PCI for Bifurcations: Techniques and Outcomes

Fellows Workshop
June 2014

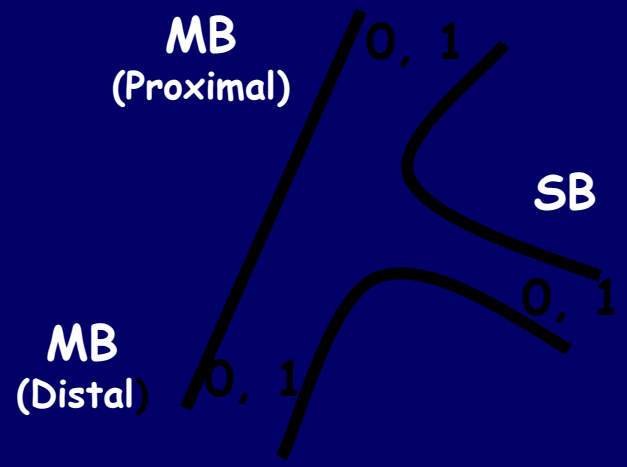
Chris Zambakides

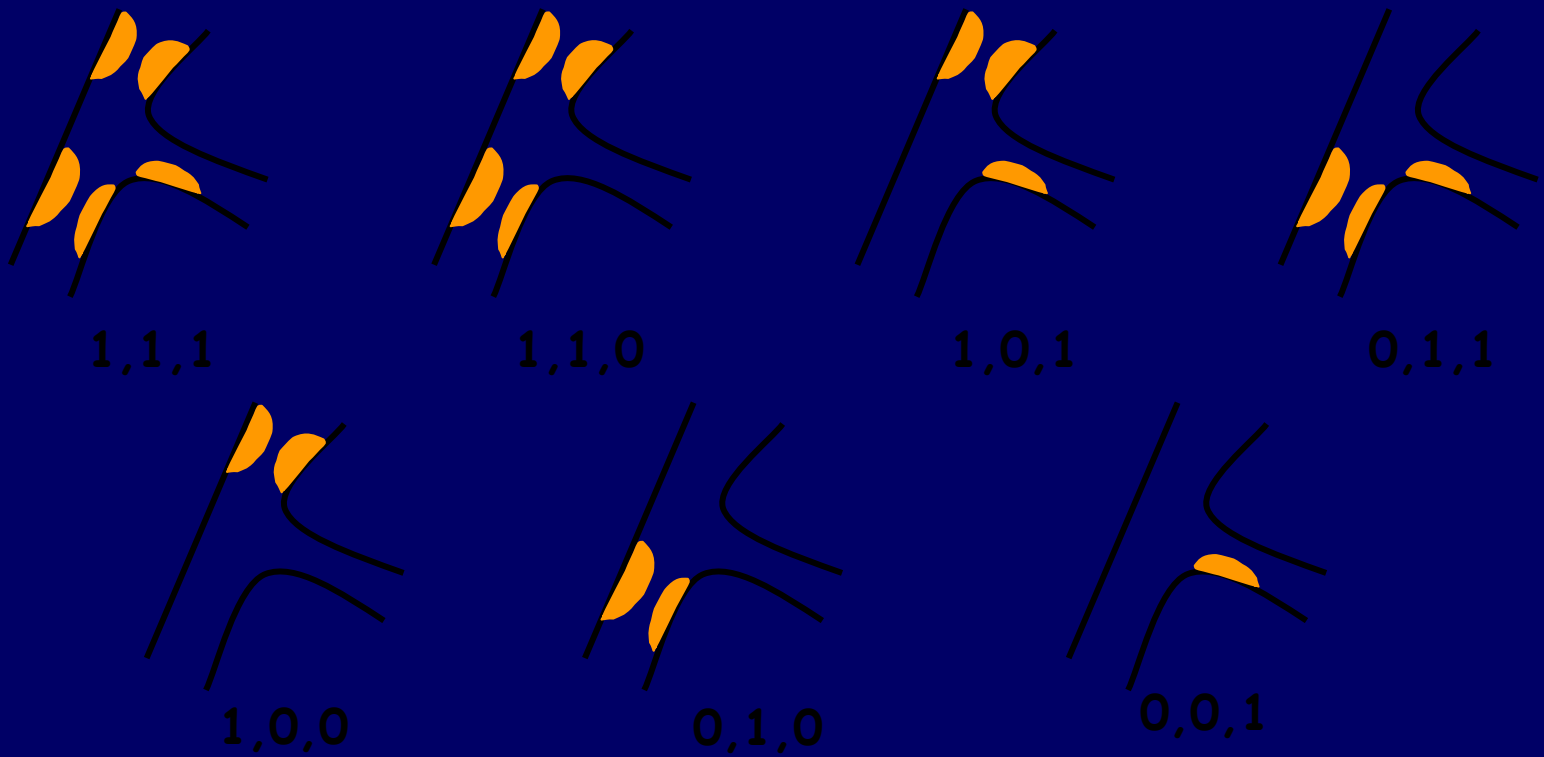
Bifurcation PCI

- Account for 15-20% of PCI
- Why an indivdualized approach?
  - Variations in Anatomy
    - Left main bifurcation disease
    - Plaque burden & location of plaque
    - Angle between MB and SB
  - Dynamic changes in anatomy during treatment
    - Plaque shift
    - Dissection

  No two bifurcations are identical
- An appropriate strategy from the outset saves time and minimizes complication

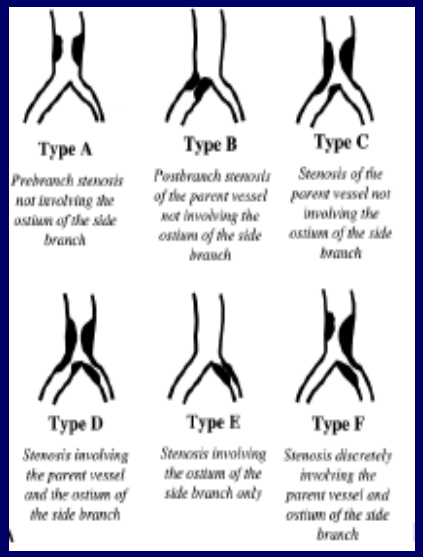
Medina Classification



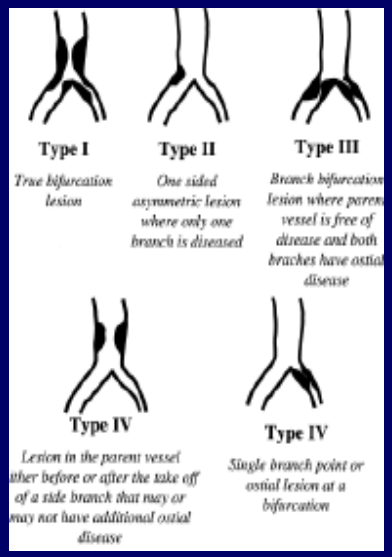


Medina et al. Rev. Esp. Cardiol 2006; 59(2): 183-4

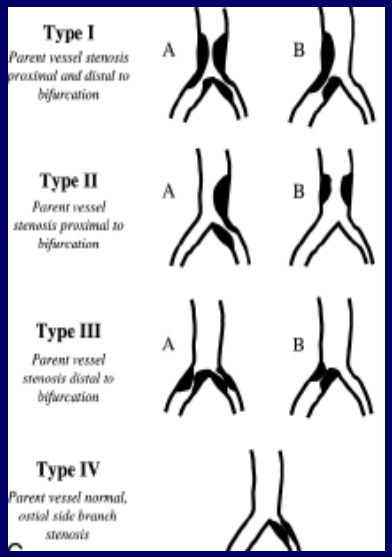
Classifications of lesions



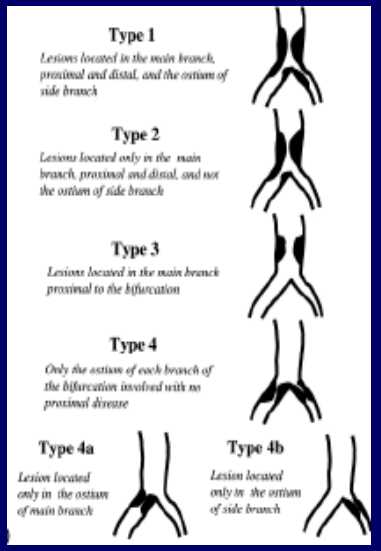
Duke



Sanborn

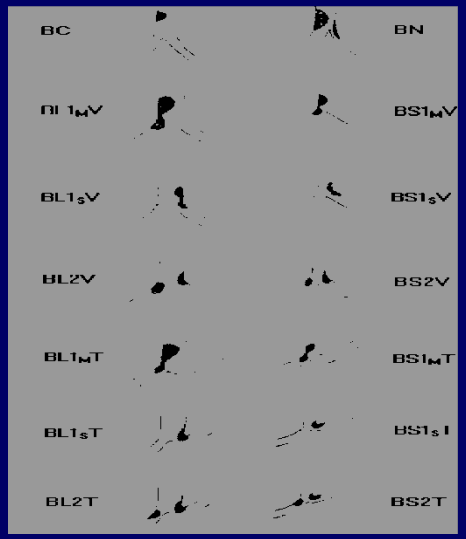


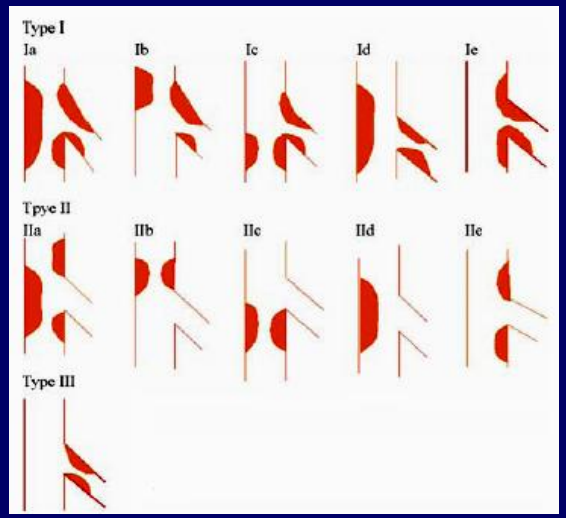
Safian



Icps-Lefevre

Movahed

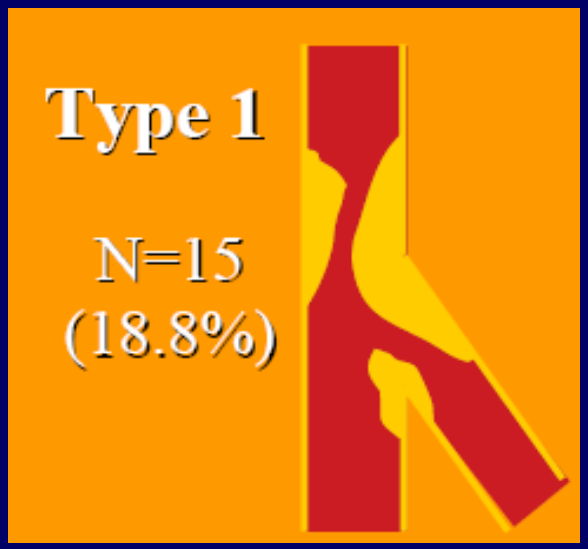


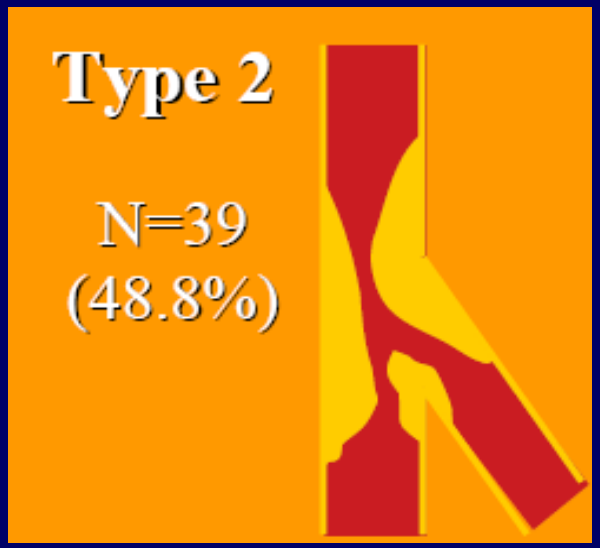


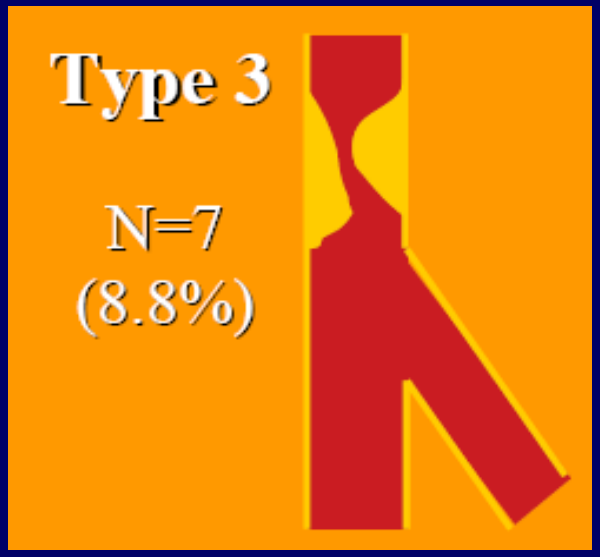
Chen - Gao

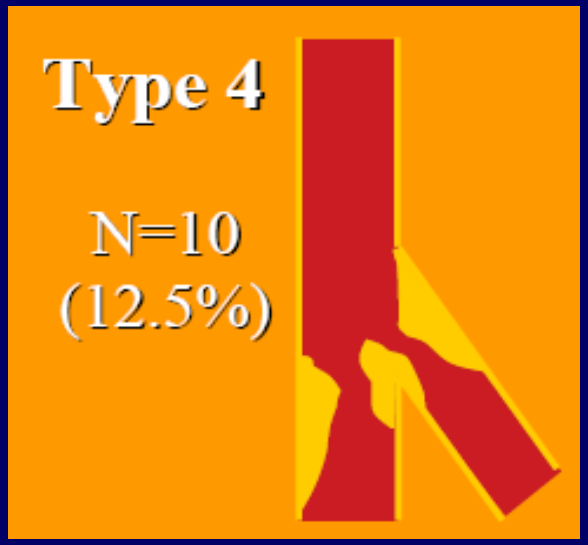
Bifurcation Stenting: Diverse Lesion Profile

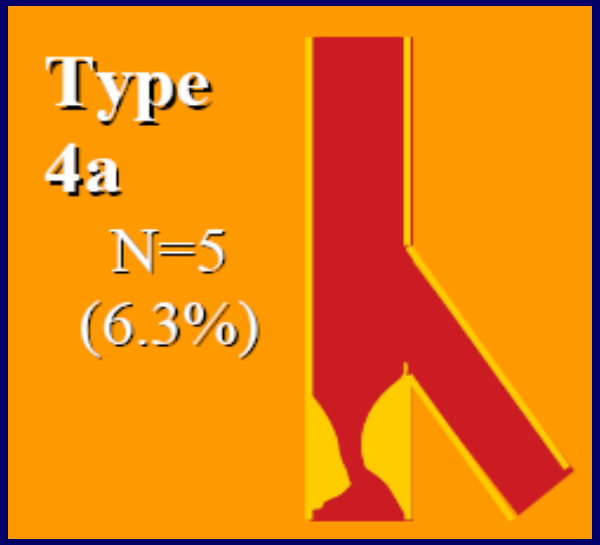
* Type 1 and 2 most difficult to treat comprise nearly 70% of lesions
* Only Type 3 Requires Single Stent

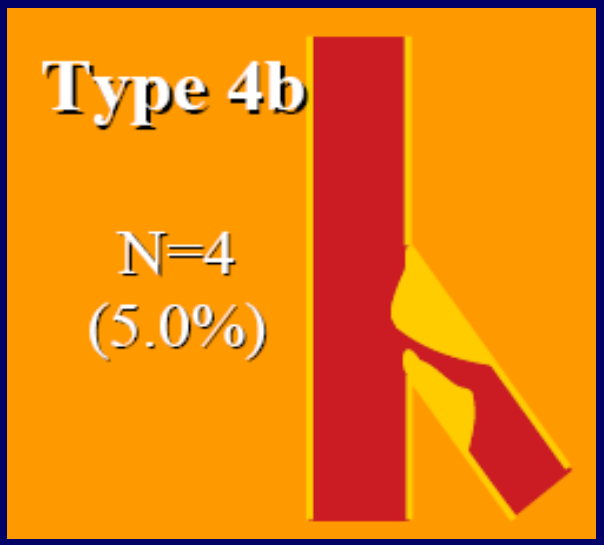












The Approach to Bifurcation PCI

- The provisional approach of implanting one stent in the MB should be the default approach in most bifurcations lesions
- The approach is dictated by the SB:
  - True vs. Non-true
  - Size of SB
  - Extent and distribution of disease in SB
  - How important the side branch is for that patient and for that specific anatomy
  - Angle from the main branch

Randomized Bifurcation Trials

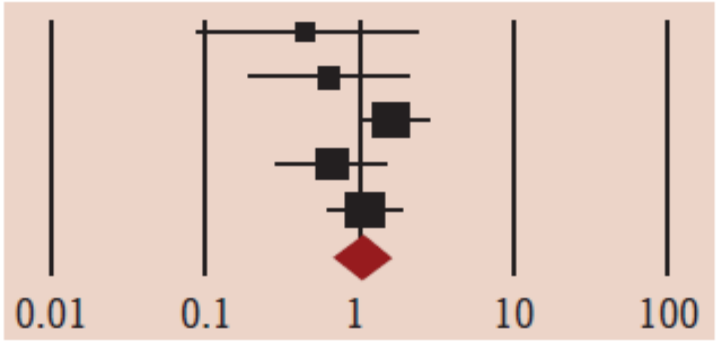
	Patients (N)	Randomization	Primary End Point	Outcome (Provisional vs Systematic Unless Otherwise Specified)
NORDIC	413	Provisional vs systematic (crush, culotte, T)	Death, MI (nonprocedural), TVR, or stent thrombosis at 6 mo	2.9% vs 3.4% (P=NS)
CACTUS	350	Provisional vs systematic (crush)	Death, MI, TVR at 6 mo	15% vs 15.8% (P=NS)
BBC ONE	500	Provisional vs systematic (crush, culotte)	Death, MI, TVF at 9 mo	8.0% vs 15.2% (P<0.05)
Ference et al.	202	Provisional vs systematic (T)	Death, MI, TVF at 9 moAngiographic restenosis (side branch) 9 mo	23.0% vs 27.7% (P=NS)
Colombo et al.	85	Provisional vs systematic (crush, T, culotte)	Angiographic restenosis (either branch) 6 mo	18.7% vs 28.0% (P=NS)
Pan et al.	91	Provisional vs systematic (T)	Angiographic restenosis (either branch) 6 mo	7% vs 25% (P=NS)
NORDIC 2	424	Systematic (crush vs culotte)	Death, MI (nonprocedural), TVR, or stent thrombosis at 6 mo	Crush 4.3% vs culotte 3.7% (P=NS)

Meta-Analysis - Bifurcations with DES
One (Provisional) vs Two Stents

Side Branch Restenosis
Angiographic outcome -> No difference

E **Side branch restenosis**

Study	Year	Events / Total: Provisional	Events / Total: Two stents	MH risk ratio and 95% CI	MH risk ratio	Lower limit	Upper limit
Pan et al	2004	2 / 47	4 / 44		0.47	0.09	2.43
Colombo et al	2004	3 / 21	12 / 55		0.65	0.21	2.09
NORDIC	2006	29 /151	18 / 156		1.66	0.97	2.87
Ferenc et al	2008	9 / 96	13 / 96		0.69	0.31	1.54
CACTUS	2009	22 / 150	20 / 152		1.11	0.64	1.96
Overall		65 / 465	67 / 503		1.09	0.79	1.51



