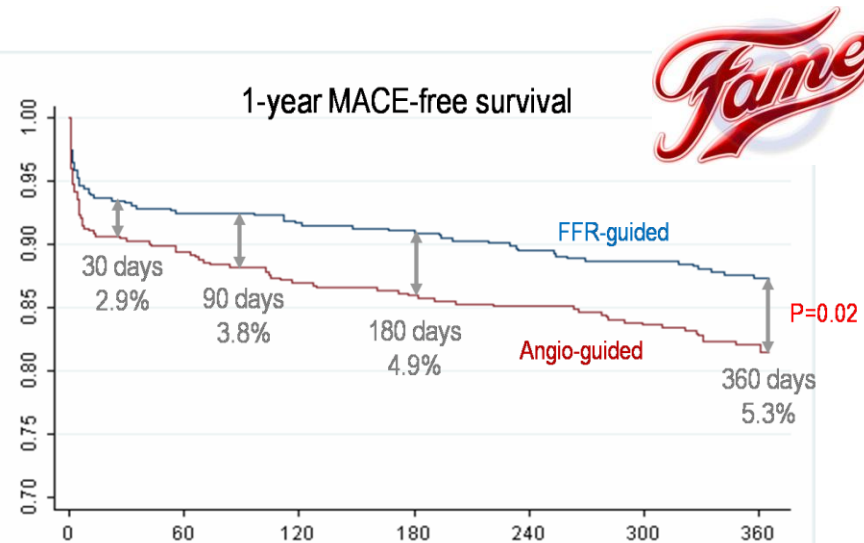
ESTABLISHED IN 1812

JANUARY 15, 2009

VOL. 360 NO. 3

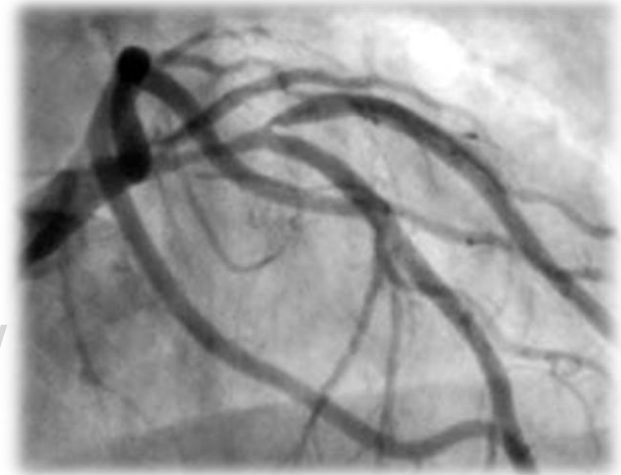
### Fractional Flow Reserve versus Angiography for Guiding Percutaneous Coronary Intervention

Pim A.L. Tonino, M.D., Bernard De Bruyne, M.D., Ph.D., Nico H.J. Pijls, M.D., Ph.D., Uwe Siebert, M.D., M.P.H., Sc.D., Fumiaki Ikeno, M.D., Marcel van 't Veer, M.Sc., Volker Klauss, M.D., Ph.D., Ganesh Manoharan, M.D., Thomas Engstrom, M.D., Ph.D., Keith G. Oldroyd, M.D., Peter N. Ver Lee, M.D., Philip A. McCarthy, M.D., Ph.D., and William F. Fearon, M.D., for the FAME Study Investigators\*

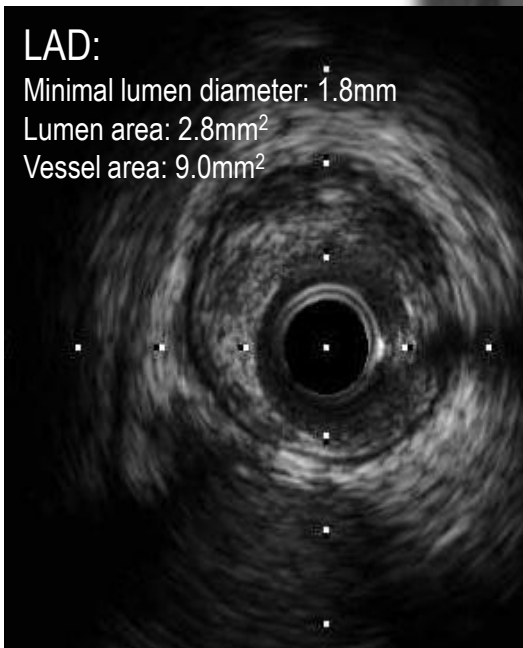
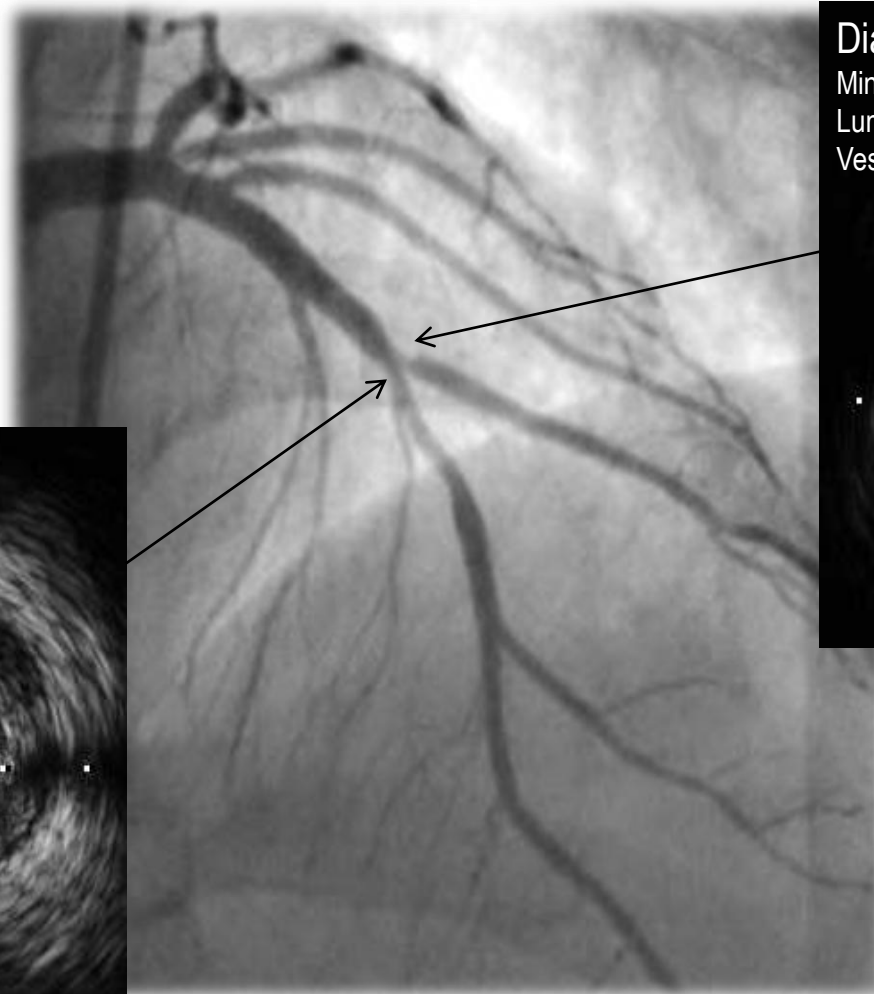