Test for heterogeneity: Q=5.3, df=4, P=0.26 I^2=25%
Test for overall effect: Z=-0.53, P=0.60

Fixed Effects Model

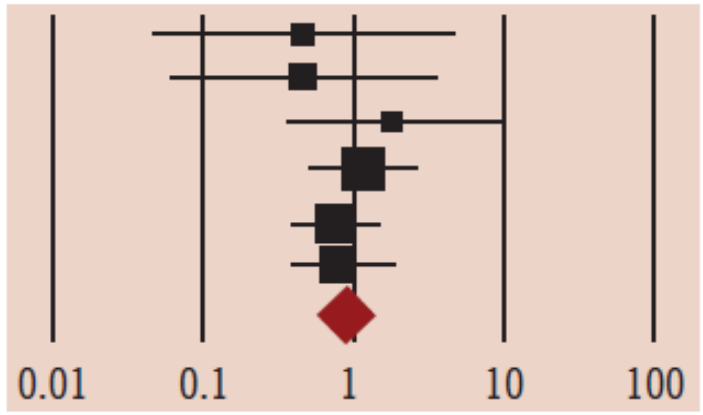
Brar SS et al. Eurointervention 2009;5:475:84

Meta-Analysis - Bifurcations with DES
One (Provisional) vs Two Stents

TLR

Clinical outcome -> No difference

Study	Year	Events / Total		MH risk ratio and 95% CI	Statistics for each study		
		Provisional	Two stents		MH risk ratio	Lower limit	Upper limit
Pan et al	2004	1 / 47	2 / 44		0.47	0.04	4.98
Colombo et al	2004	1 / 22	6 / 63		0.48	0.06	3.75
NORDIC	2006	4 / 207	2 / 206		1.99	0.37	10.75
Ferenc et al	2008	11 / 101	9 / 101		1.22	0.53	2.82
BBC ONE	2008	14 / 250	18 / 250		0.78	0.40	1.53
CACTUS	2009	11 / 173	13 / 177		0.87	0.40	1.88
Overall		42 / 800	50 / 841		0.91	0.61	1.35



Test for heterogeneity: Q=2.2, df=5, P=0.82 I^2=0%
Test for overall effect: Z=-0.49, P=0.63

Fixed Effects Model

Brar SS et al. Eurointervention 2009;5:475:84

Meta-Analysis - Bifurcations with DES

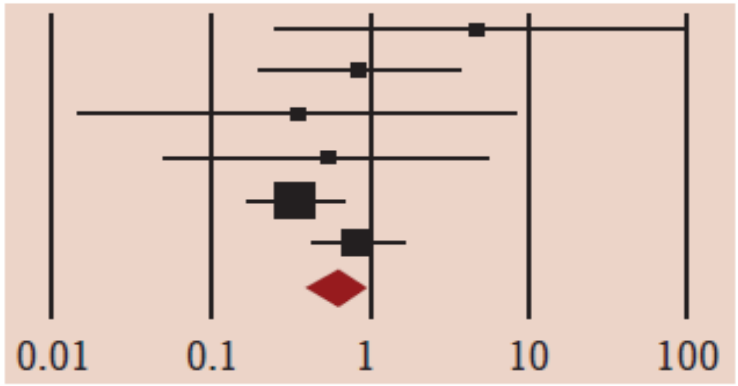
One (Provisional) vs Two Stents

Myocardial Infarction

Provisional -> Significantly lower

B **Myocardial infraction**

Study	Year	Events / Total		MH risk ratio and 95% CI	MH risk ratio	Lower limit	Upper limit
		Provisional	Two stents				
Pan et al	2004	2 / 47	0 / 44		4.69	0.23	95.00
Colombo et al	2004	2 / 22	7 / 63		0.82	0.18	3.65
NORDIC	2006	0 / 207	1 / 206		0.33	0.01	8.10
Ferenc et al	2008	1 / 101	2 / 101		0.50	0.05	5.43
BBC ONE	2008	9 / 250	28 / 250		0.32	0.15	0.67
CACTUS	2009	15 / 173	19 / 177		0.81	0.42	1.54
Overall		29 / 800	57 / 841		0.57	0.37	0.87



Test for heterogeneity: Q=5.72, df=5, P=0.33 I^2=13%
Test for overall effect: Z=-2.58, P=0.01

Fixed Effects Model

Brar SS et al. Eurointervention 2009;5:475:84

Meta-Analysis - Bifurcations with DES
One (Provisional) vs Two Stents

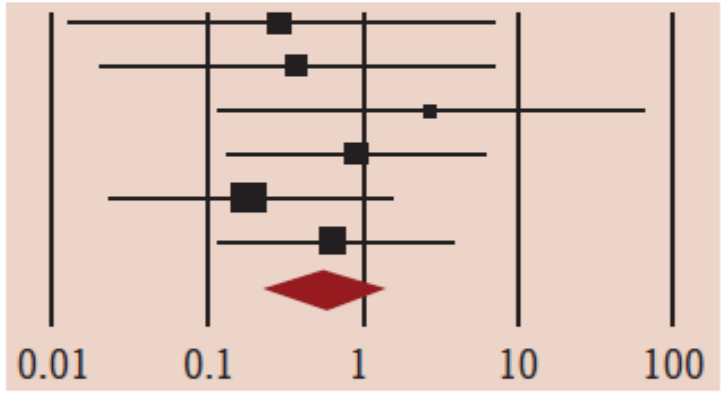
Stent Thrombosis

Provisional -> ”Trend” for lower

F

Stent thrombosis

Study	Year	Events / Total		MH risk ratio and 95% CI	MH risk ratio	Lower limit	Upper limit
		Provisional	Two stents				
Pan et al	2004	0 / 47	1 / 44		0.31	0.01	7.47
Colombo et al	2004	0 / 22	3 / 63		0.40	0.02	7.40
NORDIC	2006	1 / 207	0 / 206		2.99	0.12	72.87
Ferenc et al	2008	2 / 101	2 / 101		1.00	0.14	6.96
BBC ONE	2008	1 / 250	5 / 250		0.20	0.02	1.70
CACTUS	2009	2 / 173	3 / 177		0.68	0.12	4.03
Overall		6 / 800	14 / 841		0.56	0.23	1.35



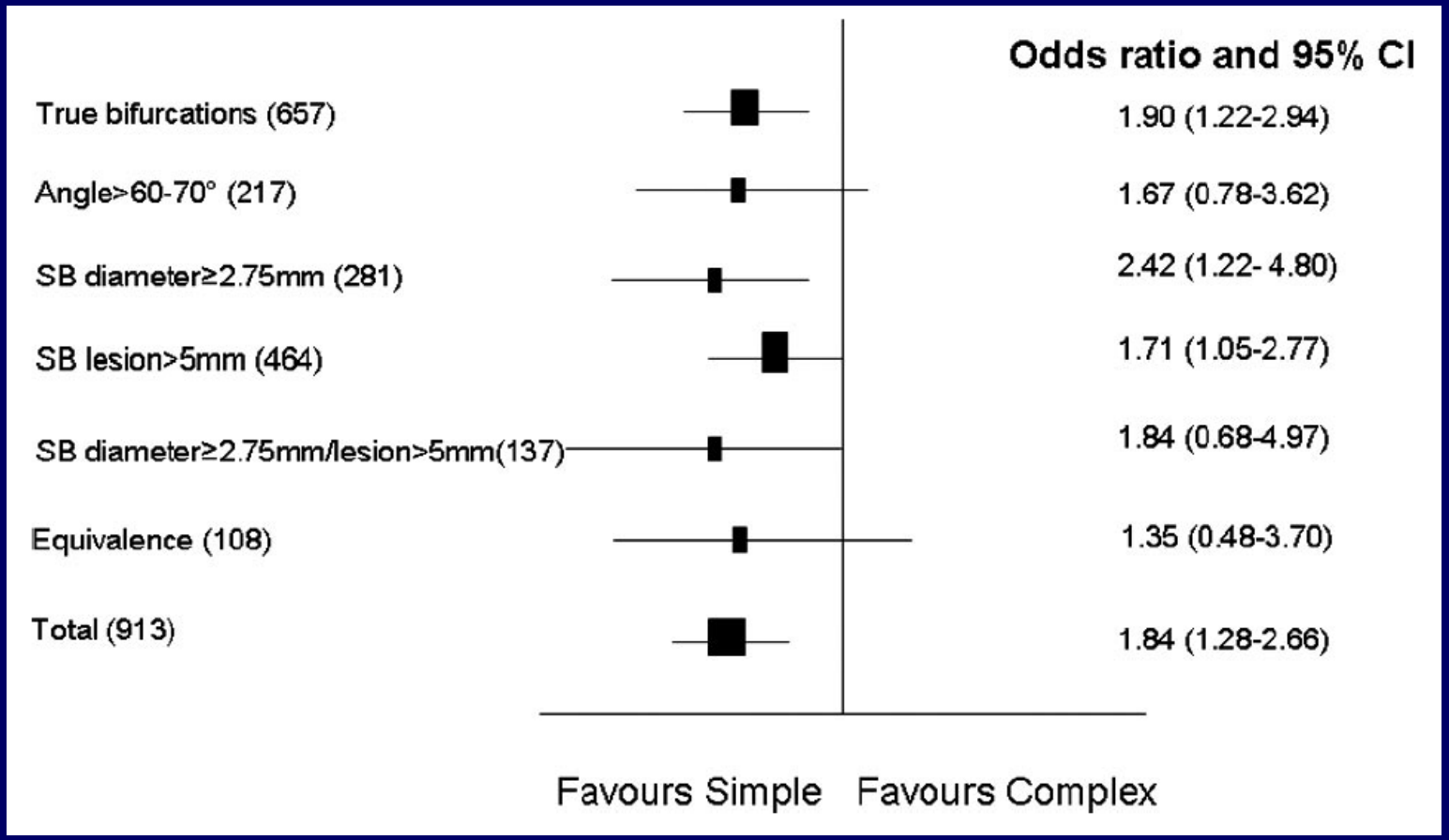
Test for heterogeneity: Q=2.2, df=3, P=0.52 I^2=0%
Test for overall effect: Z=-0.76, P=0.45

Fixed Effects Model

Brar SS et al. Eurointervention 2009;5:475:84

Patient-Level Pooled-Analysis of Nordic 1 and BBC

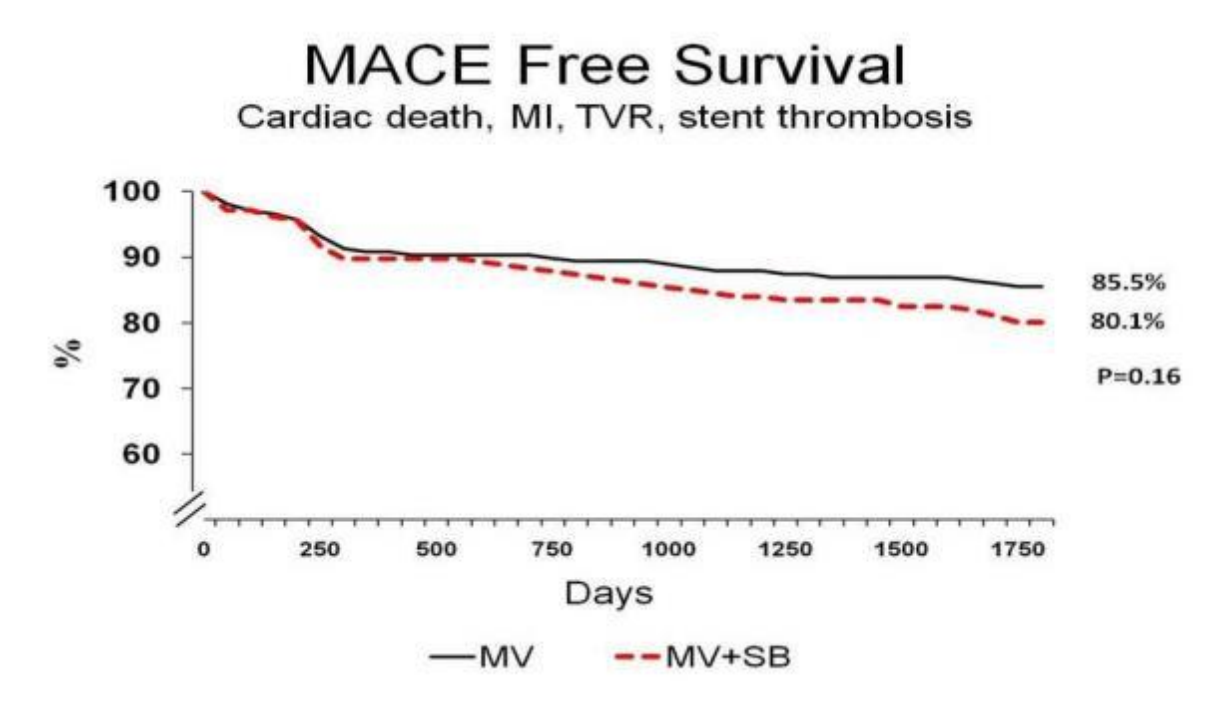
Primary outcome (death, MI, TVR) for individual subgroups



Behan et al. Circ Cardiovasc Interv. 2011;4:57-64

5 Year Follow-Up Nordic Bifurcation Study

Simple vs Complex Stenting Strategy in Non-LM PCI

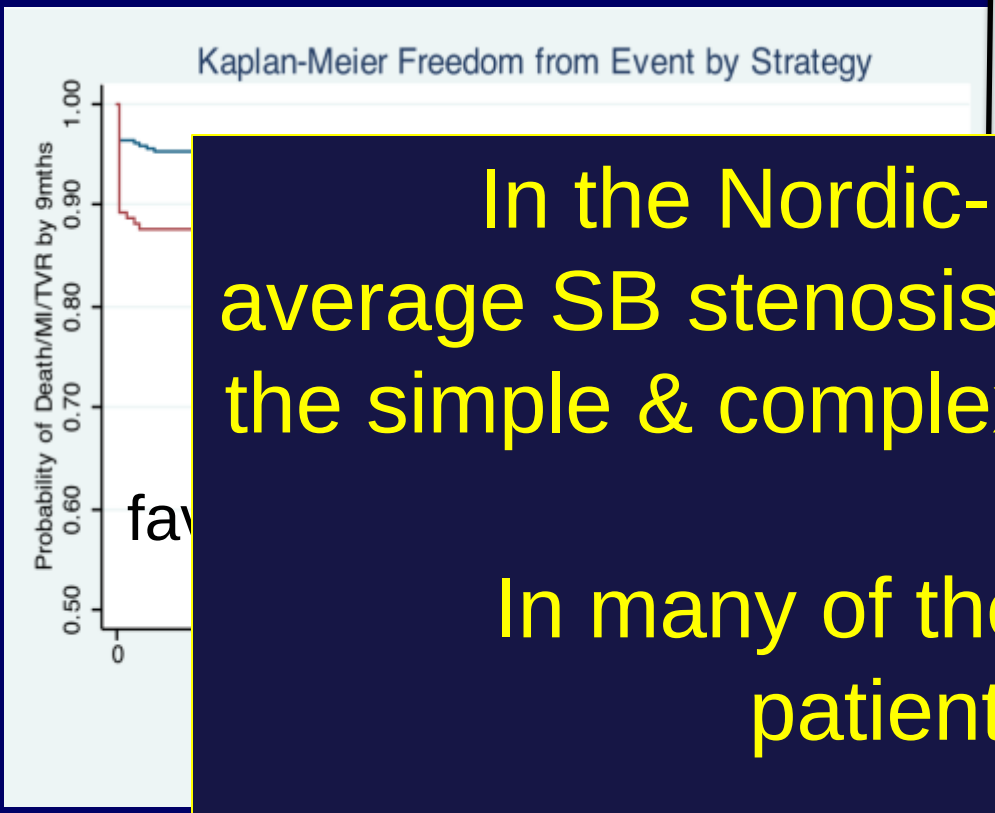


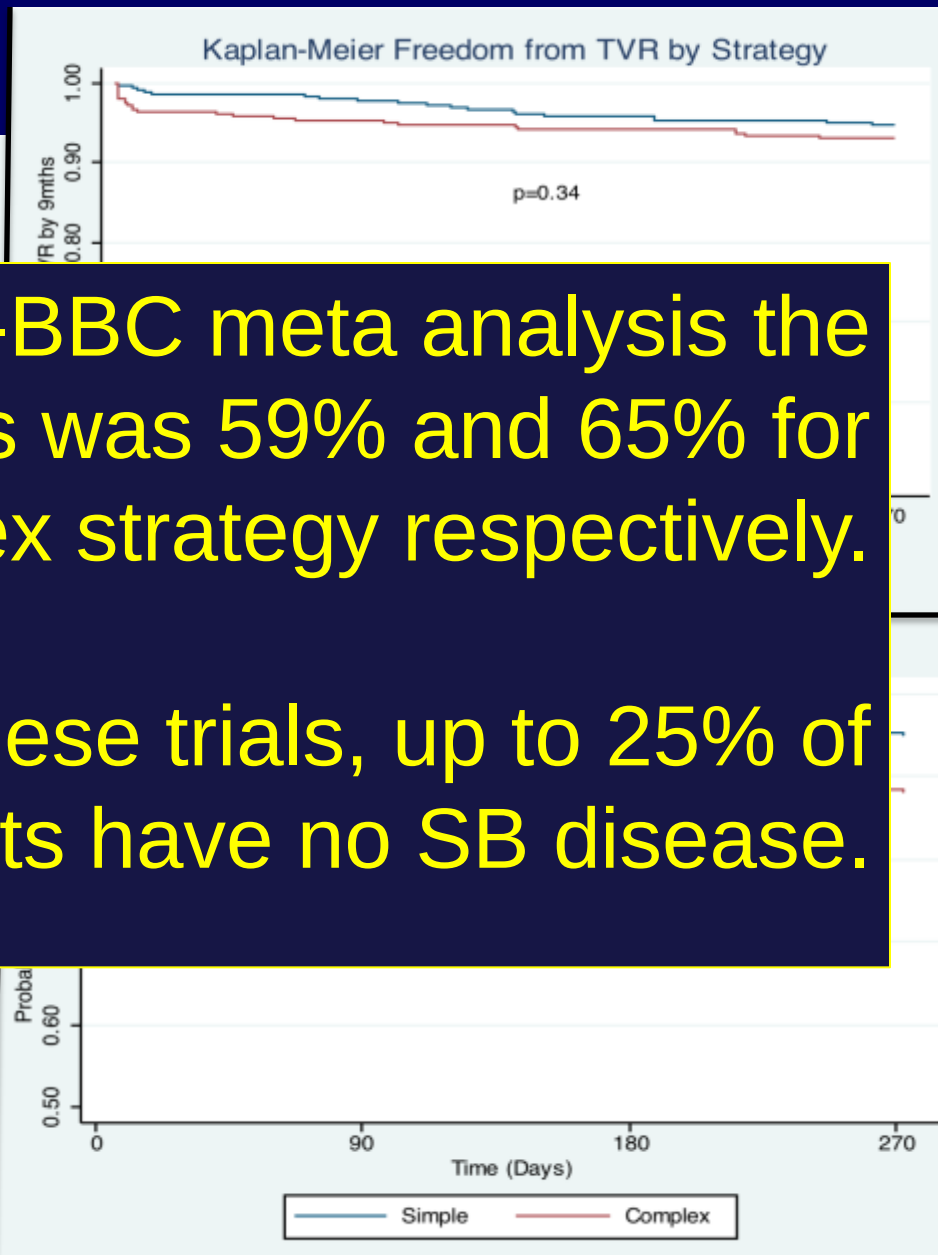
	MV (n=203)	MV+SB (n=202)	P-value
MV stented (%)	99.5	98.5	0.37
SB stented (%)	4.4	95.0	<0.0001
Kissing balloon (%)	32	74	<0.0001
Tx successful (%)	97	94	0.25

(Residual stenosis <30% of MV + TIMI flow III in SB)

- MACE event were low and did not differ significantly in patients treated with a simple versus a complex bifurcation stenting technique.
- Stent thrombosis rate was not increased in patients treated with 2-stents.