# Integrated use of IVUS and FFR in non-LM bifurcation PCI

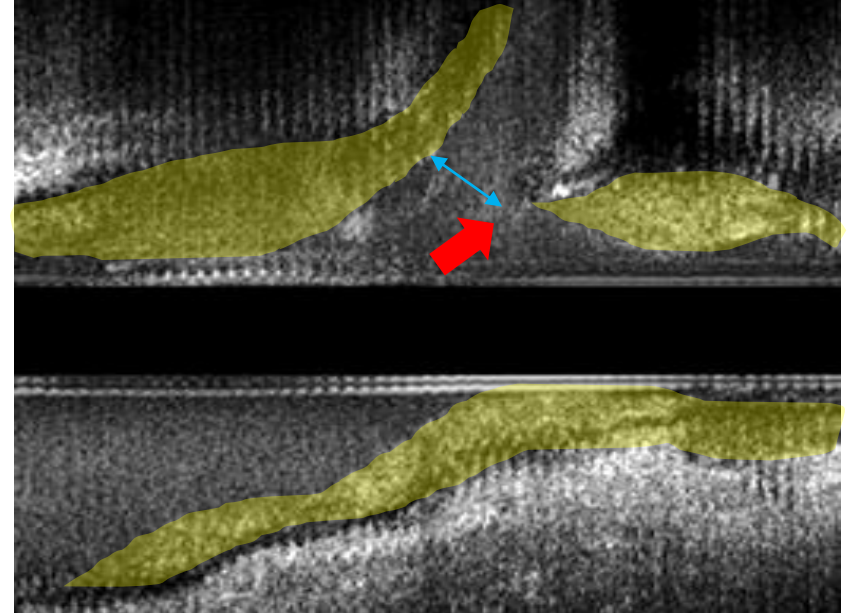
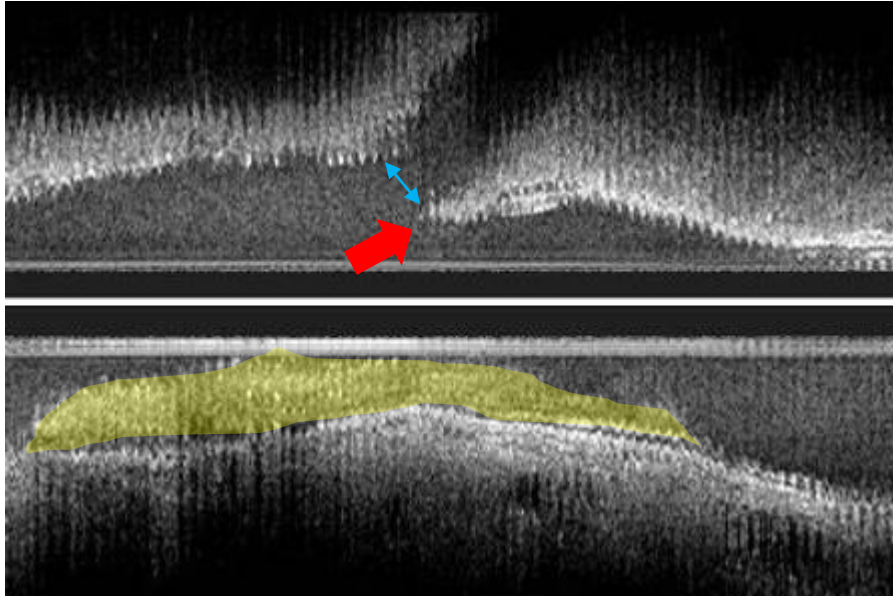
- Pre-intervention
- After main branch stent implantation
- After side branch balloon angioplasty
- After side branch stenting



# Precise anatomical assessment

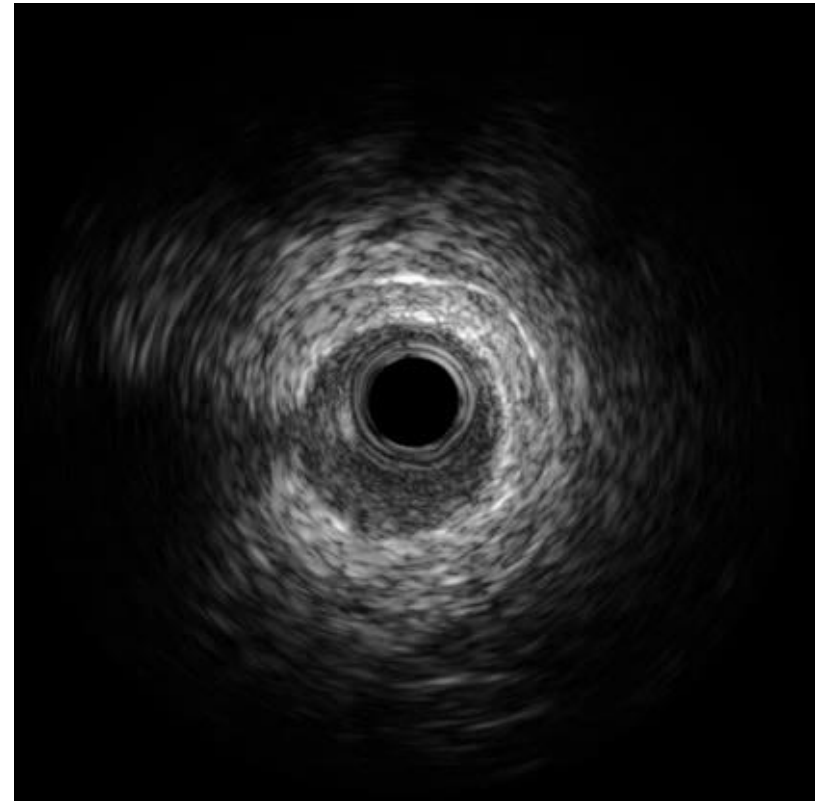
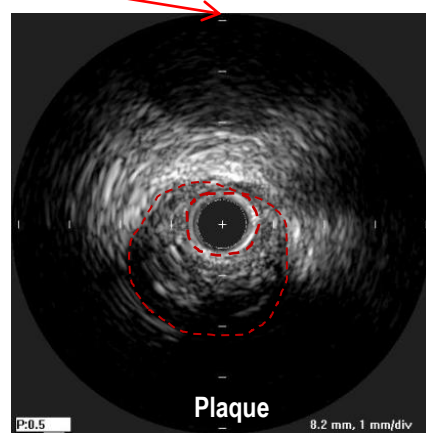
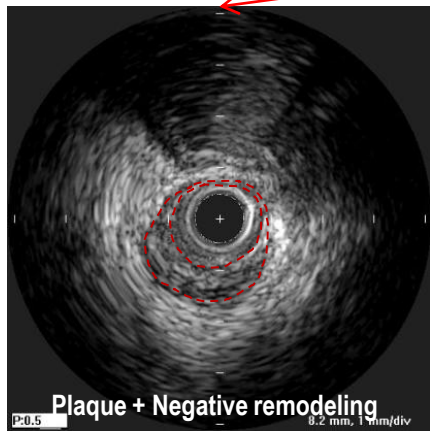
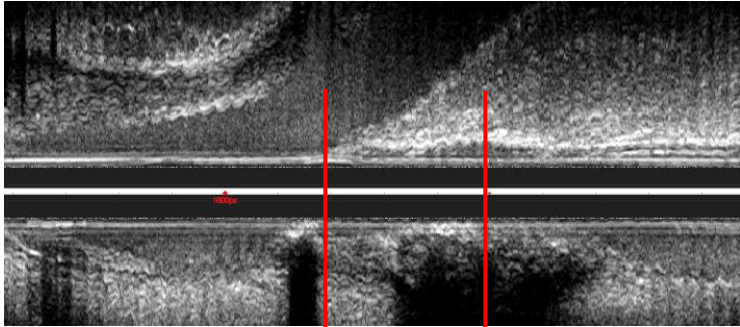
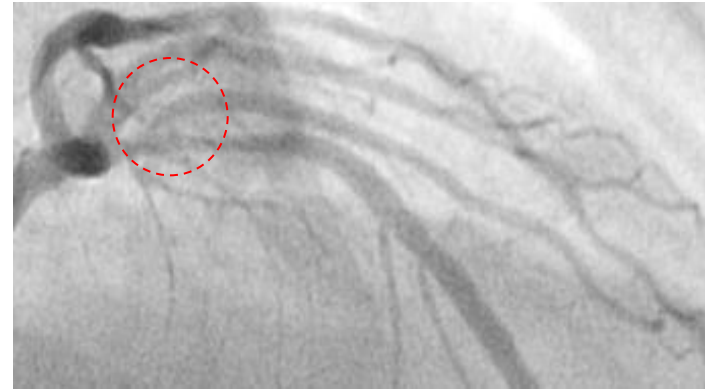
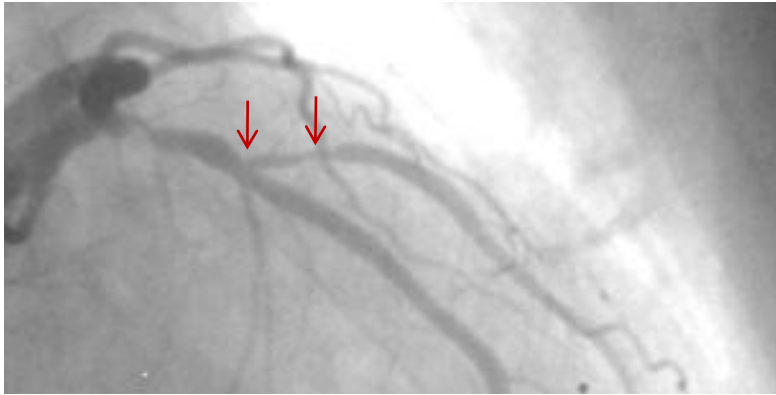


# Important anatomical information



- 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



# 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,<sup>1</sup> MD, PhD, Won-Jang Kim,<sup>1</sup> MD, Sung-Cheol Yun,<sup>2</sup> PhD, Duk-Woo Park,<sup>1</sup> MD, PhD, Seung-Whan Lee,<sup>1</sup> MD, PhD, Young-Hak Kim,<sup>1</sup> MD, PhD, Cheol Whan Lee,<sup>1</sup> MD, PhD, Seong-Wook Park,<sup>1</sup> MD, PhD, Gary S. Mintz,<sup>3</sup> MD, and Seung-Jung Park,<sup>1\*</sup> MD, PhD

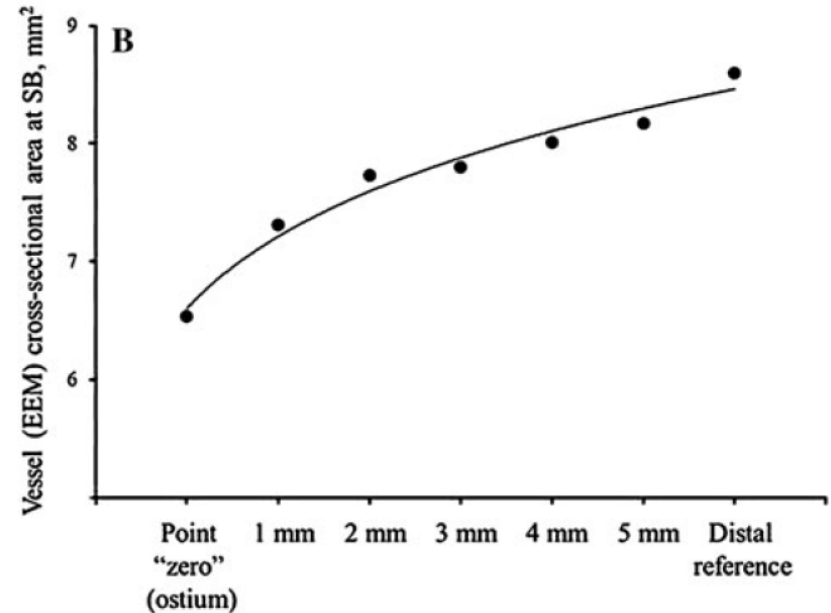
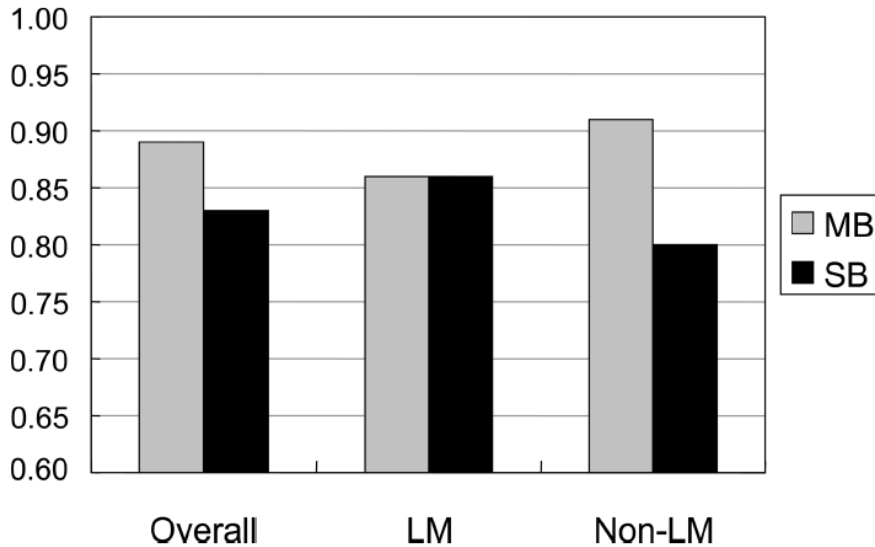
Int J Cardiovasc Imaging  
DOI 10.1007/s10554-013-0263-1