Meta-Analysis: NORDIC I & BBC I (Non LM Bifurcations)
Probability of MACE (Death/MI/TVR)





In the Nordic-BBC meta analysis the average SB stenosis was 59% and 65% for the simple & complex strategy respectively.

In many of these trials, up to 25% of patients have no SB disease.

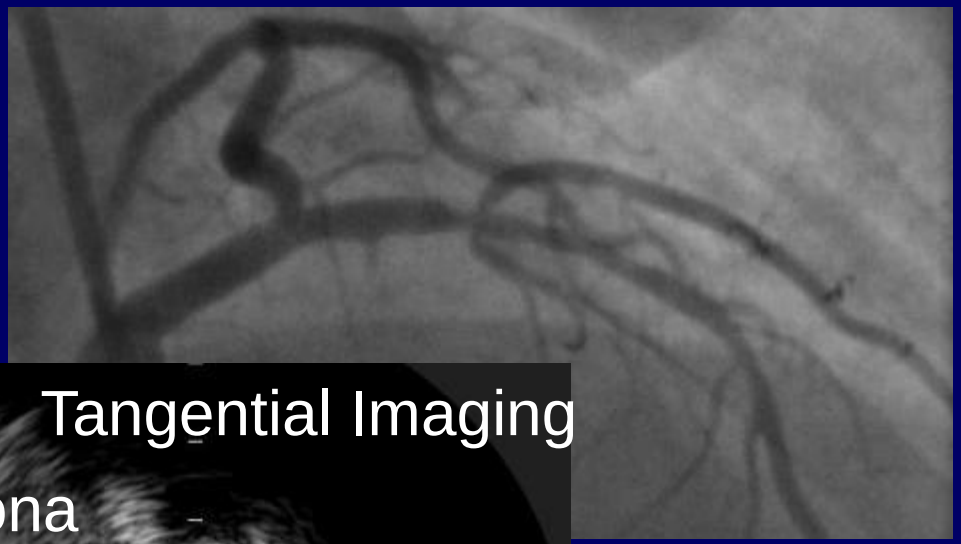
In non-LM bifurcation PCI multiple studies have demonstrated the superiority of IVUS guidance over angiographic guidance.

More durable long term outcomes.

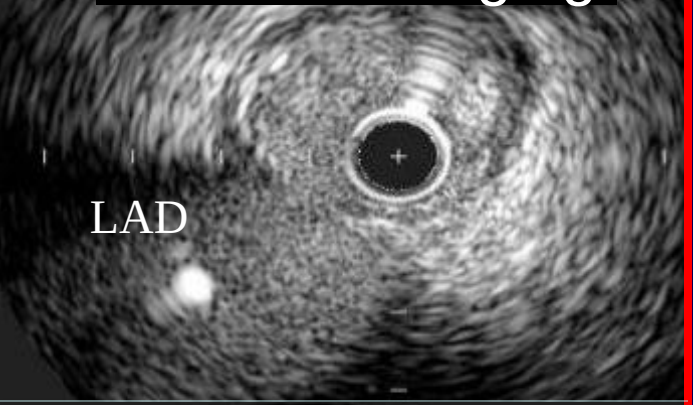
- Kim et al. Am Heart J 2011;161:180-7
  - Bifurcation lesions, propensity score matching (n=487 in each group)
- Kim et al. Am J Cardiol 2010;106:612-8
  - Bifurcation lesions, propensity score matching (n=303 / n=111)
- Patel et al. Am J Cardiol,
  - Bifurcation lesions, propensity score matching (n=247 / n=202)

An Important Principle of IVUS Imaging

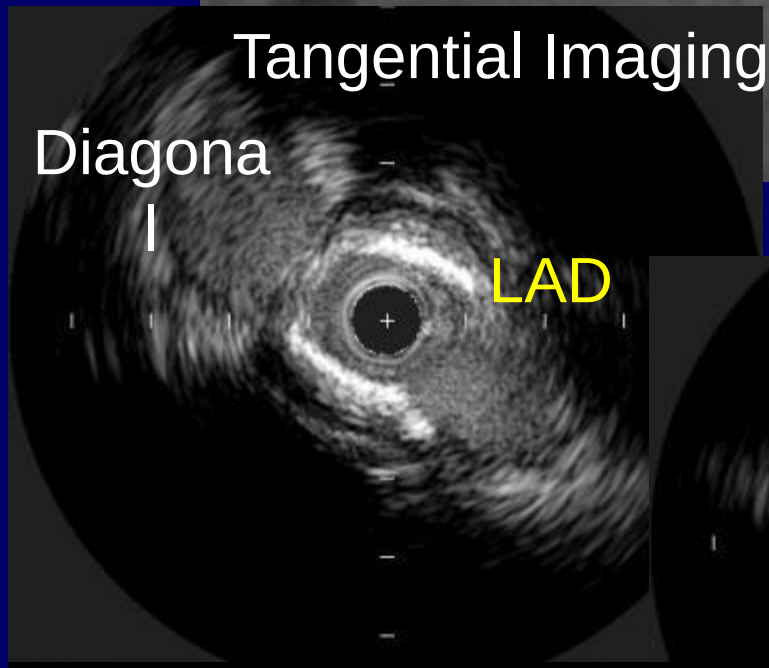
Direct Imaging of Both Parent & Daughter Vessel



Indirect LAD imaging



Tangential Imaging



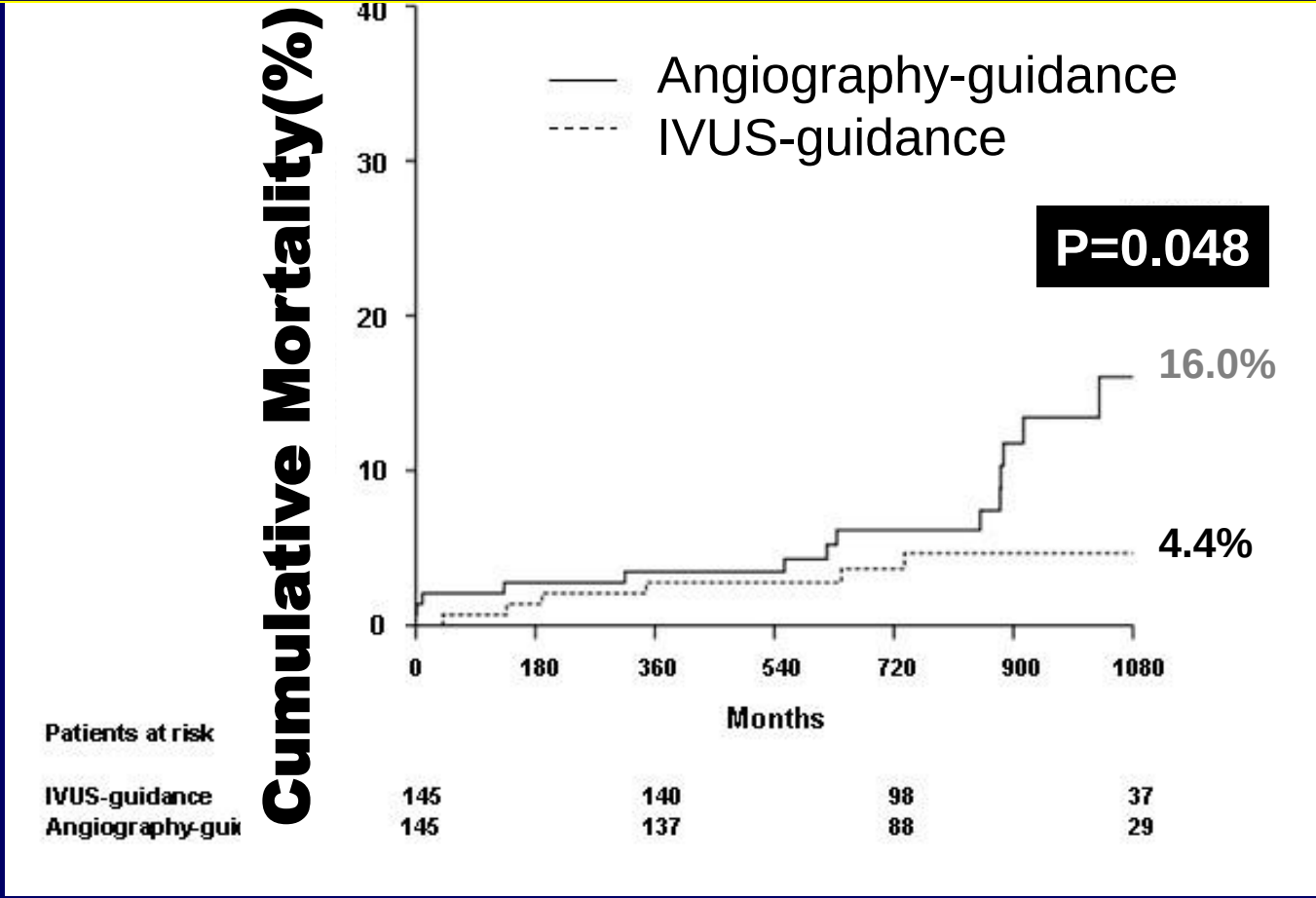
Direct Imaging

Direct LAD imaging

On indirect imaging the Diagonal branch appears disease free

IVUS Guidance Saves Lives in UPLM PCI

A finding yet to be convincingly demonstrated in Non-LM bifurcation PCI



Park SJ et al, Circulation. Cardiovasc Interv. 2009 Jun;2(3):167-77.

DK Crush Technique
Double Kiss and Crush

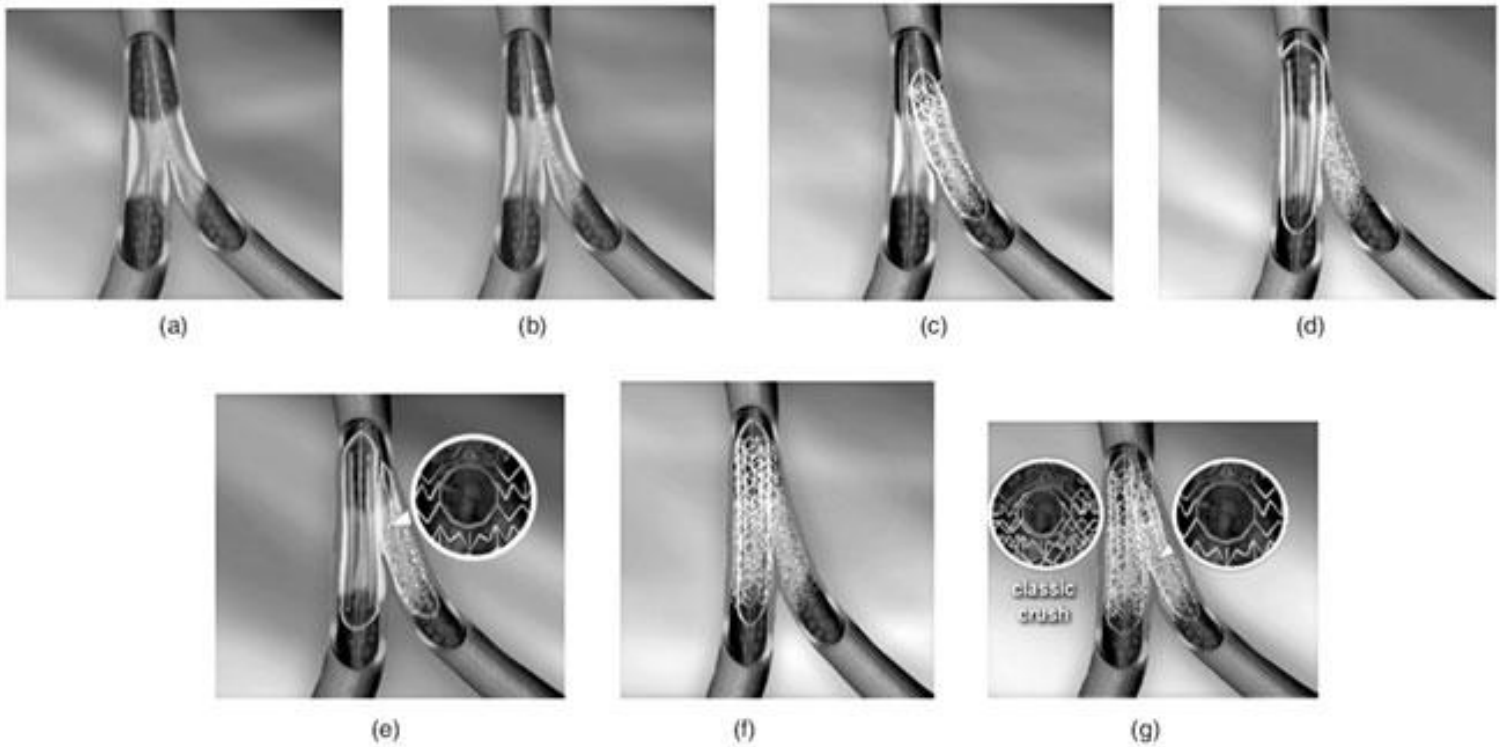


Figure 4. Double kissing (DK) crush technique. Two wires are inserted into two vessels (a). One stent and balloon are advanced into side branch and main vessel simultaneously (b). Inflated side stent firstly (c), then the balloon in the main artery is inflated after removal of stent balloon and wire from side branch (d). First kissing balloon inflation is performed after successful rewiring to side branch (e). Stenting main vessel is underwent (f), with final kissing inflation as the final step (g). The orifice of side branch is relatively largely expanded, compared to classical crush (g).

1 Year Outcomes DK Crush Versus Provisional Stenting

↓TLR and ↓TVR favoring DK Crush

↓ in MB and SB angiographic restenosis favoring DK Crush

Trend toward reduced MACE

Table 1. One-Year Outcomes

DK Crush in non-LM Bifurcation

	Double Kissing Crush	Provisional Stenting	*P* Value
MACE	10.3%	17.3%	0.070
Cardiac Death	1.1%	1.1%	1.000
MI	3.2%	2.2%	0.751
TVR	6.5%	14.6%	0.017
TLR	4.3%	13.0%	0.005
Definite Stent Thrombosis	2.2%	0.5%	0.372

(J Am Coll Cardiol 2011;57:914–20) © 2011 by the American College of Cardiology Foundation

DK CRUSH vs Cuolotte in UPLM

DK Crush in UPLM PCI

	DK Crush (n = 176)	Culotte (n = 174)	*P* Value
In-stent Restenosis	6.8%	12.6%	0.037
Diameter Stenosis	16.39 ± 7.45%	25.50 ± 7.36%	0.001
In-stent Late Loss, mm	0.20 ± 0.30	0.39 ± 0.36	0.001

At 1 year, the primary endpoint of MACE (cardiac death, MI, and TVR) was more than halved in the DK crush group, driven mainly by a reduction in TVR. TLR was also decreased in the DK crush group (table 2).

Table 2. One-year Outcomes

	DK Crush (n = 210)	Culotte (n = 209)	*P* Value
MACE	6.2%	16.3%	0.001
Cardiac Death	1.0%	1.0%	1.0
MI	3.3%	5.3%	0.377

ACC 2013

The DKCRUSH studies: An Overview

	DKCRUSH-1	DKCRUSH-II	DKCRUSH-III
Lesion types	111/011/101	111/011	111/011
Techniques DES	DK/crush PES	DK/provisional SES	DK/culotte SES
Locations	all	all	LM
SB diameter	2.0 mm	>2.5 mm	LCX
lesion length	10.2 mm	11.3 mm	16.9 mm
MI (not acute)	✓	✓	✓
CTO	✓	✓	✓
No. patients	312	370	420
Endpoint	MACE 8-m	MACE 12-m	MACE 12-m

c/o S. Chen, from EJCI, JACC, JACC

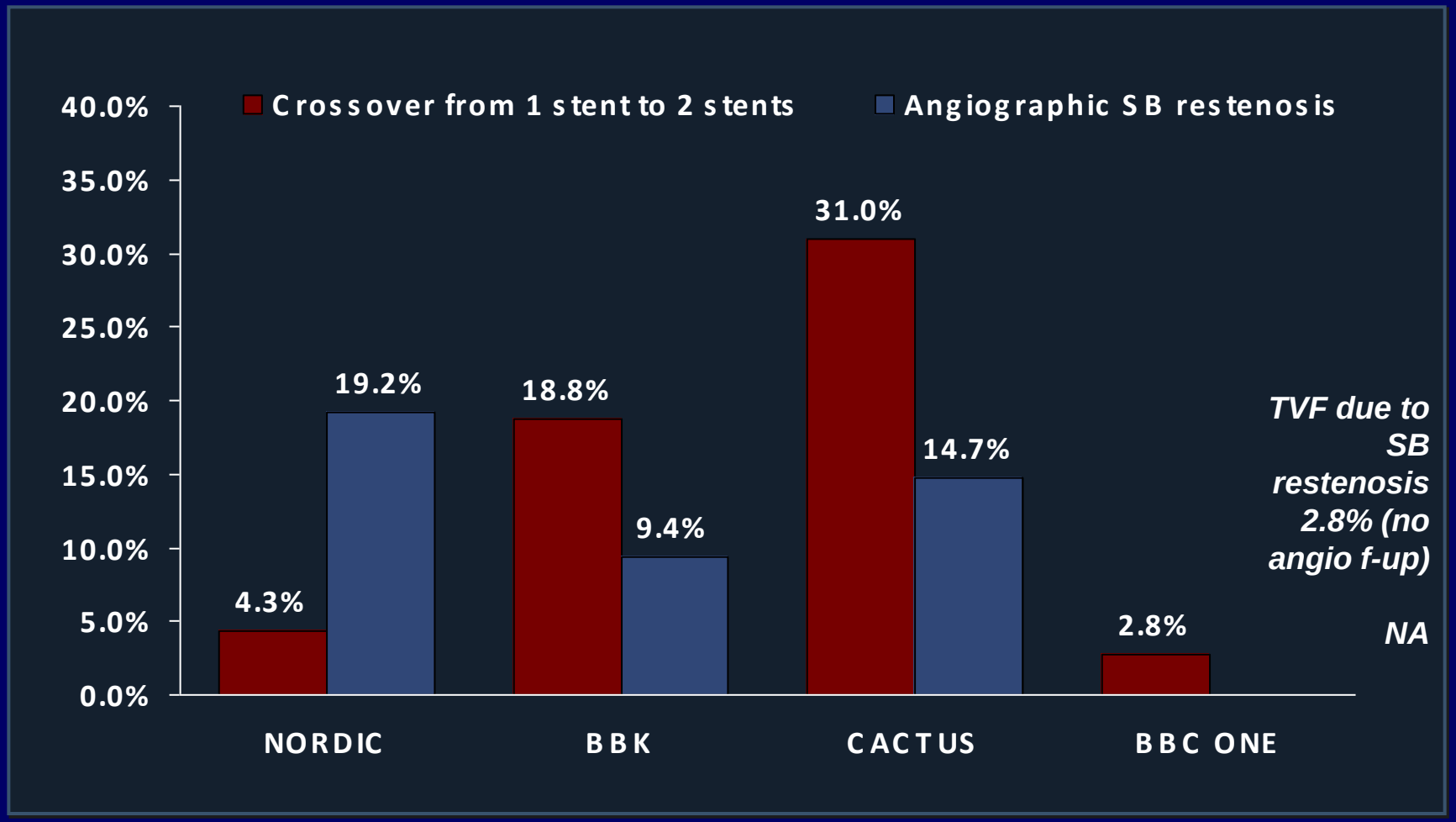
DKCRUSH studies:
Angiographic/Procedural Characteristics

	DKCRUSH-1 Crush vs DK	DKCRUSH-II PT vs DK	DKCRUSH-III Culotte vs DK
RVD-MV,mm	2.6±0.41	2.8±0.50	3.20±0.52
RVD-SB,mm	2.30±0.33	2.32±0.45	2.83±0.46
DS-SB, %	61.7±5.1	63.2±9.4	64.6±7.9
No. stent in SB	1.15±0.2	1.24±0.31	1.29±0.30
FKBI, %	76 vs 100	79.5* vs 100	99.5 vs. 99.5
Proc. Time (min)	35 vs 47	37 vs 38	55 vs 57

c/o S. Chen, from EJCI, JACC, JACC

How Often We Need 2nd Stent after MV Stent?

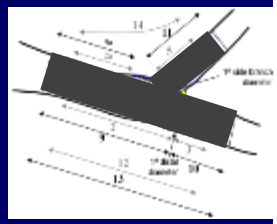
Crossover from 1 Stent to 2 Stents

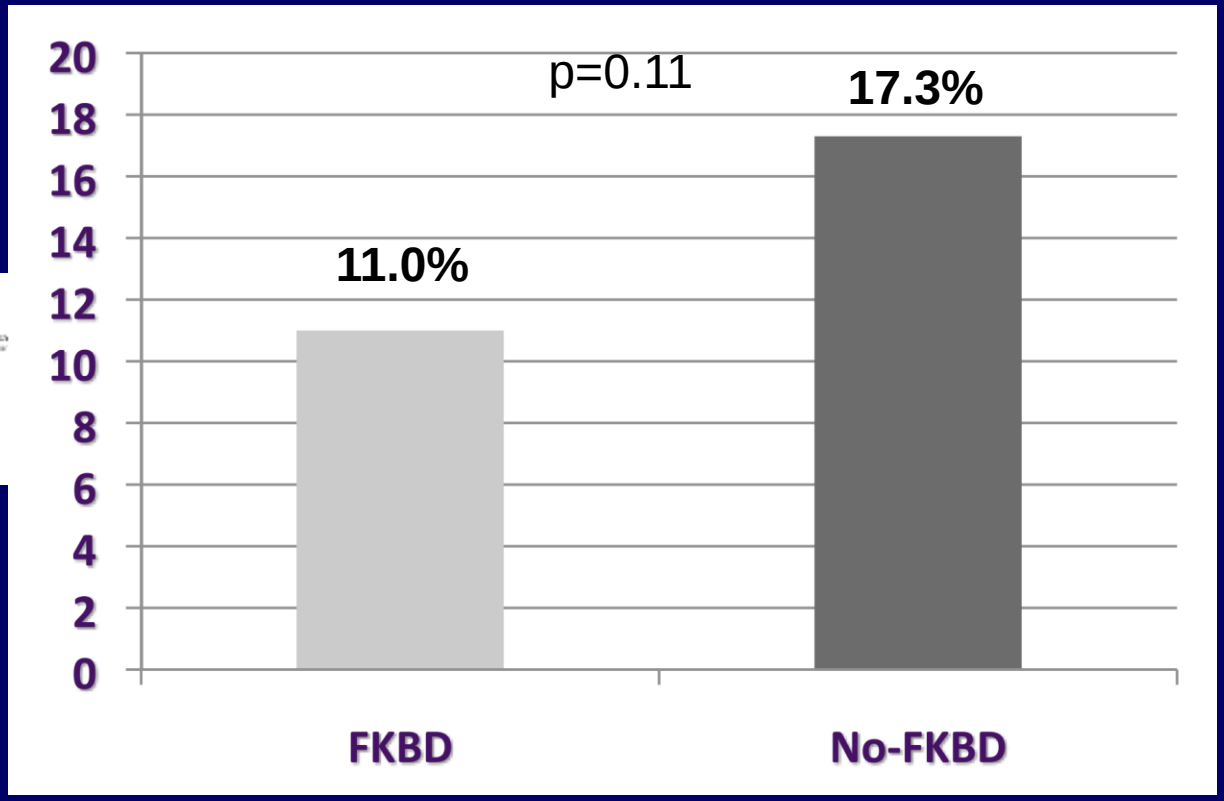


Steigen TK et al. *Circulation*. 2006;114:1955-1961 Ferenc M et al. *Eur Heart J* 2008; 29: 2859–2867 Colombo A et al. *Circulation*. 2009;119:71–78 Hildick-Smith D et al. *Circulation*. 2010;121:1235-1243

Nordic-Baltic Bifurcation Study III

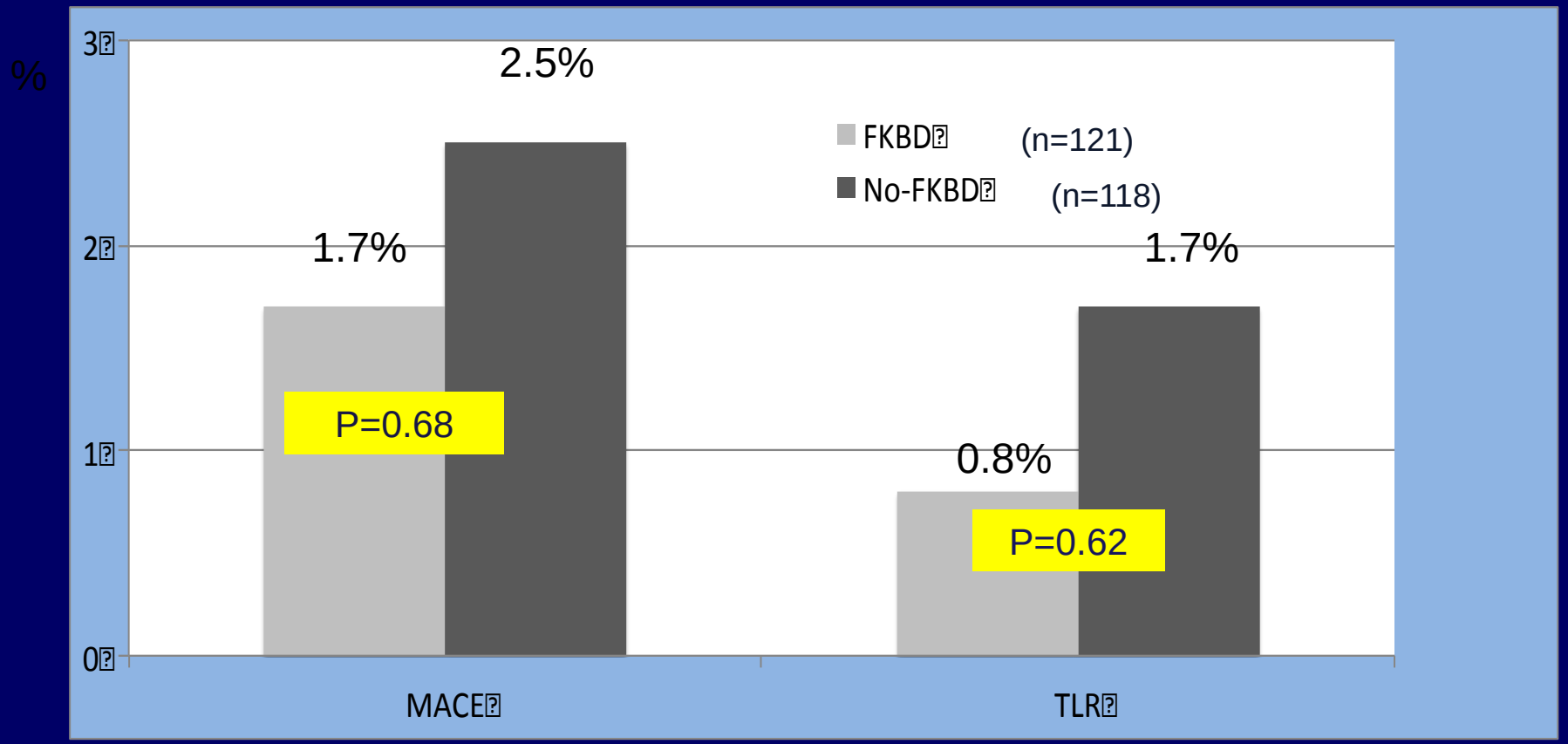
(Re)stenosis at 8-months QCA: Entire bifurcation lesion



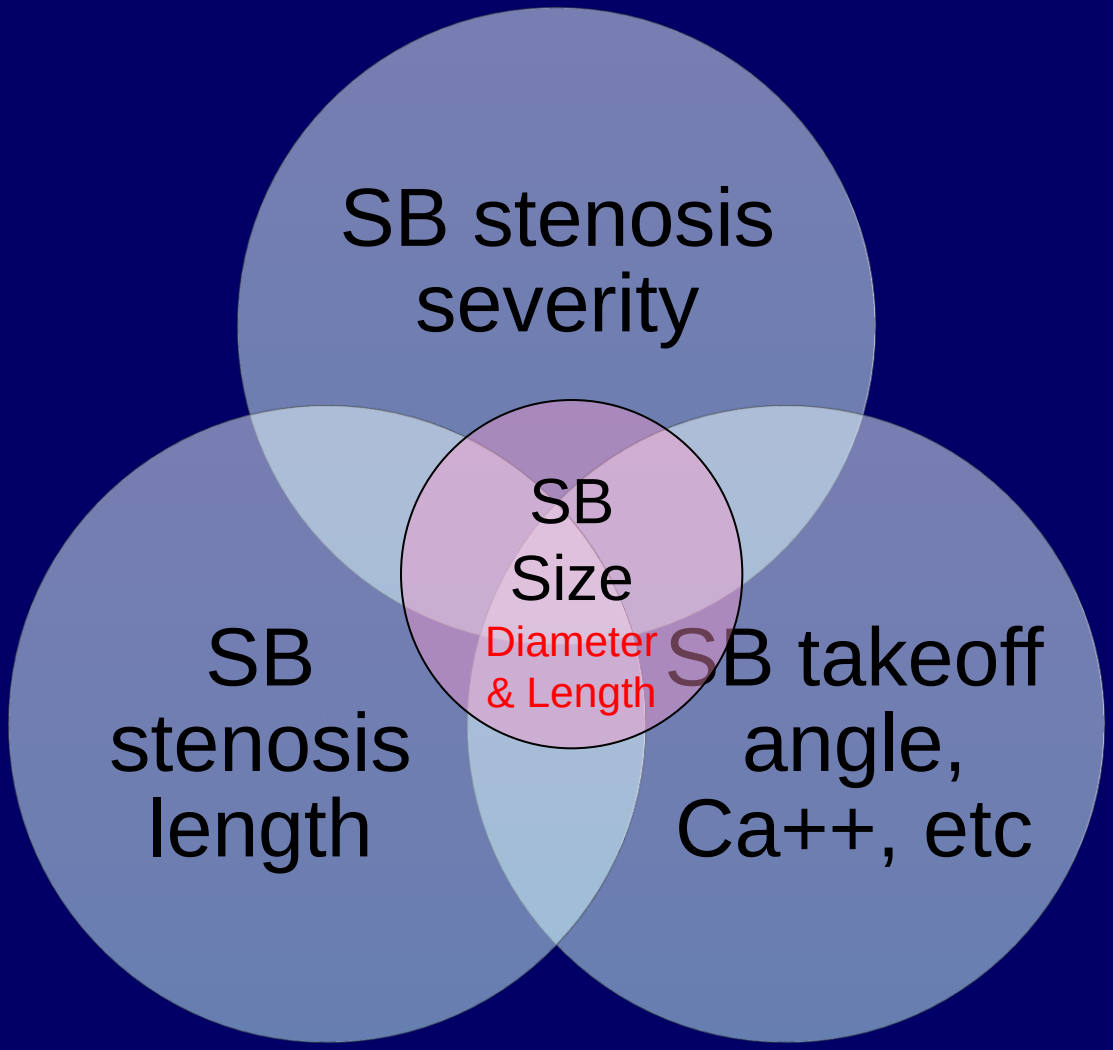


Binary Restenosis: ≥50% diameter stenosis at follow-up

True bifurcation subgroup
MACE and TLR at 6 month clinical FU



What is a “Complex Bifurcation”?



Provisional Stenting Technique

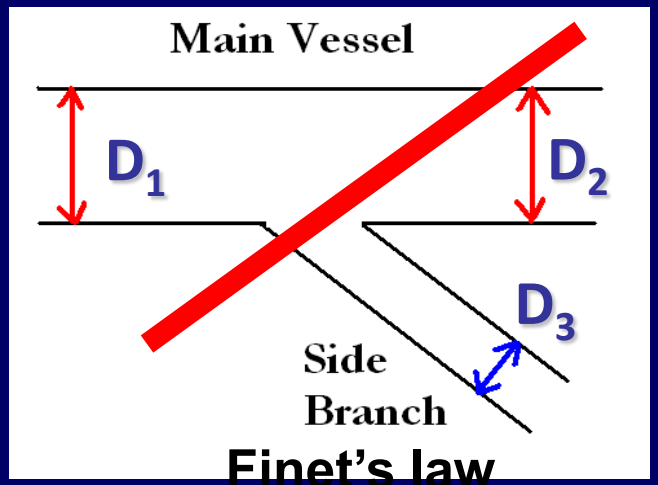
Why wire both branches in Provisional Stenting

- Protects SB from closure due to plaque shift and/or stent struts during MB stenting
- Jailed SB wire facilitates re-wiring of the SB:
  - widening the angle between the MB and SB
  - by acting as a marker for the SB ostium if SB occludes
  - changing the angle of SB take-off
- In the Tulipe multicenter study, absence of this jailed wire was associated with a higher rate of re-interventions (OR:4.26; 1.27–14.35) during follow-up
- CAUTION WHEN REMOVING JAILED WIRES!

Why Protect SB's from Closure?

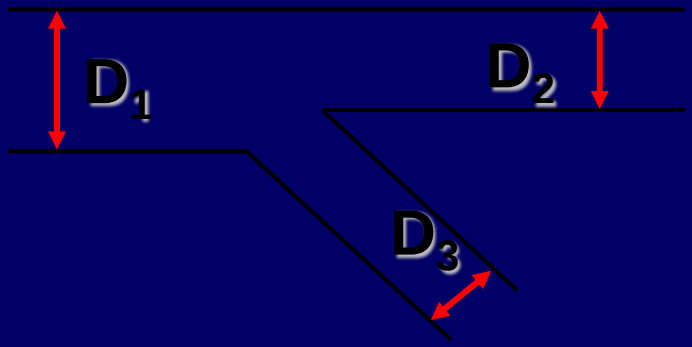
- Occlusion of SB's >1mm associated with 14% incidence of myocardial infarction
  - Arora RR et al. *Cathet Cardiovasc Diagn* 1989;18:210-2
- SB closure associated with large periprocedural MI
  - Chaudhry EC et al. *J Thromb Thrombolysis* 2007

Murray's law



Finet's law

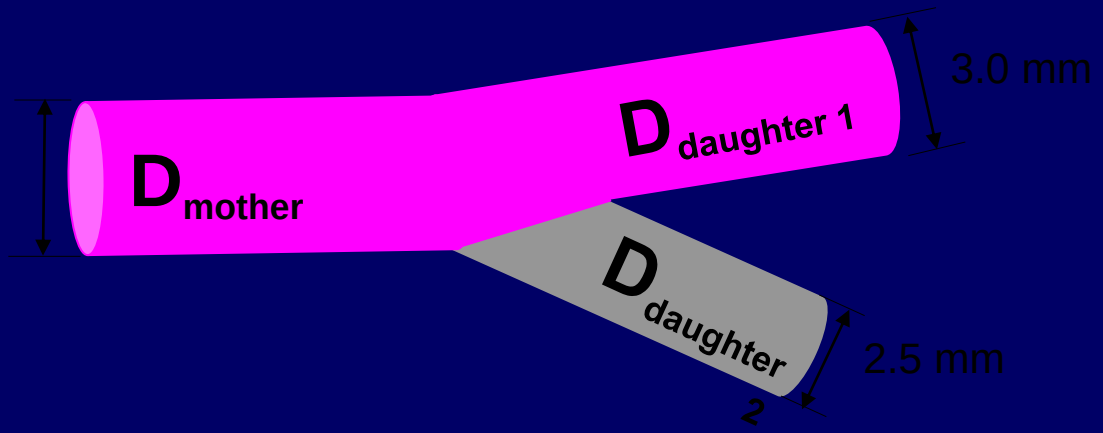
$D_1 = 0.678\ (D_2 + D_3)$



$D_1^3 = D_2^3 + D_3^3$

(Murray's law)

3.68 = 0.67 * (3.0 + 2.5)

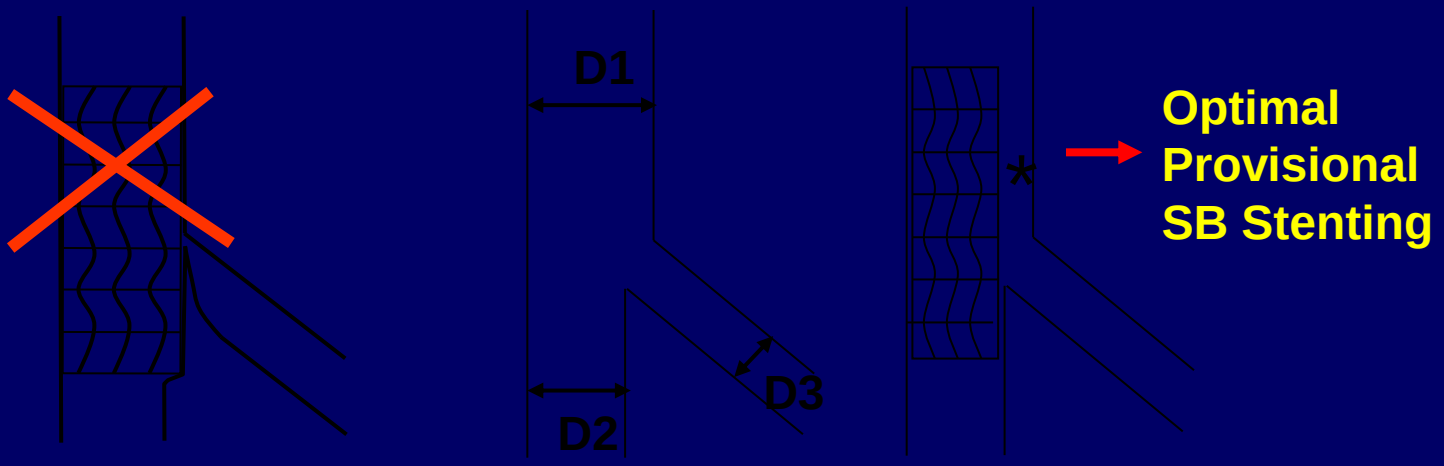


$D_{mother} = 0.67 * (D_{daughter\ 1} + D_{daughter\ 2})$

Insights from the 2nd meeting of the EBC. EuroIntervention 2007;3:44

Finet, G et al. EuroIntervention 2008; 3(4): 490-8.