ORIGINAL PAPER

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

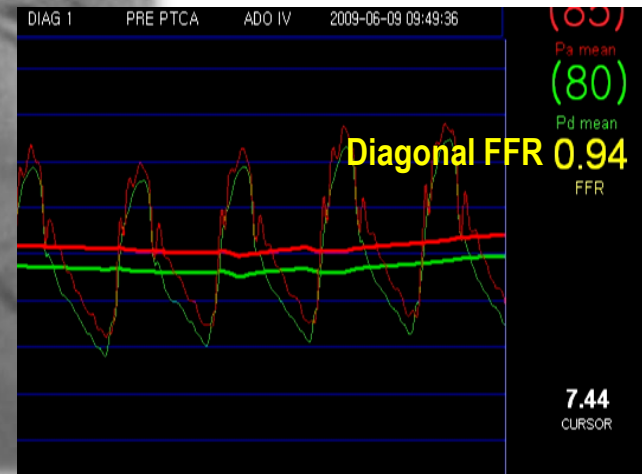
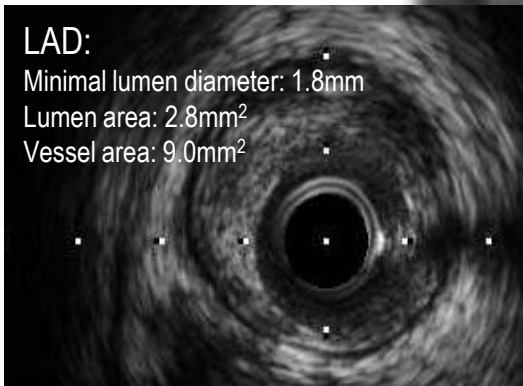
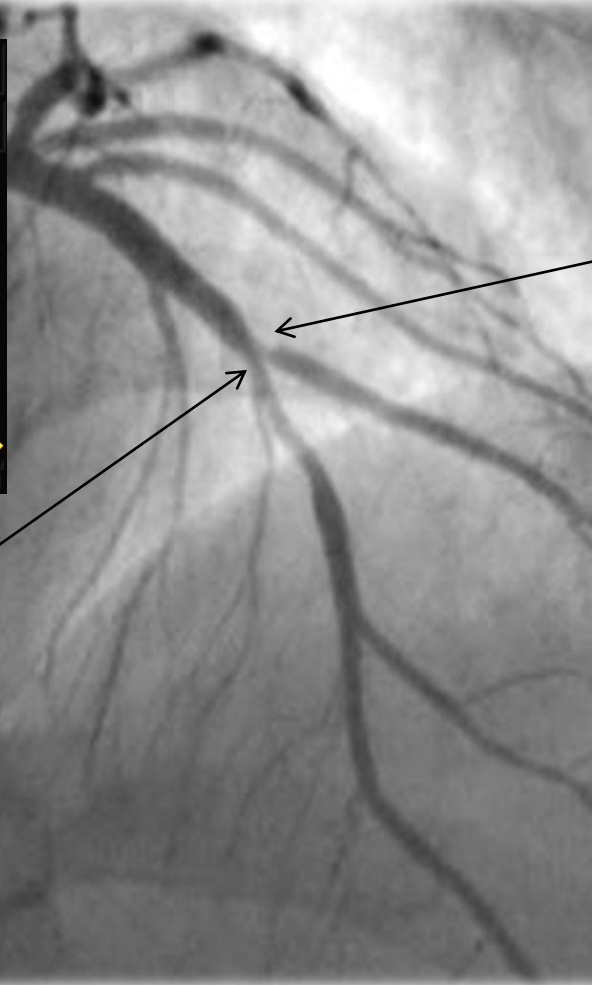
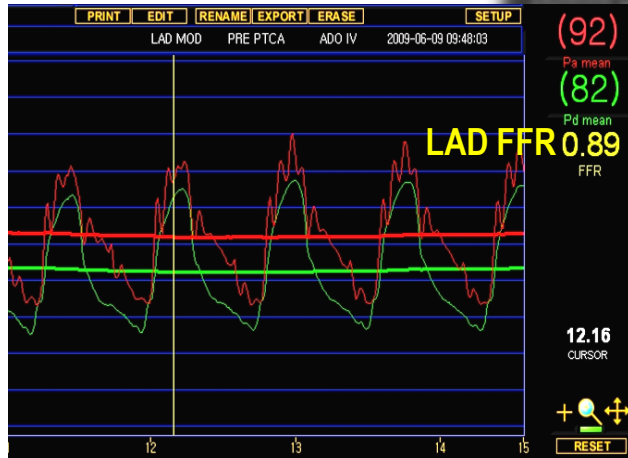
Ricardo A. Costa · Fausto Feres · Rodolfo Staico · Alexandre Abizaid · J. Ribamar Costa Jr. · Dimytri Siqueira · Luiz F. Tanajura · Lucas P. Damiani · Amanda Sousa · J. Eduardo Sousa · Antonio Colombo