The 3 Diameter Rule



D1 = 0.67 * (D2 + D3)

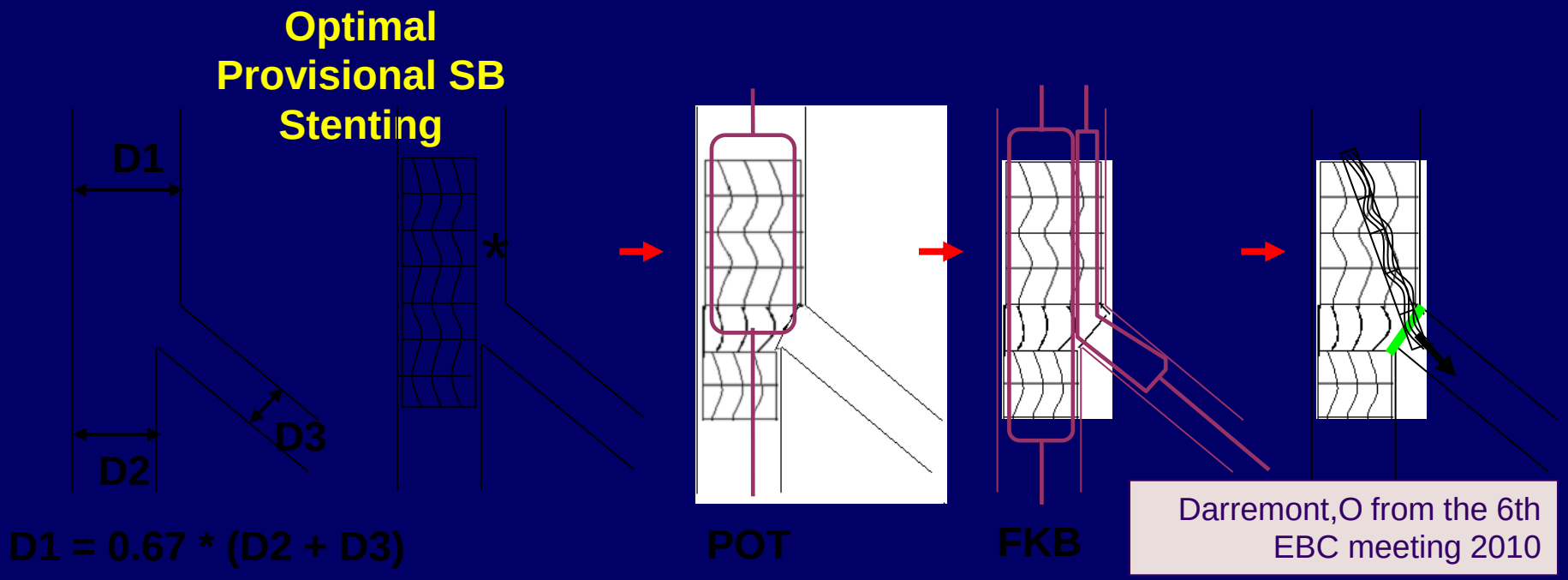
Recommendations:

- **In single stent techniques, the primary stent should be sized according to the <u>distal main vessel diameter</u>**
- **Postdilatation (POT), or kissing balloon inflations (FKB), are required to optimise the proximal main vessel stent diameter**

Insights from the 4nd meeting of the EBC. EuroIntervention 2009;5:39-49

Consensus from 5th EBC meeting. EuroIntervention 2010;6(1):34-8

Proximal Optimisation Technique (POT)

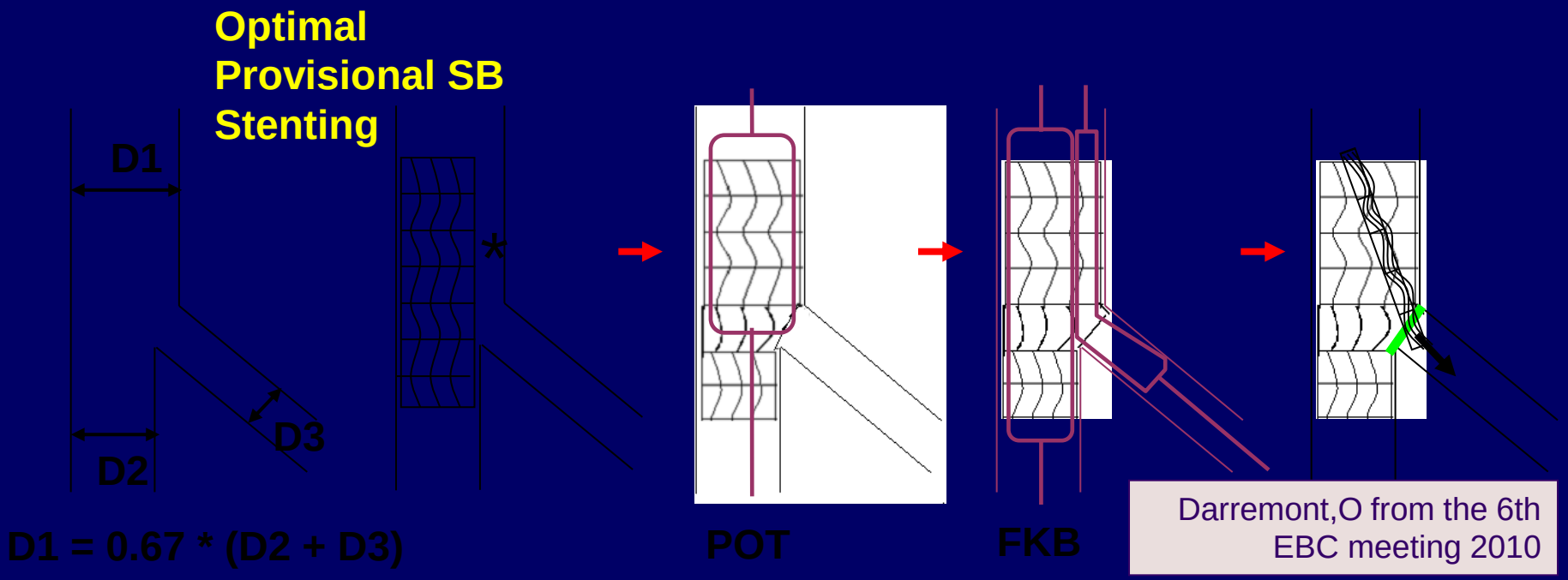


- Expansion of the stent at the carina, using a short oversized balloon
- Produces curved expansion of the stent into the bifurcation point and facilitates recrossing, distal recrossing, kissing inflations and ostial stent coverage of the side branch

First Recommendation: the **POT** technique **should be used in any case of difficulty recrossing into a side branch**

Consensus from 5th EBC meeting. EuroIntervention 2010;6(1):34-8

Proximal Optimisation Technique (POT)

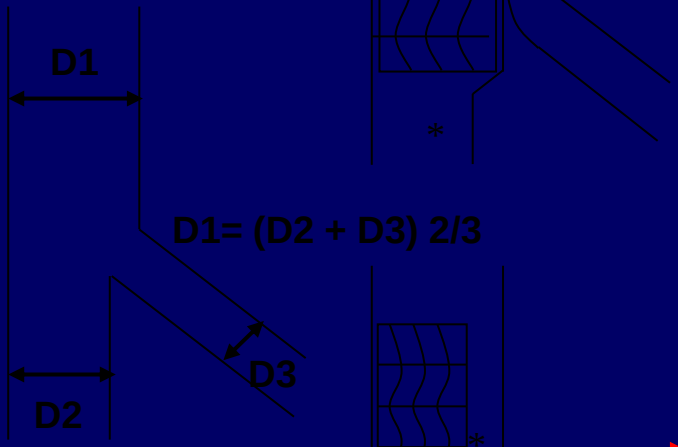


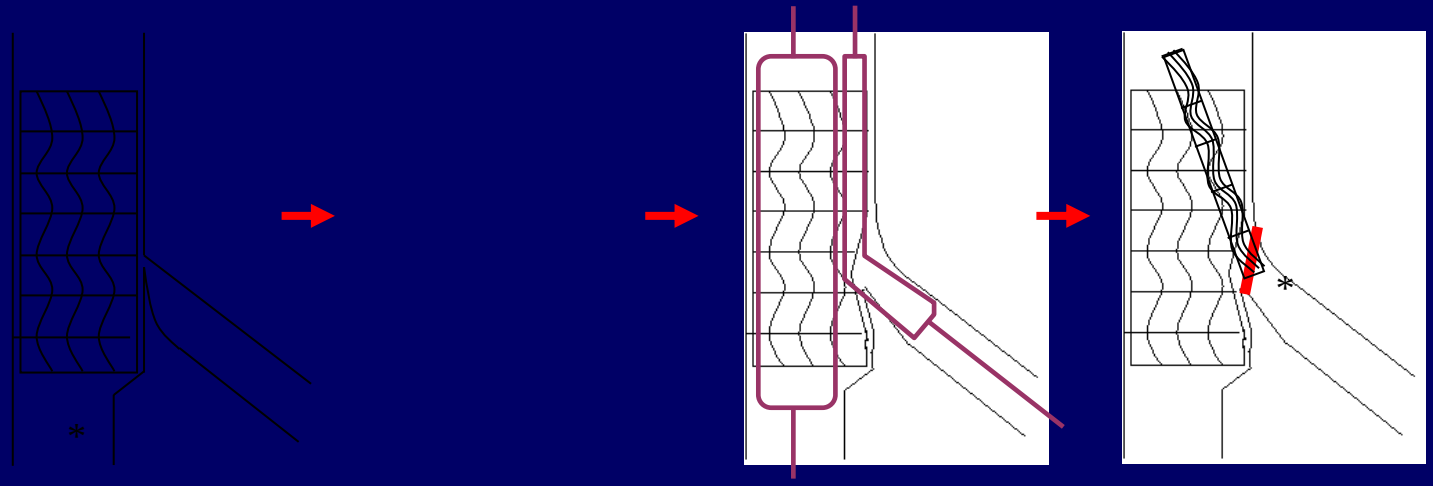
Second Recommendation:

- **When using a single stent technique (in the absence of kissing balloon inflations) the proximal main vessel stent should be postdilated (POT) to an appropriate diameter**

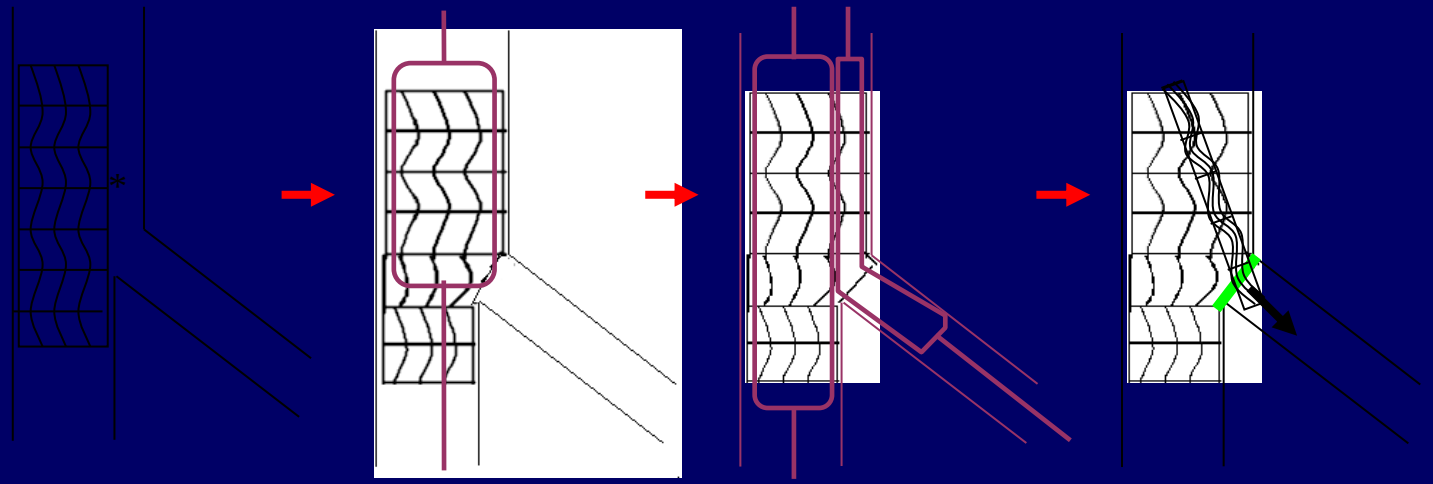
Consensus from 5th EBC meeting. EuroIntervention 2010;6(1):34-8

Stent diameter = PM diameter





Stent diameter = DM diameter

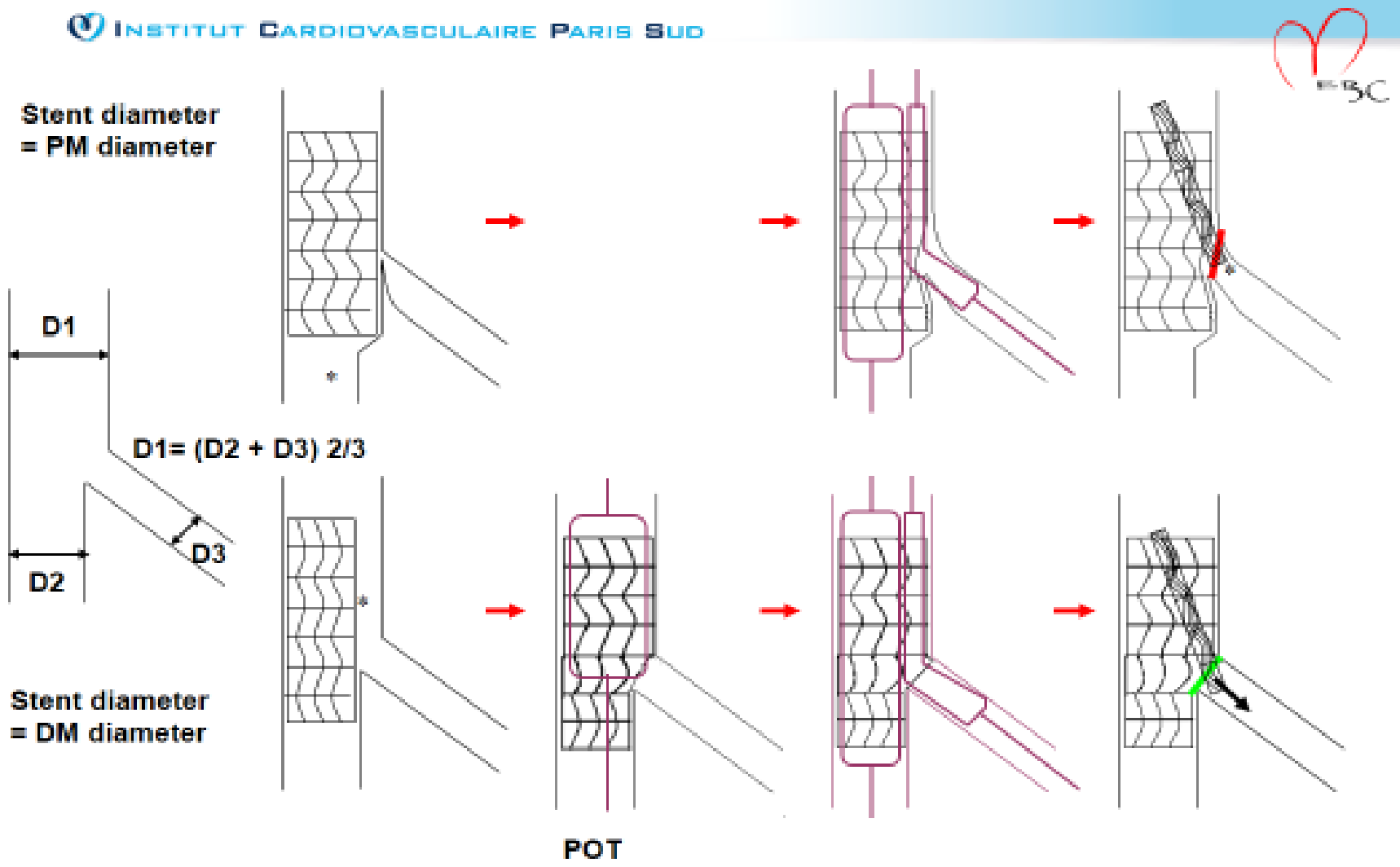


POT

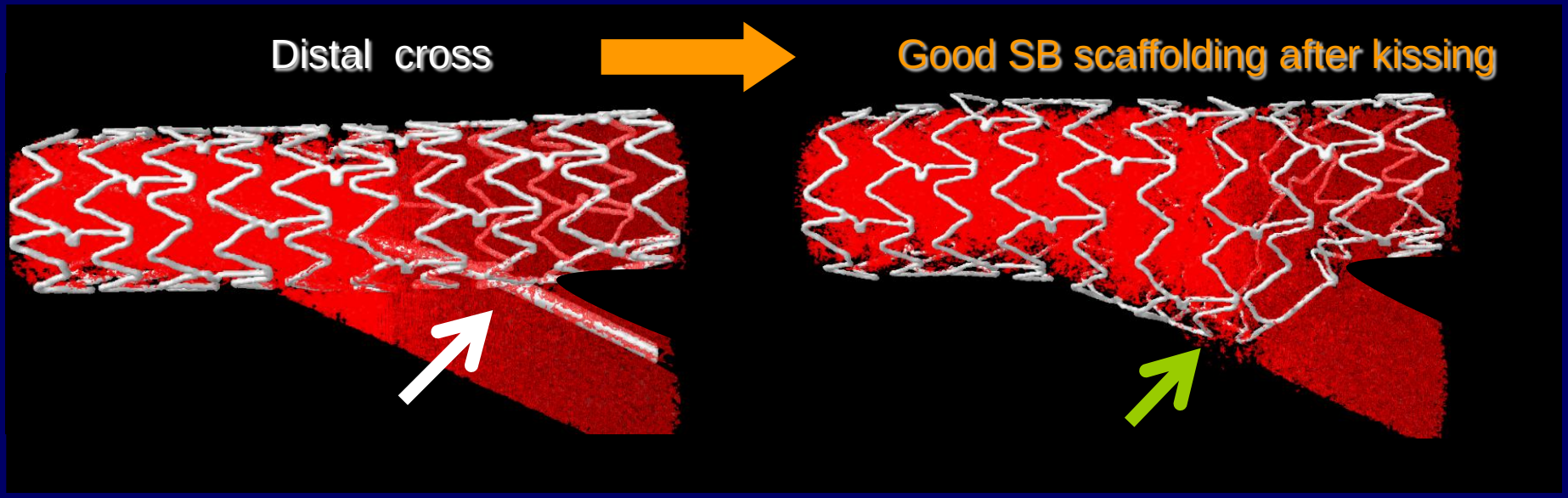
After MV stenting, cross into the SB through the distal strut

In the provisional technique, wire cross following MV stenting should be done through the distal strut, because it creates better SB scaffolding than a proximal crossing

Insights from the 4nd meeting of the EBC. EuroIntervention 2009;5:39-49


Stent diameter
= PM diameter
D1
D1= (D2 + D3) 2/3
D3
D2
Stent diameter
= DM diameter
POT

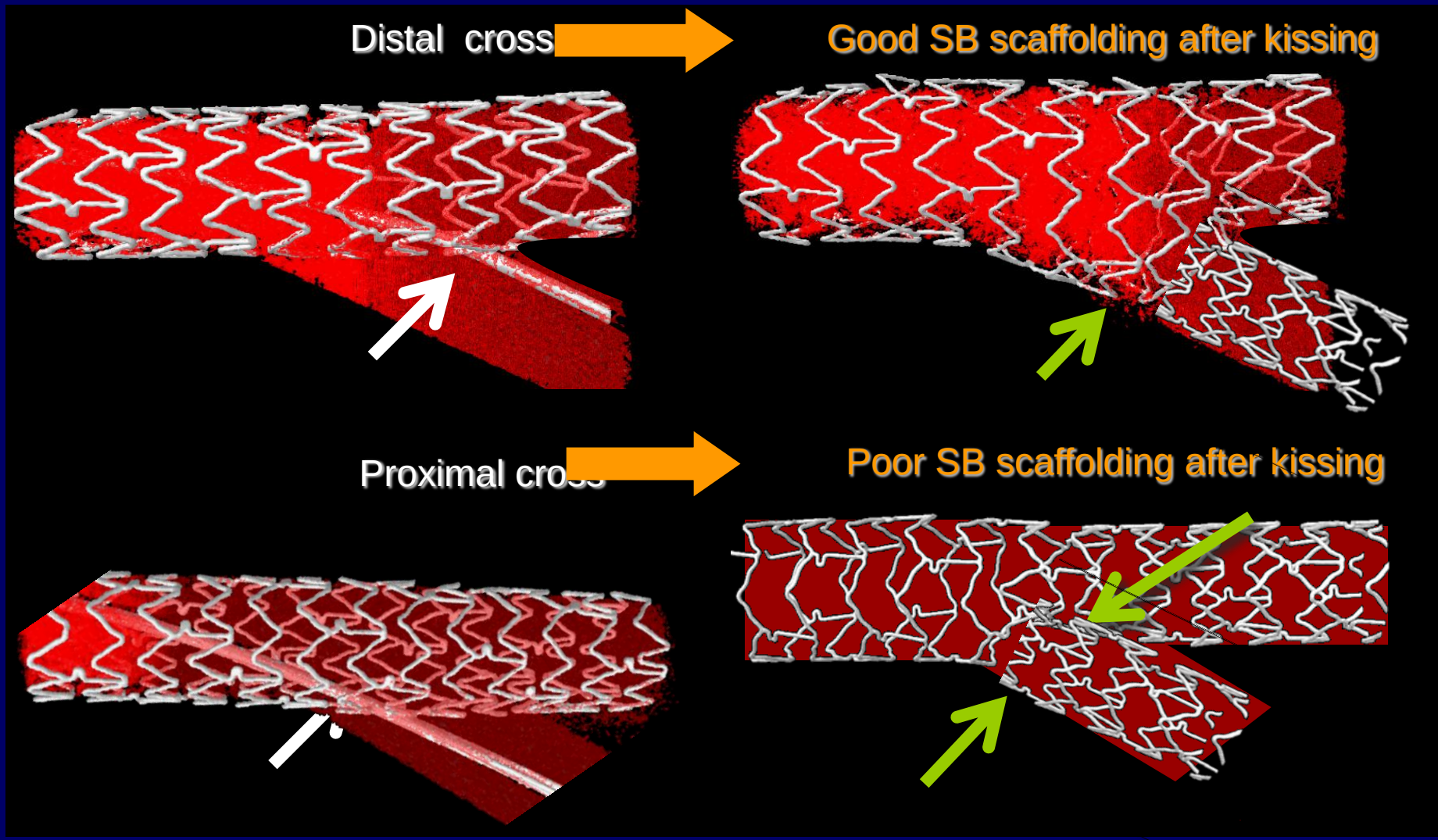
Wire should cross the MV into the SB through the distal strut