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

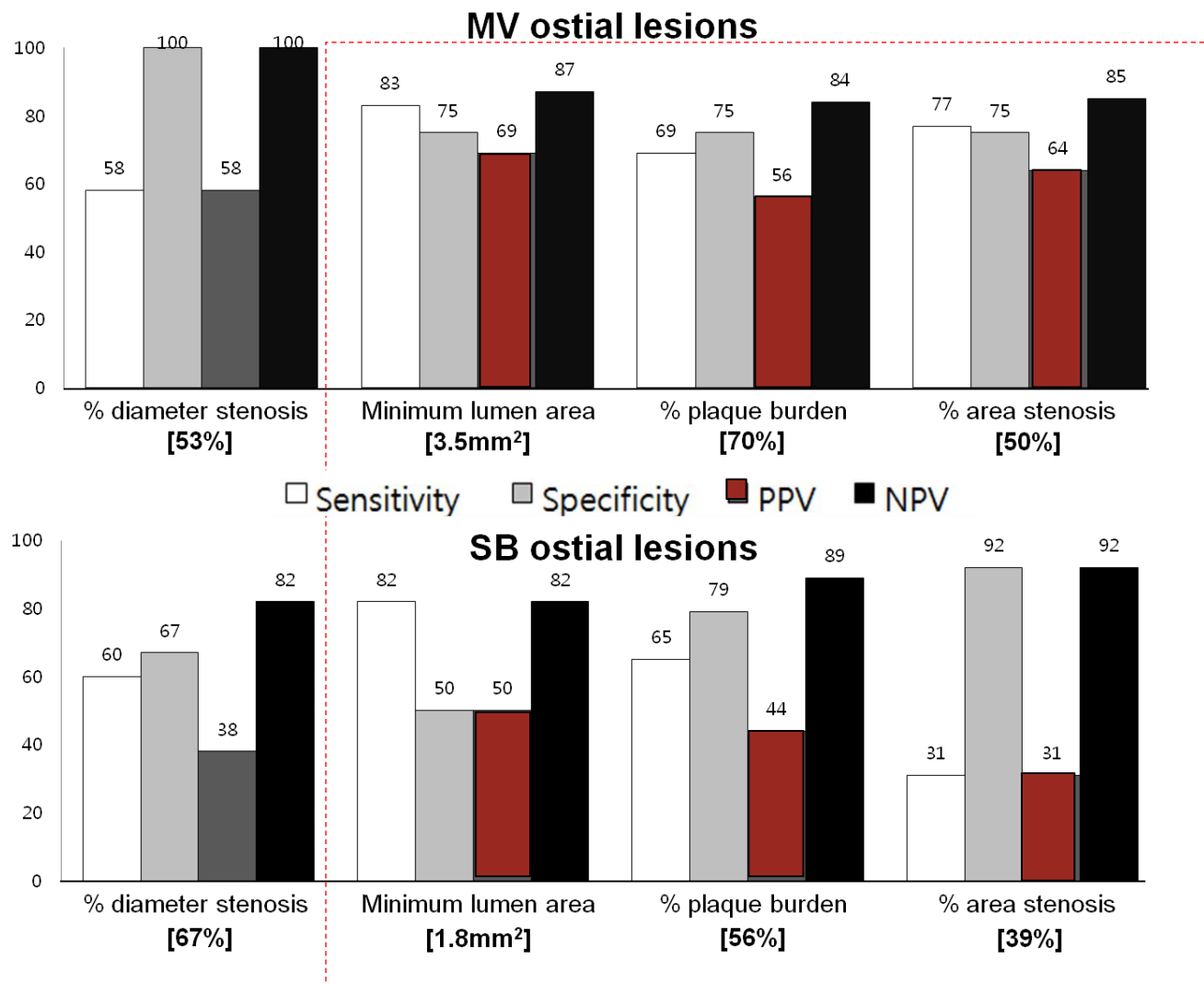




# Precise physiological assessment

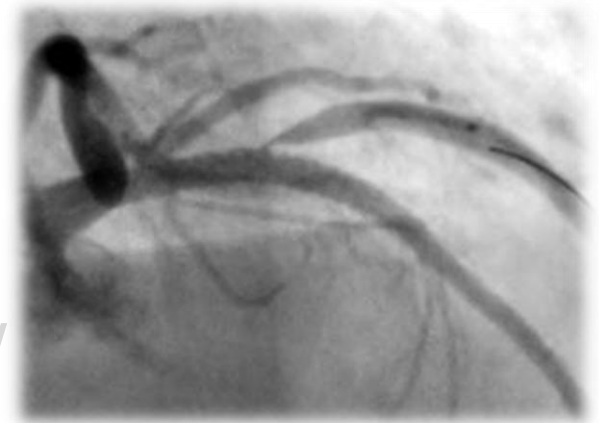


# Diagnostic accuracy of IVUS parameters in pure ostial lesions



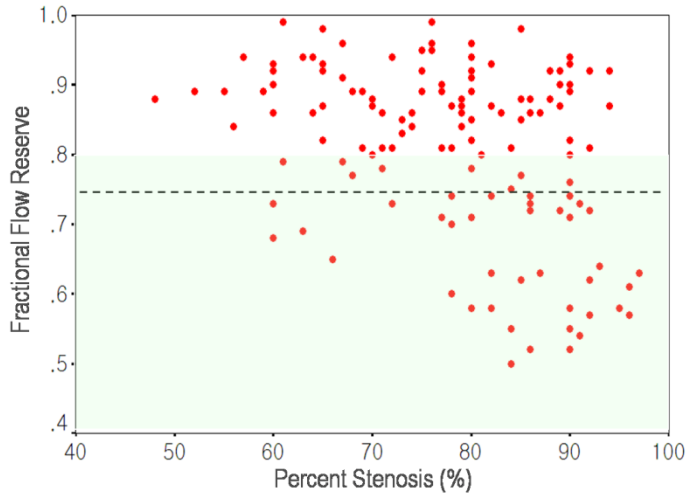
# Integrated use of IVUS and FFR in non-LM bifurcation PCI

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

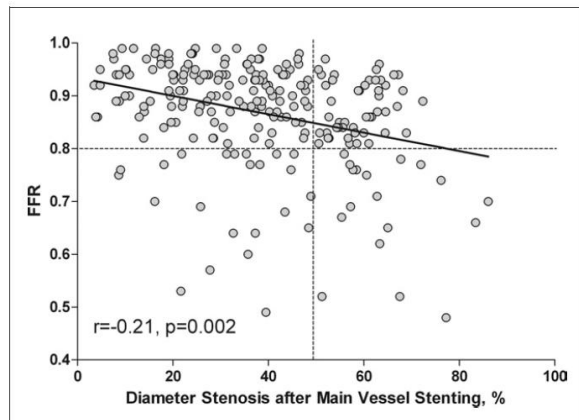


# Can anatomical severity predict the functional significance?

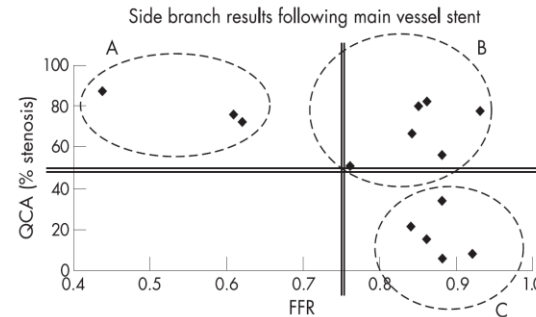
## FFR vs. anatomical stenosis in Jailed side branches