- **Recommendation: When rewiring a side branch, efforts should be made to cross the main vessel stent distally, thereby ensuring stent coverage of the ostium of the side branch**

Consensus from 5th EBC meeting. EuroIntervention 2010;6(1):34-8

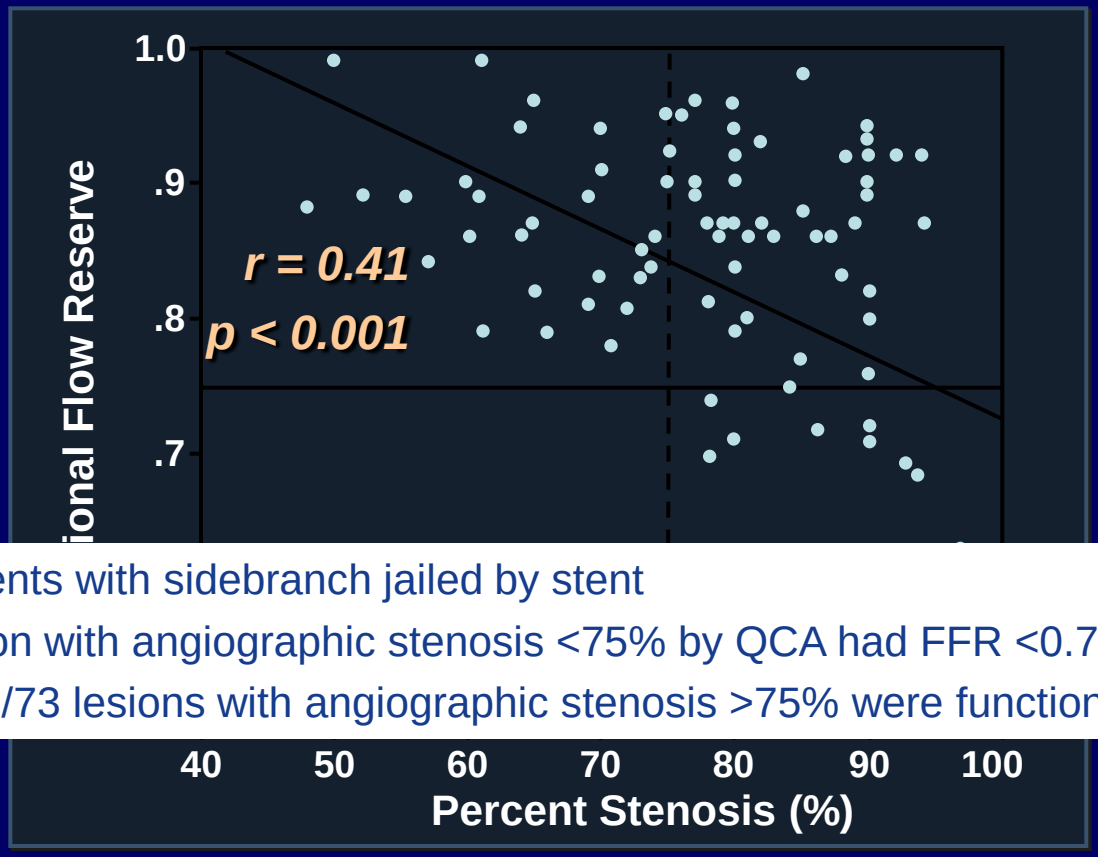
MV Stent Distortion after FKBD



Albiero Remo, MD from 4th EBC meeting

Side-Branch Stenosis Functional Significance – FFR

Correlation between FFR and % Stenosis



97 patients with sidebranch jailed by stent

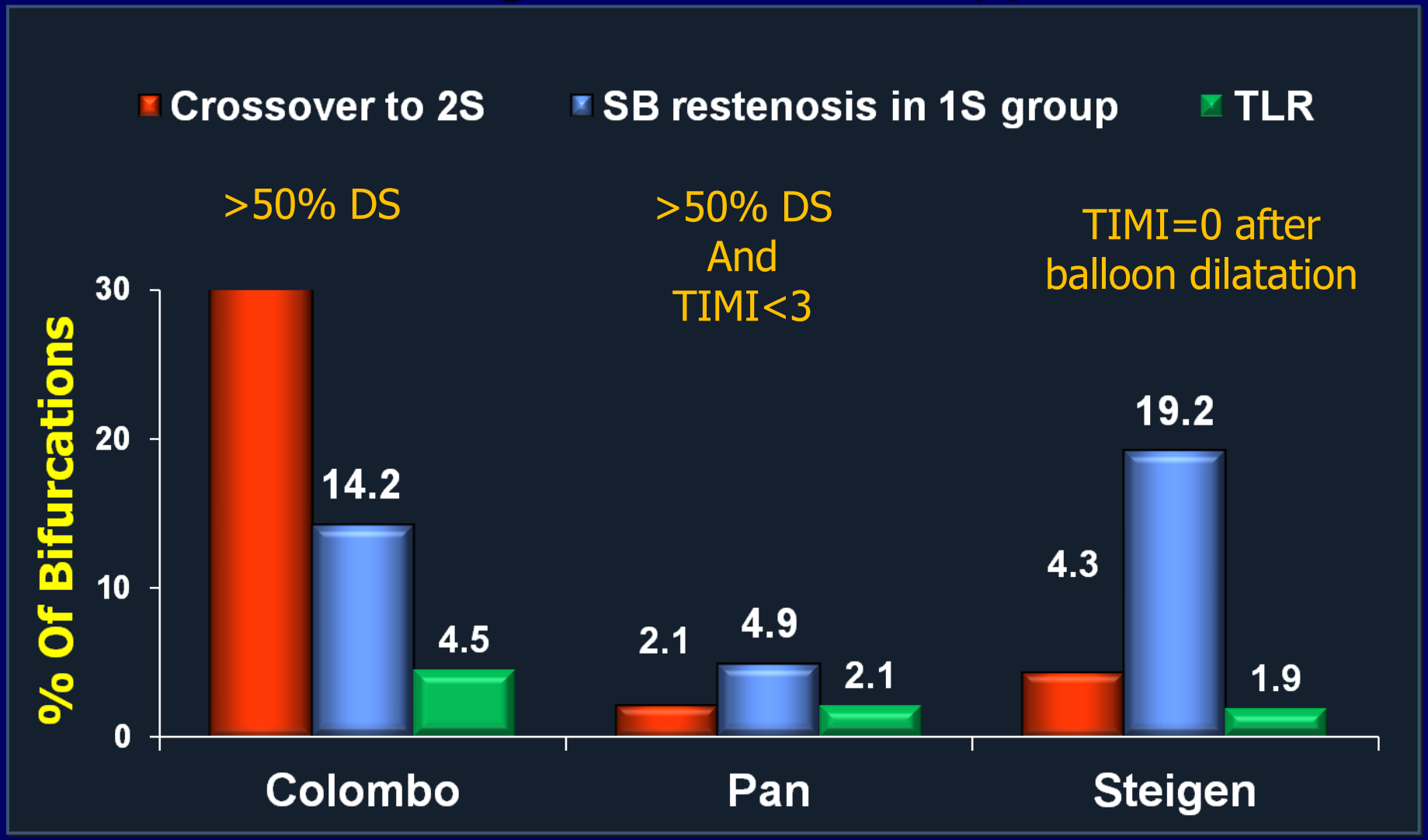
No lesion with angiographic stenosis <75% by QCA had FFR <0.75

Only 20/73 lesions with angiographic stenosis >75% were functionally significant

Almost All Side Branch Lesions <70% DS Are Not Functionally Significant

Koo et al, *JACC* 2005;46:633-7

How often do we need a second stent when using the Provisional approach?

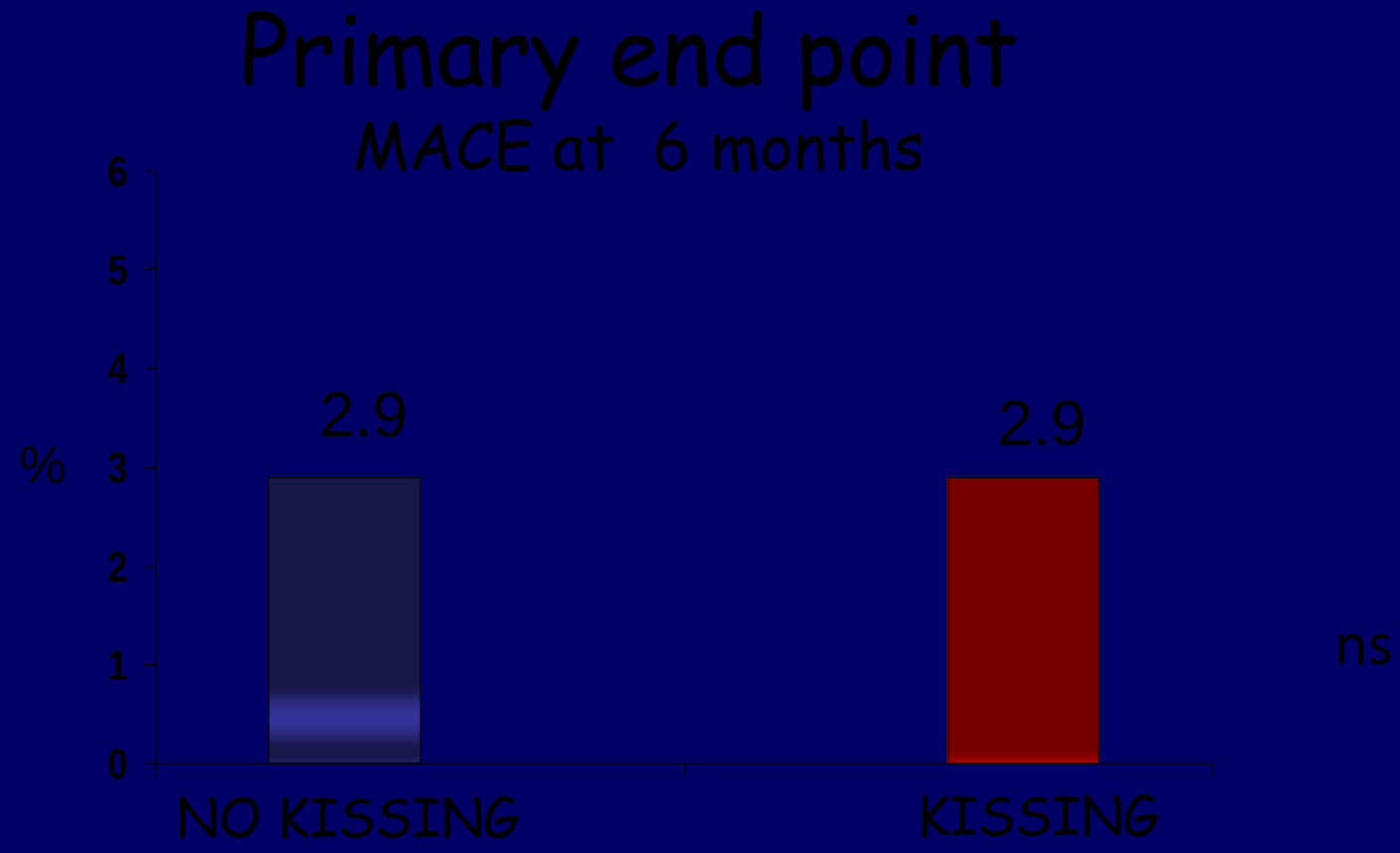


•Colombo A, et al. Circulation 2004;109:1244-9
•Pan M, et al. Am Heart J 2004;148:857-64.
•Steigen TK, et al. Circulation 2006;114:1955-61.

NORDIC 3

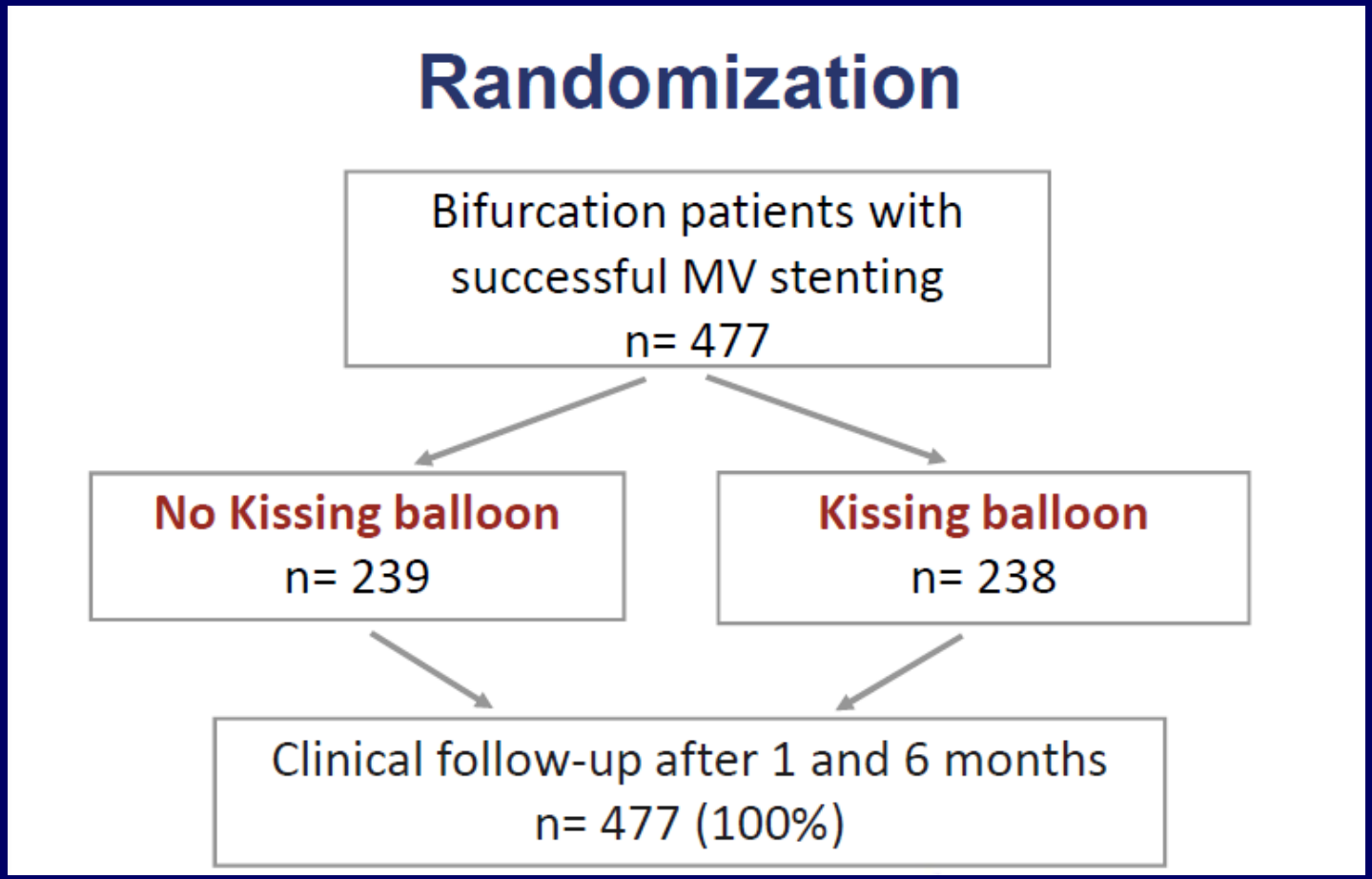
RCT on FKB vs no FKB in All Bifurcations

Only 50 % of the cases had a True Bifurcation Lesion!!



Niemela et al Circulation 2011 (123): 79-86

NORDIC III
RCT on FKB or No FKB on all Biurcations
Only 50 % of the cases had a True Bifurcation Lesion

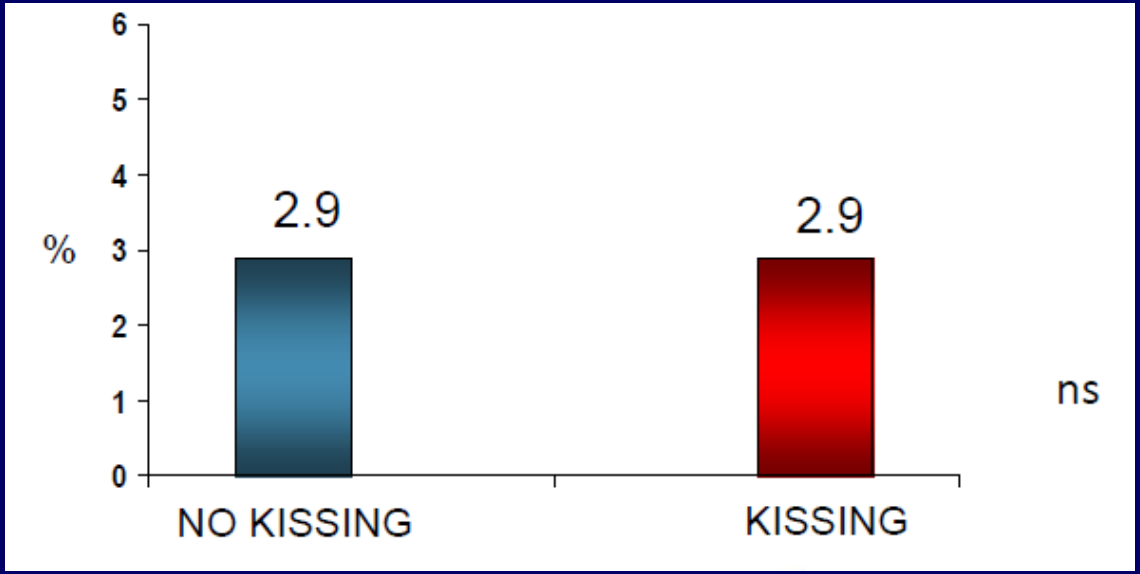


Niemela, M.et al. Circulation 2011; 123(1): 79-86.

NORDIC III

Primary end point

MACE (cardiac death, index lesion MI, TLR, stent thrombosis) after 6 months



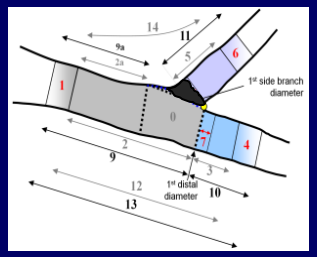
- **Conclusion: Routine use of Final Kissing Balloon (FKB) *did not improve clinical outcome*, but there was not a penalty for undertaking FKB**

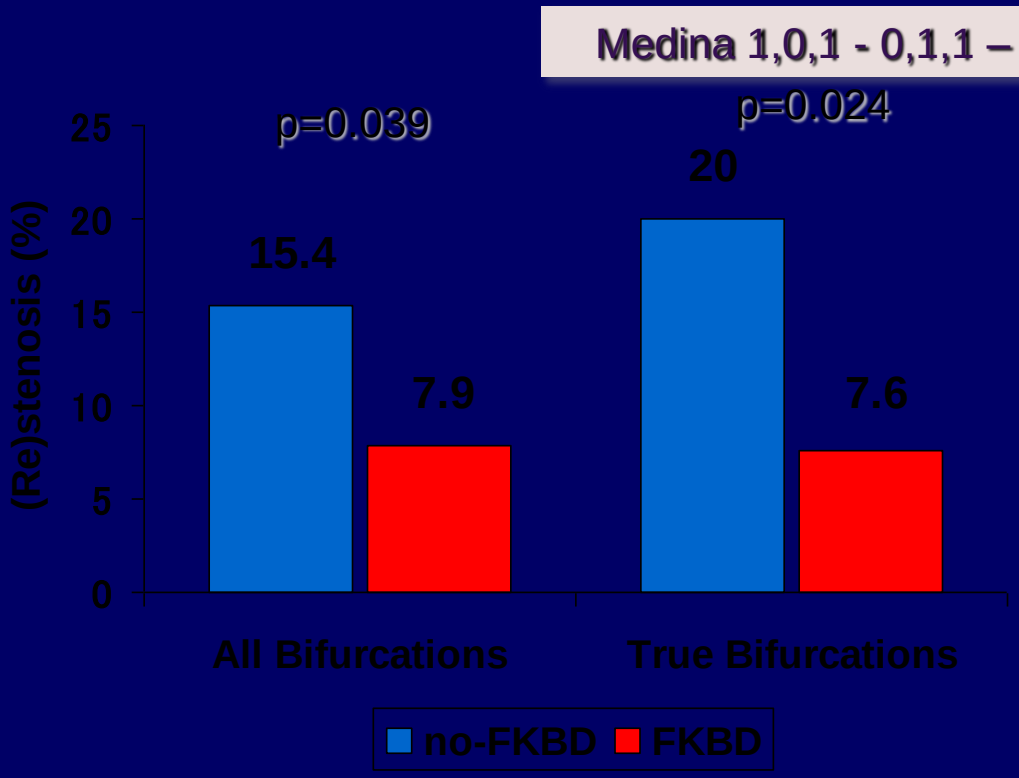
Niemela, M.et al. Circulation 2011; 123(1): 79-86.

NORDIC III

Secondary end point

Side Branch (SB) Binary (Re)stenosis after 8 months



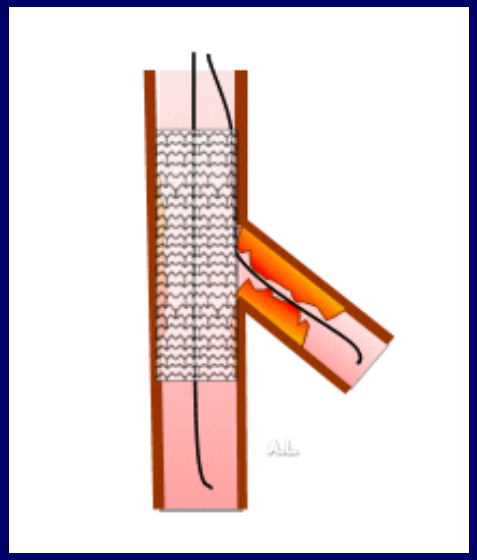
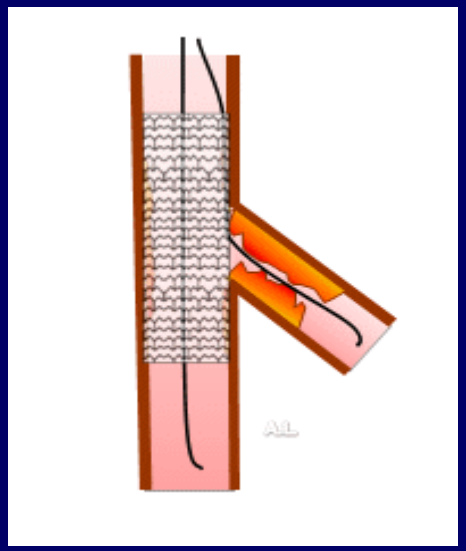
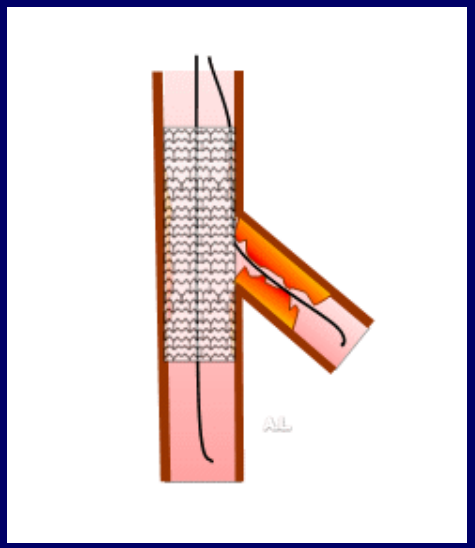


In the MV was 2.5% vs 3.1% (P=0.68)

- **Conclusion: FKBD reduced angiographic side branch (re)stenosis, especially in patients with true bifurcation lesions**

Niemela, M.et al. Circulation 2011; 123(1): 79-86.

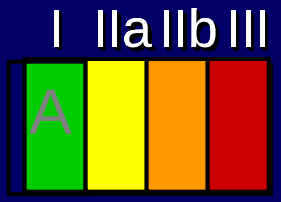
Provisional Approach
-requiring a 2nd stent in the SB

	TAP	Reverse Crush	Culotte
			
Advantages	Easy to perform No recrossing	Complete coverage of ostium Any anatomy	Complete coverage of ostium
Disadvantages	Struts protruding into MB	Recrossing into SB 3 layers of struts	More labourious Rewiring both branches Double stent layer

Courtesy Dr. Chieffo

The Guidelines

Provisional versus Elective SB stenting



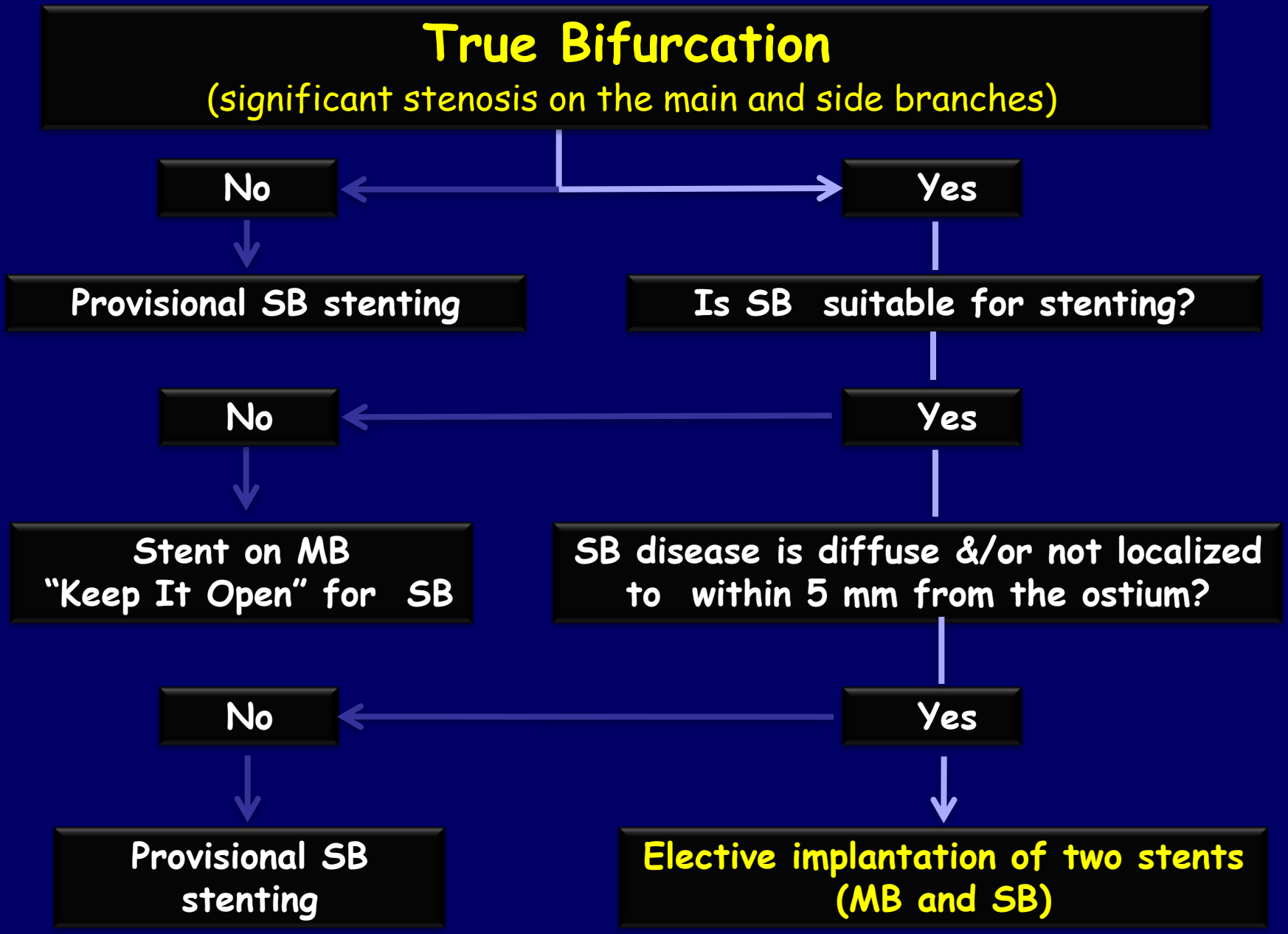
Provisional side-branch stenting should be the intitial approach in patients with bifurcation lesions when the side branch is not large and has only mild or moderate foal disease at the ostium

It is reasonable to use elective double stenting in patients with complex bifurcation morphology involving a large side branch where the risk of side-branch occlusion is high and the likelihood of successful side branch re access is low

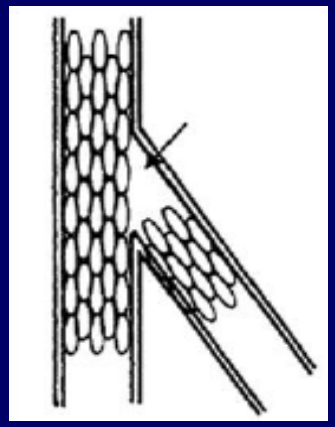
JACC. 2011 Dec 6;58(24):e44-122. 2011 ACCF/AHA/SCAI Guideline for PCI.

Can you treat all of these bifurcations in the same way?

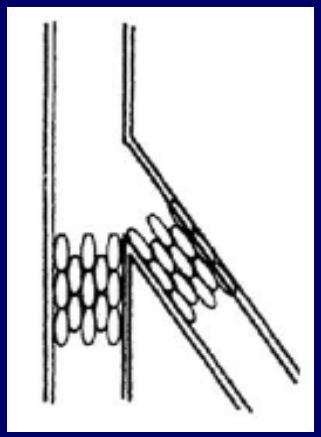
Two Stent Bifurcation Techniques


True Bifurcation
(significant stenosis on the main and side branches)
No
Yes
Provisional SB stenting
Is SB suitable for stenting?
No
Yes
Stent on MB
"Keep It Open" for SB
SB disease is diffuse &/or not localized to within 5 mm from the ostium?
No
Yes
Provisional SB stenting
Elective implantation of two stents (MB and SB)

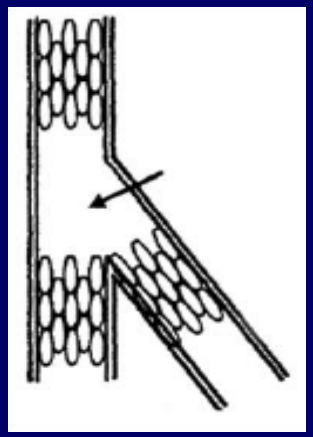
Bifurcation Stenting Techniques with Workhorse Stents



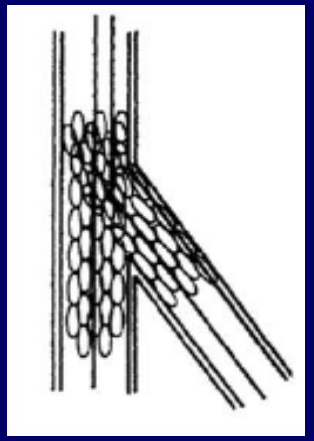
T Stenting



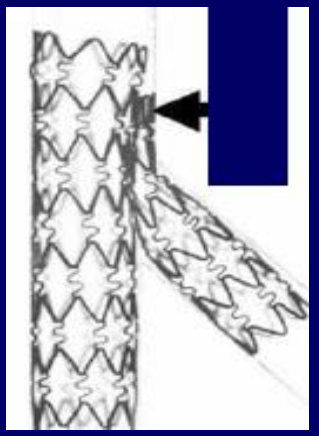
V Stenting



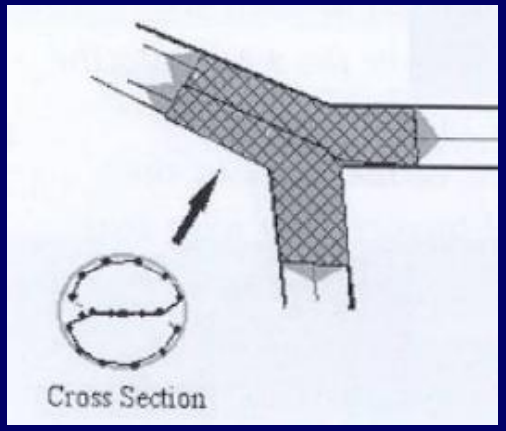
Y Stenting



Culotte



Crush

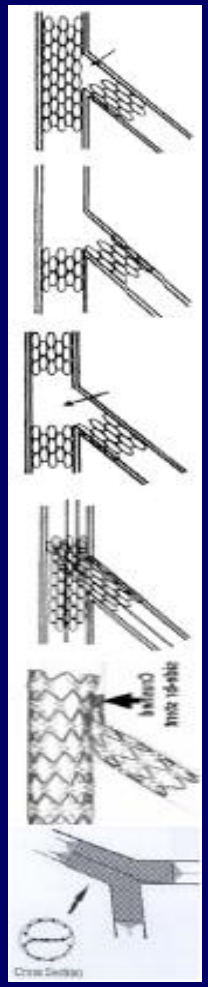


Kissing Stent

Workhorse Stents, a Suboptimal Solution

A = Best

C = Worst



	Coverage	Amount of metal	Branch jailing	Number of stents
T stenting	~~B~~ C	A	B	B
V stenting	C	A	A	B
Y stenting	C	A	A	C
Culotte stenting	A	C	C	B
Crush stenting	A	C	C	B
Kissing Stent	A	C	A	B

Bifurcation PCI
Provisional and Dedicated 2-Stent Techniques

Performed with 6 Fr Guide	Performed with a 7F Guide
Provisional Single Stent	Crush and Mini-Crush
T- and modified T	V-stent
T and Protrusion (TAP)	Simultaneous Kissing Stents (SKS)
Step and Double Kiss Crush	
Culotte	
Reverse Crush	

Double Stenting Techniques for Bifurcations

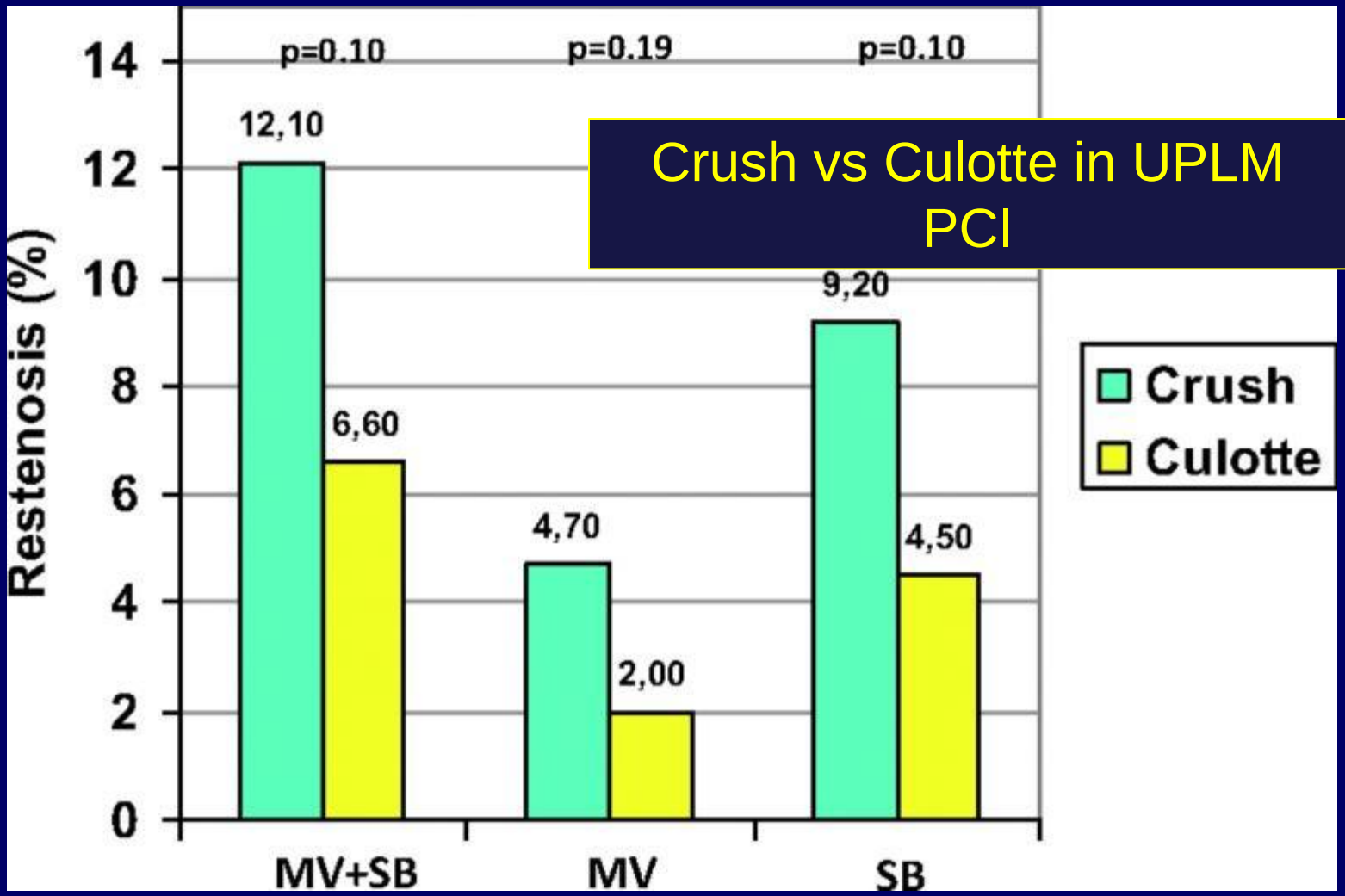
Step-by-Step Handbook

Crush, Culotte, SKS : What Do They Have in Common?