Park SH & Koo BK J Geriatr Cardiol 2012



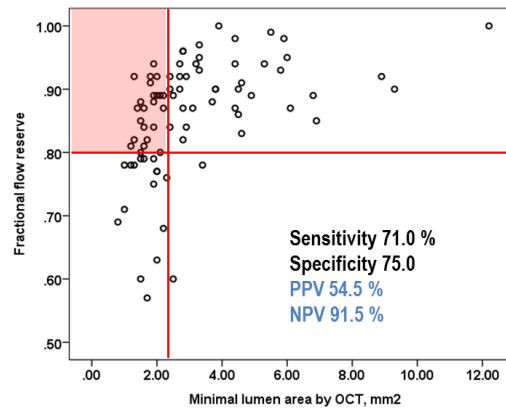
Ahn JM, et al. JACC interv 2012



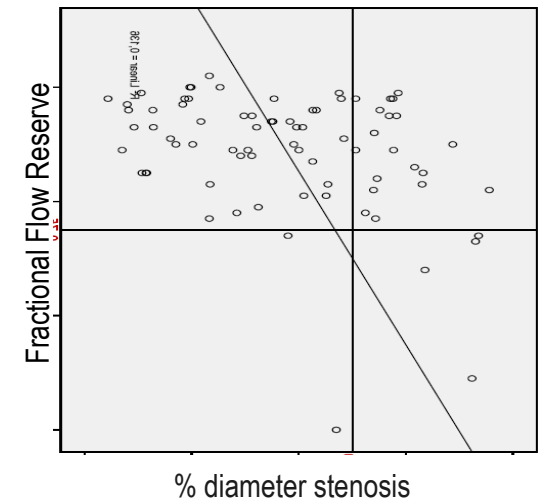
Bellenger, et al. Heart 2007

SB FFR substudy  
Nordic Baltic Bifurcation III

### OCT 2.05mm<sup>2</sup> Vs. FFR 0.80

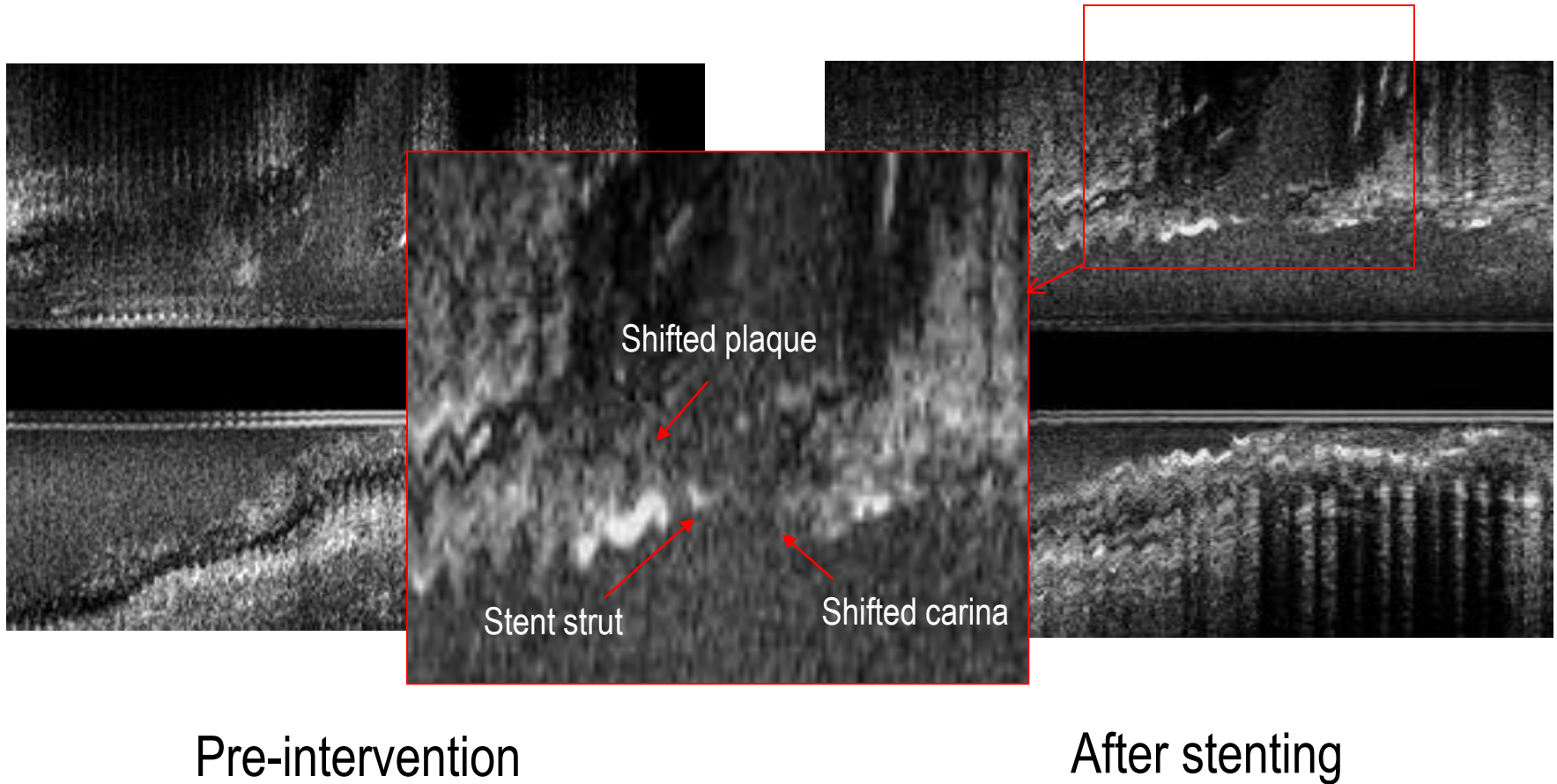


Ha J, Kim JS, et al JACC Imag 2013



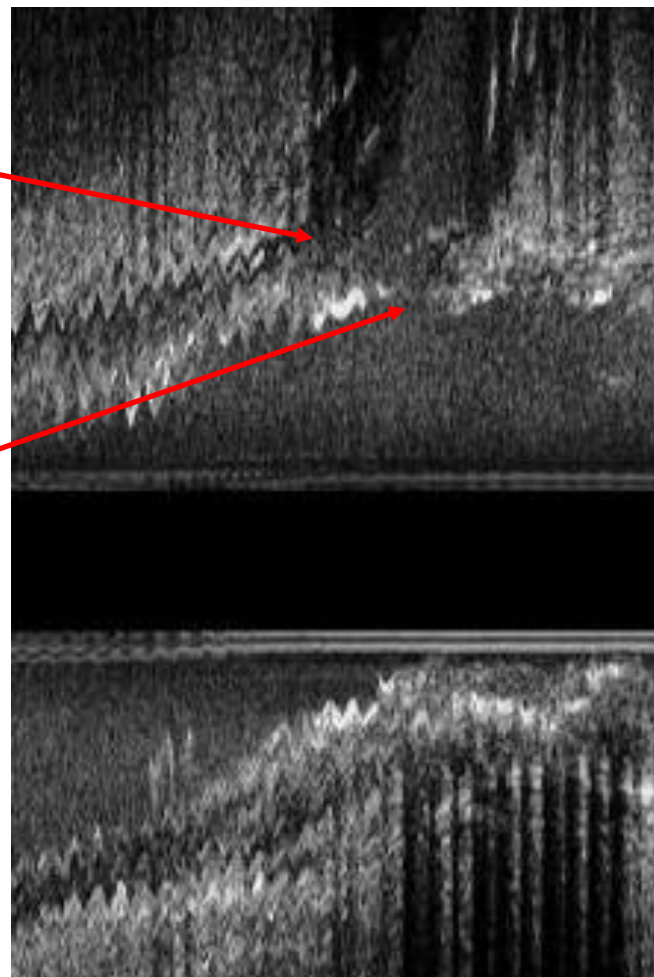
Kumsars I, et al. Eurointervention 2011

# Mechanism of SB jailing: Plaque, Carina, Stent.....



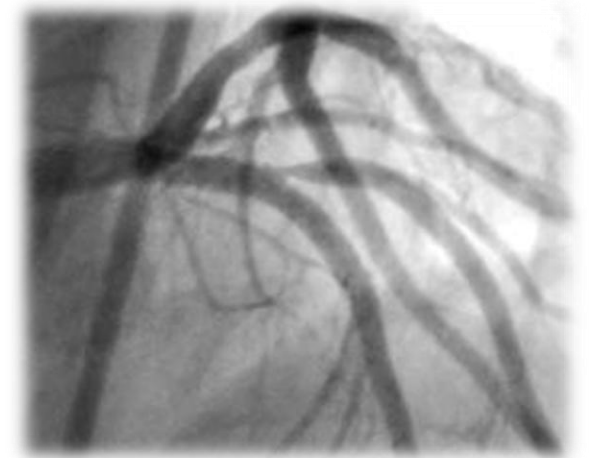
# Different target, different strategy

- **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

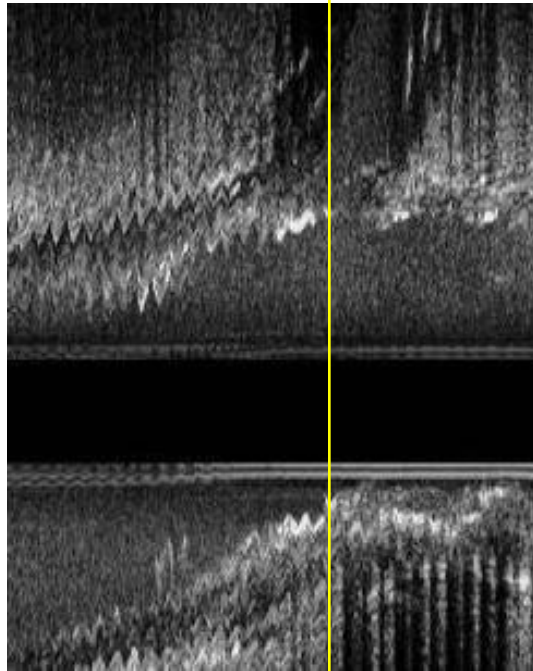
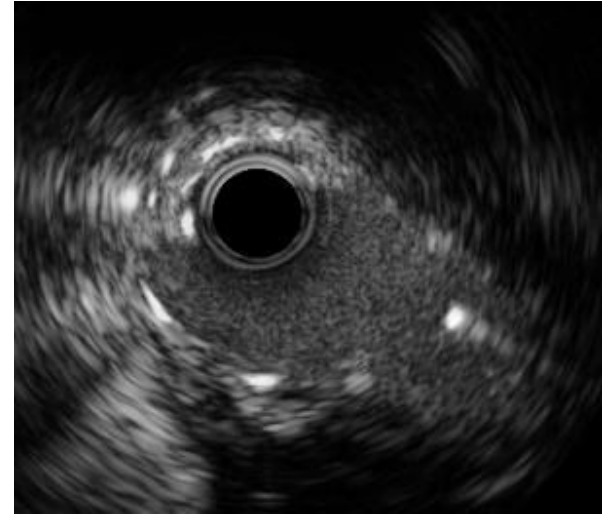
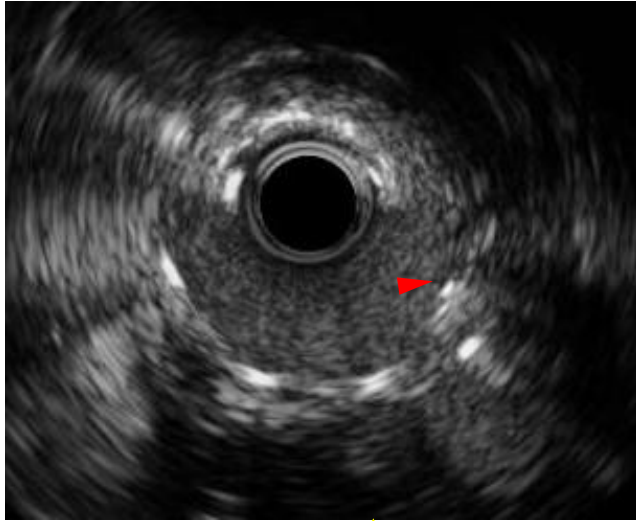


# Integrated use of IVUS and FFR in non-LM bifurcation PCI

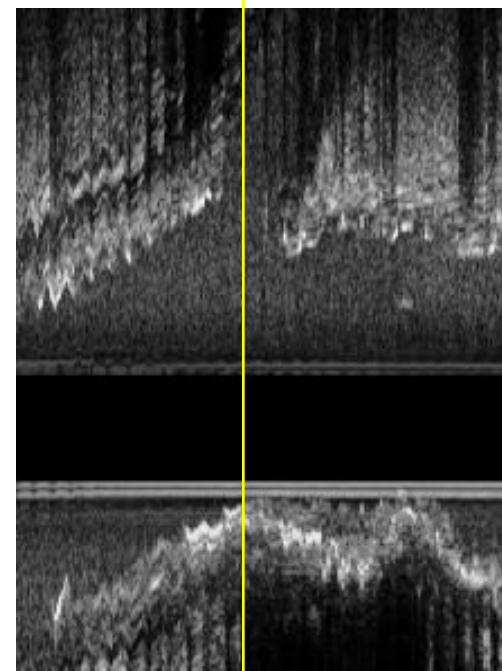
- Pre-intervention
- After main branch stent implantation
- After side branch balloon angioplasty
- After side branch stenting



# Assessment of procedural results: IVUS



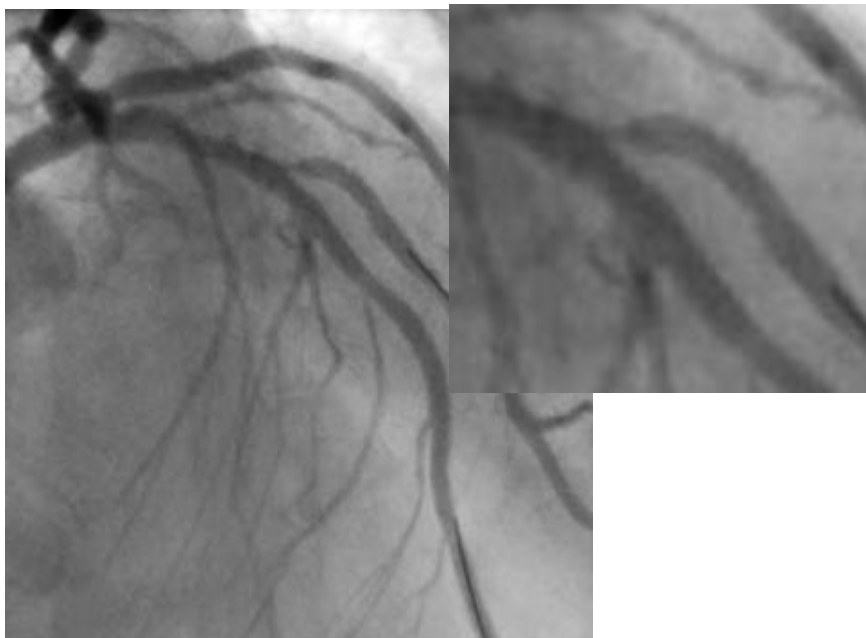
Before Kissing balloon inflation



After Kissing balloon inflation



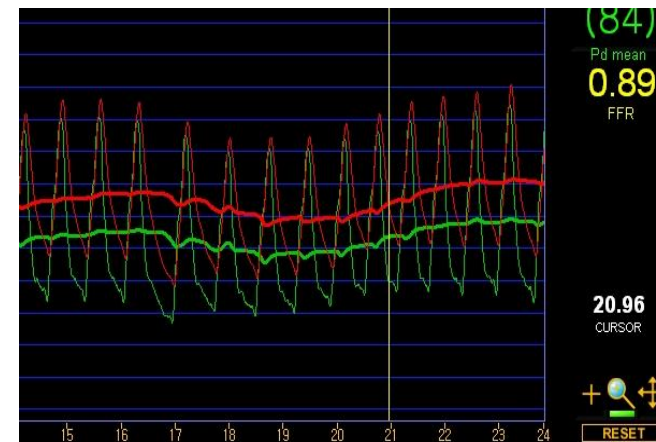
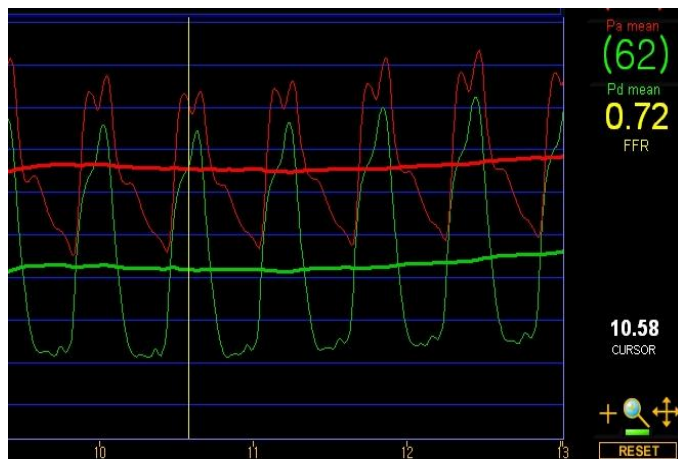
# Assessment of procedural results: FFR



After MB stenting

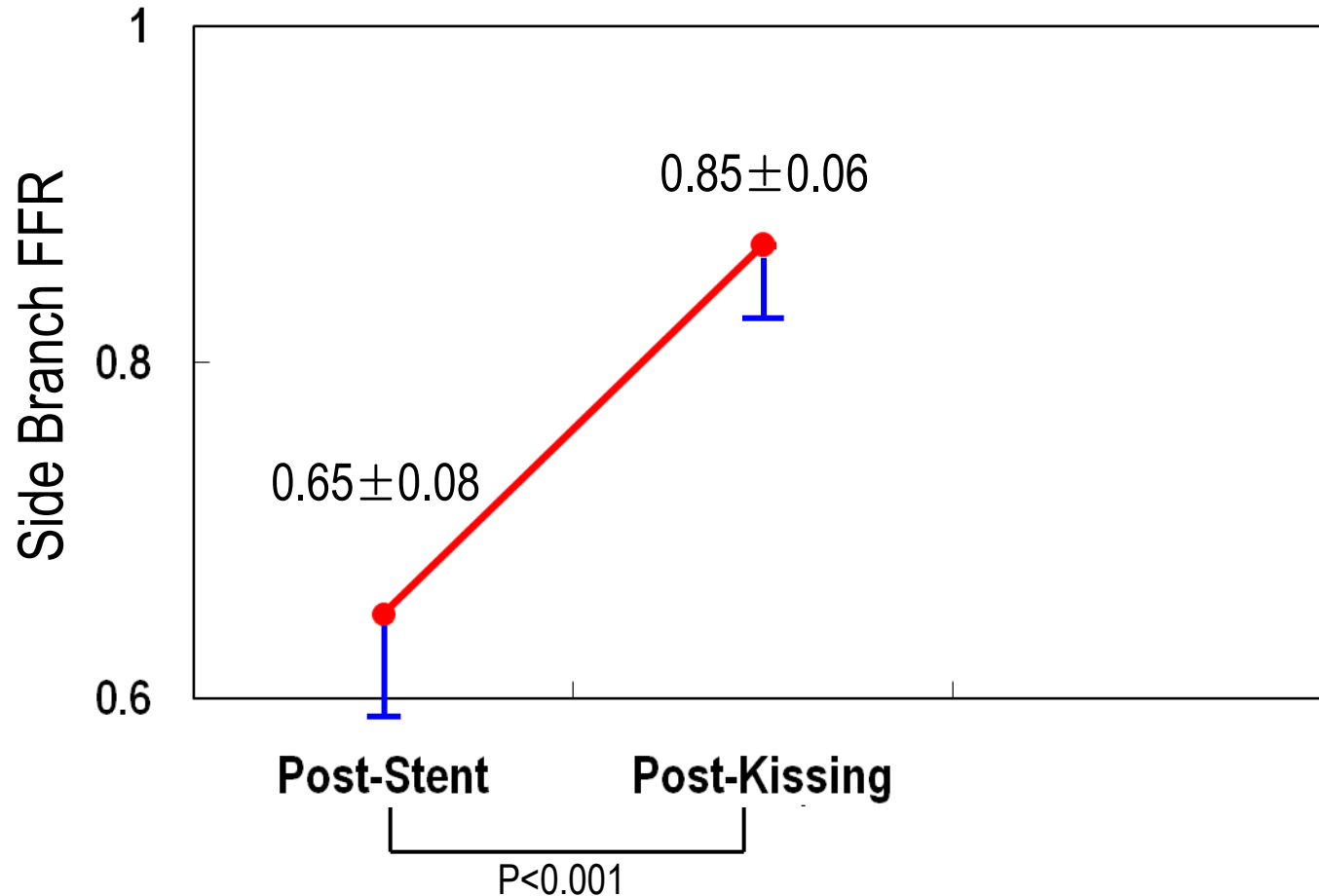


After kissing balloon



# Changes of side branch FFR after “gentle” kissing balloon

(Side branch balloon/artery ratio:  $0.9 \pm 0.1$ )

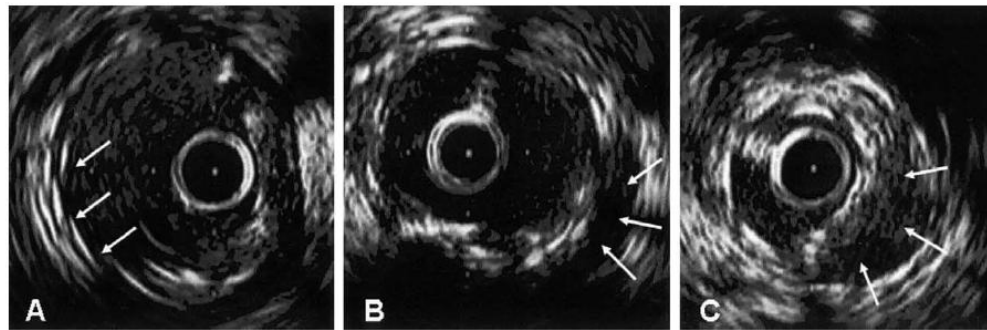


# Assessment of procedural results after 2 stenting

## Angiographically excellent, but.....

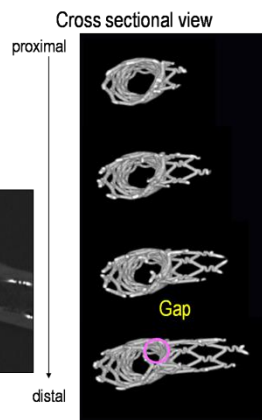
604 Costa et al.  
Crush Stenting for Bifurcation Lesions

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

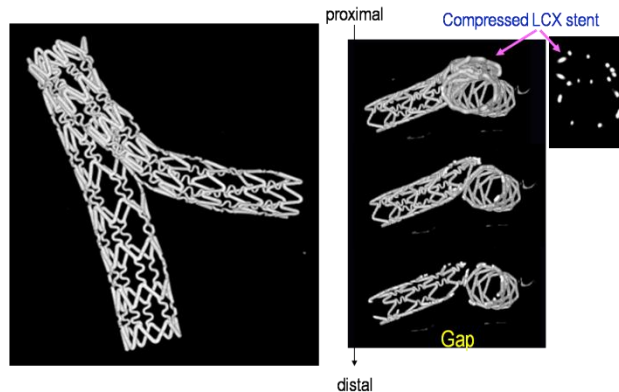


**Figure 4.** (A) Intravascular ultrasound image showing complete crush (apposition) of the side branch (SB) stent; **arrows** indicate the three layers of stent struts. (B, C) Intravascular ultrasound images showing incomplete crush (apposition) of the SB stent struts (**arrows**).

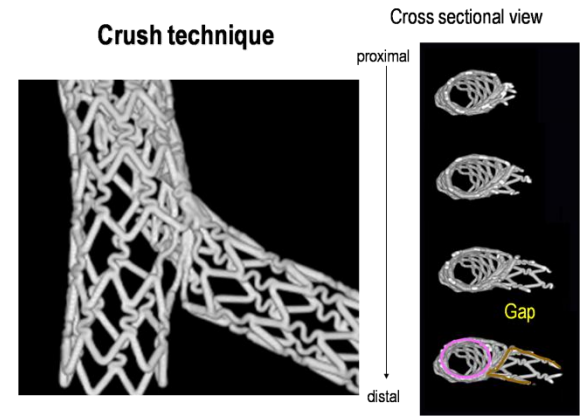
### Modified T-stenting



### Kissing stenting



### Crush technique



Courtesy of Dr. Murasato

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

- IVUS/FFR-guided intervention strategy for bifurcation lesion is feasible and helpful from the beginning till the end of the procedures.
- However, adequate knowledge on coronary anatomy/physiology and pitfalls of IVUS/FFR is essential to properly use IVUS/FFR in complex bifurcation lesion and in complex bifurcation PCI.

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