In Theory, Full Coverage of the Entire Bifurcation

	 Crush	 Culotte	 SKS
Guiding	7	6	7
MV Access	+++	–	+++
SB Access	–	–	+++
Complexity	++	+++	–
SB Cover	Mandatory	Provisional	Mandatory

Rates of in-segment restenosis in crush vs culotte-treated bifurcation lesions.



Erglis A et al. *Circ Cardiovasc Interv*. 2009;2:27-34

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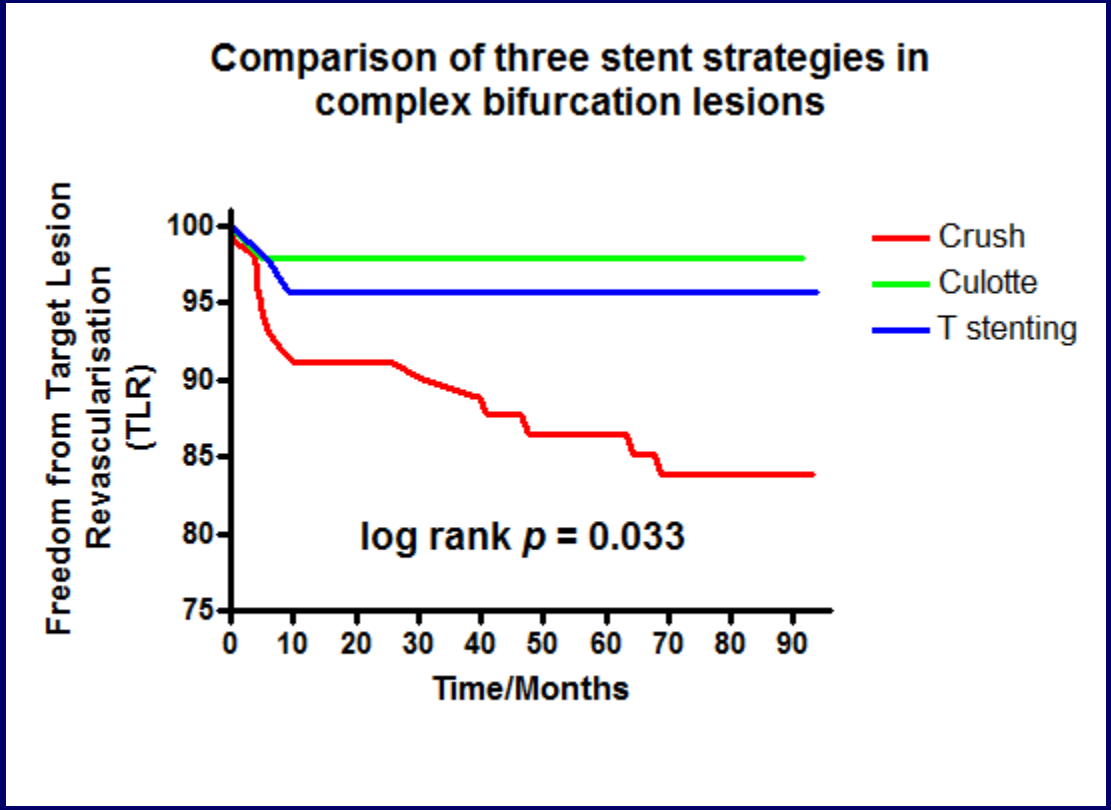
Results


Comparison of three stent strategies in complex bifurcation lesions
Freedom from Target Lesion Revascularisation (TLR)
100
95
90
85
80
75
0
10
20
30
40
50
60
70
80
90
Time/Months
log rank p = 0.033
Crush
Culotte
T stenting

DK Crush Technique
Double Kiss and Crush

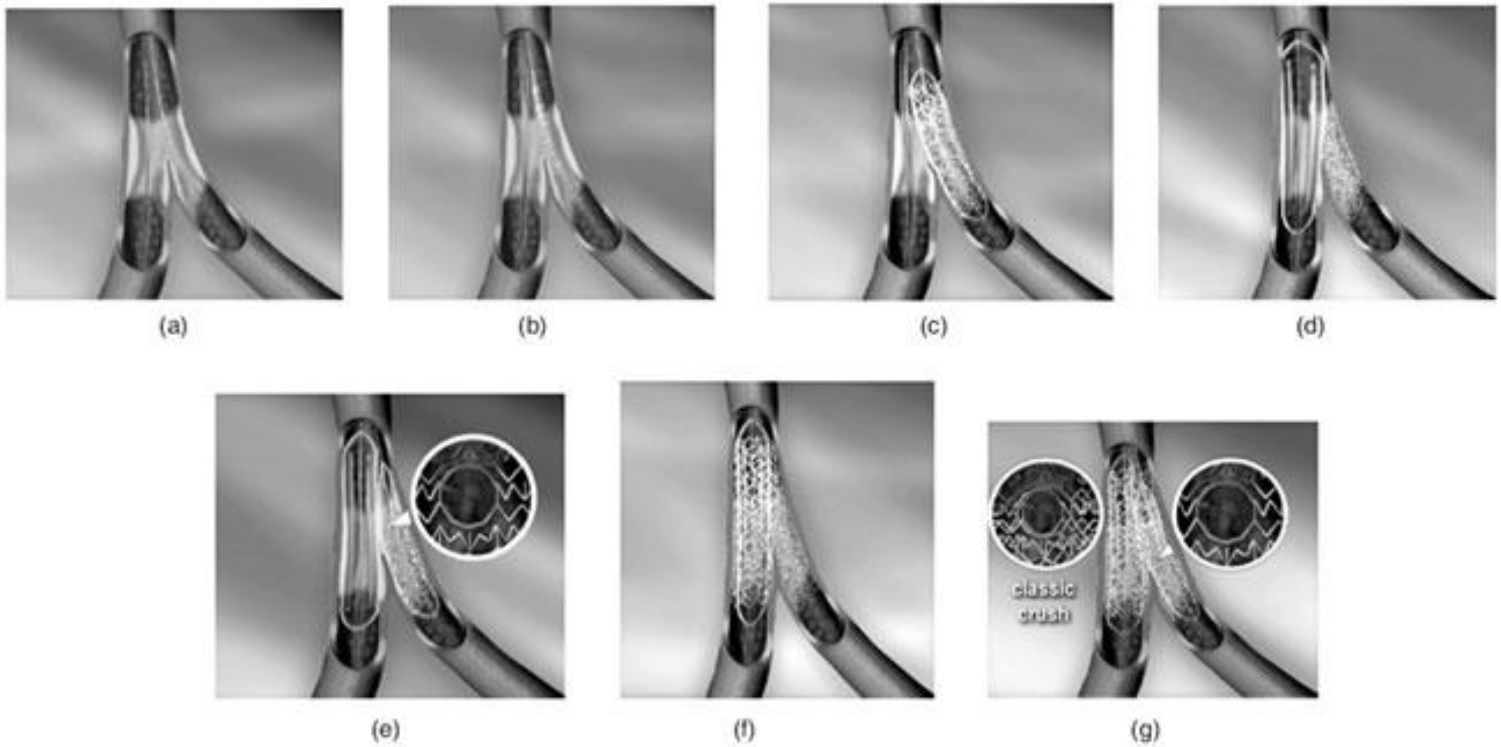


Figure 4. Double kissing (DK) crush technique. Two wires are inserted into two vessels (a). One stent and balloon are advanced into side branch and main vessel simultaneously (b). Inflated side stent firstly (c), then the balloon in the main artery is inflated after removal of stent balloon and wire from side branch (d). First kissing balloon inflation is performed after successful rewiring to side branch (e). Stenting main vessel is underwent (f), with final kissing inflation as the final step (g). The orifice of side branch is relatively largely expanded, compared to classical crush (g).

DKCRUSH studies

Completed

DKCRUSH-I

DKCRUSH-II

DKCRUSH-III

Ongoing

DKCRUSH-V: DK/PT for LMCA

DKCRUSH-VI: FFR-/Angio-SB

DKCRUSH-VII: registry, Post-DES FFR predicts MACE

DKCRUSH-IV: dynamic change of FFR after DK/PT

c/o S. Chen

DKCRUSH studies: Outcomes

	DKCRUSH-1 Crush vs DK	DKCRUSH-II PT vs DK	DKCRUSH-III Culotte vs DK
MACE,%	24.4 vs 11.4	17.3 vs 10.3	16.3 vs 6.2
TLR,%	18.9 vs 9.0	13.0 vs 4.3	6.7 vs 2.4
TVR,%	26.5 vs 10.3	14.6 vs 6.5	11.0 vs 4.3
CD,%	1.7 vs 0.6	1.1 vs 1.1	1.0 vs 1.0
QMI,%	3.5 vs 1.2	2.2 vs 3.2	5.3 vs 3.3
ST*, %	3.0 vs 1.1	0.6 vs 2.2	1.0 vs 0.5

c/o S. Chen, from EJCI, JACC, JACC

1 or 2 stents?

A) If the side branch is significantly diseased at its ostium or nearby or if it is sufficiently large to be stented or safety and duration of the PCI are an issue: use 2 stents

B) In all other conditions 1 stents and then evaluate

If you are not certain:

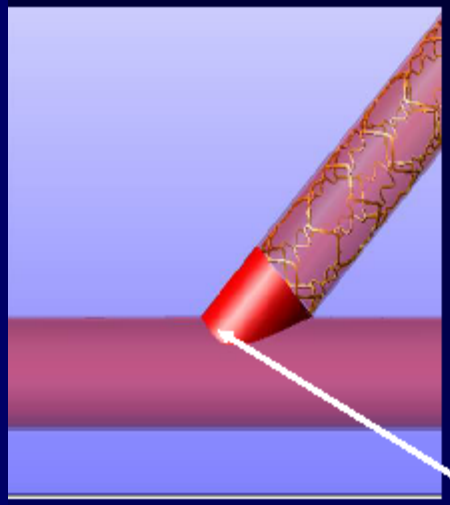
In many conditions such as A), you will get an optimal result following 1 stent in the main branch a wire in the side branch will guarantee safety and then you can make your final decision

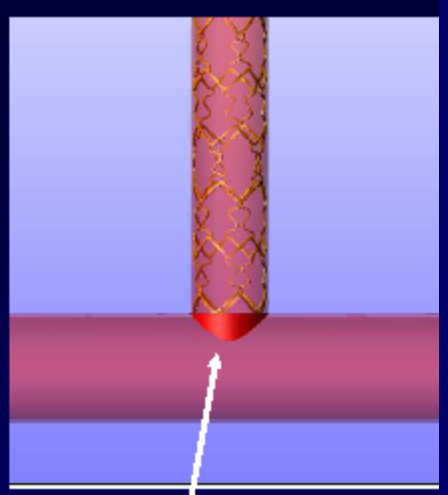
Suboptimal coverage & Drug delivery

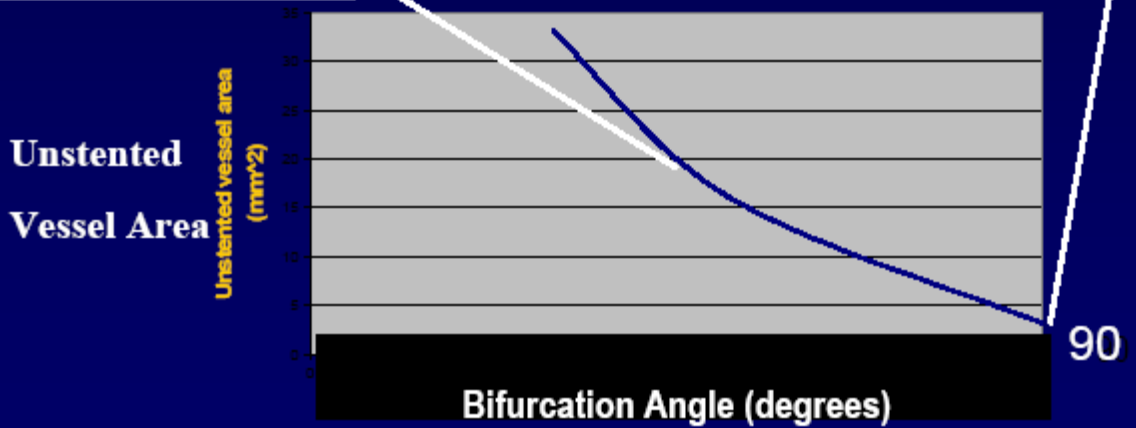
The Lindner Center

- As bifurcation angle changes from 90º, unstented vessel area increases rapidly with "workhorse stents" unless stents overlap or workhorse struts engage the ostium of side branch

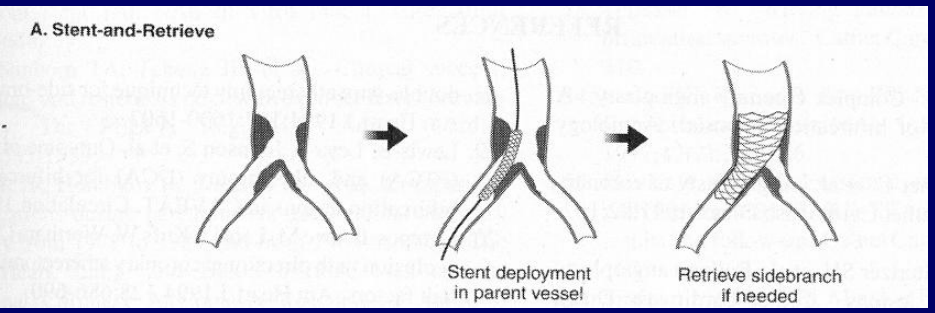
Unstented Vessel area versus Bifurcation angle

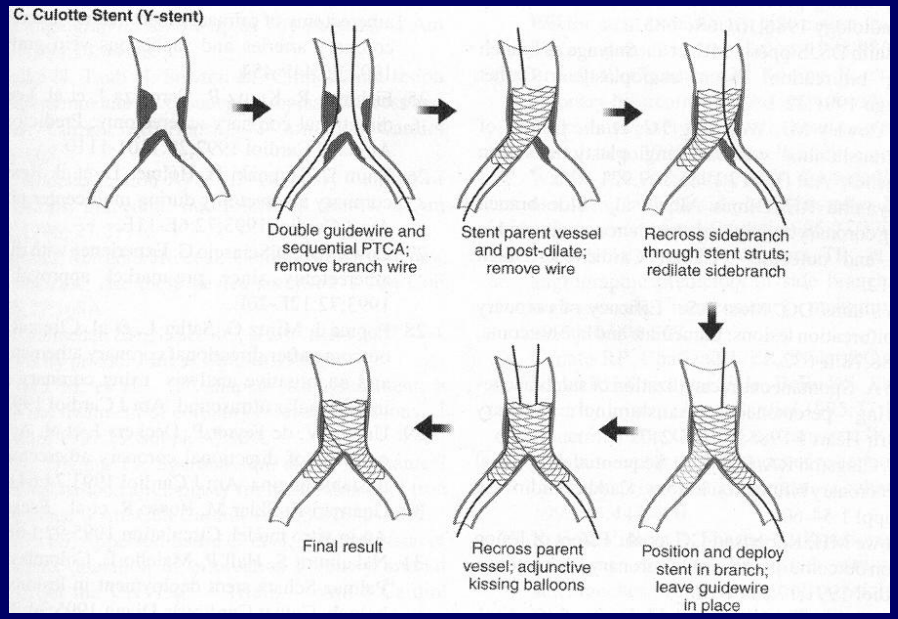


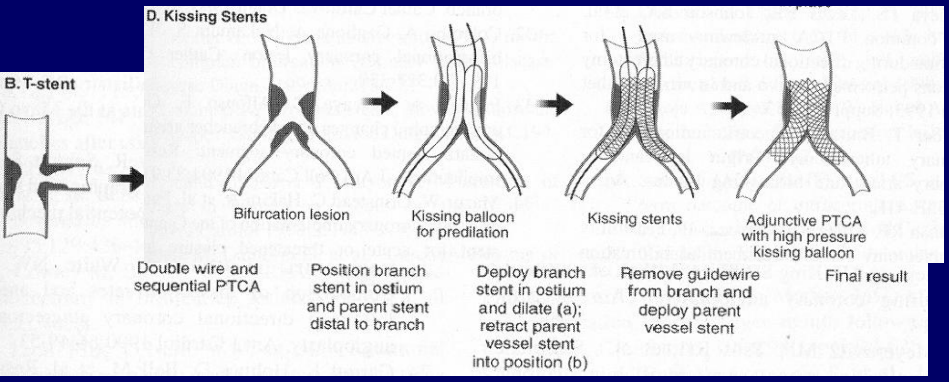




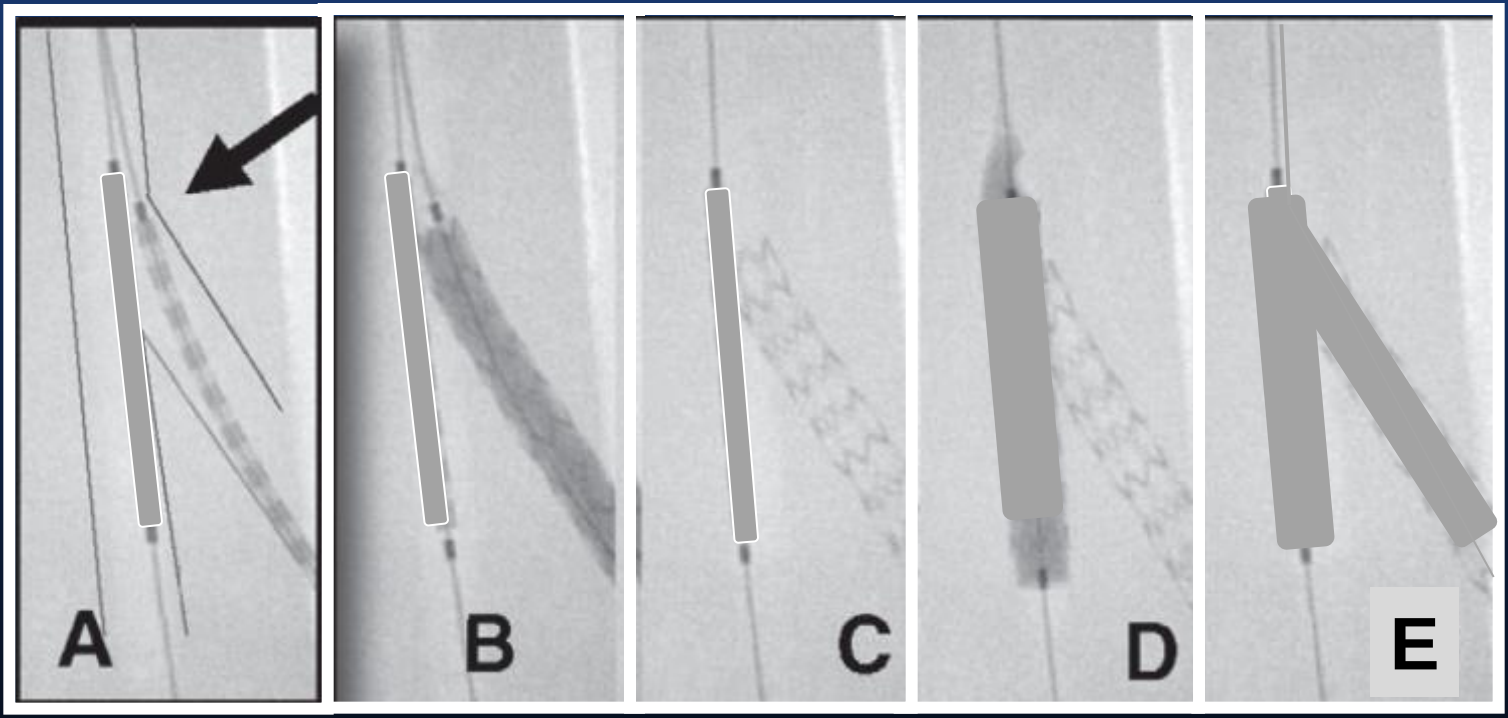
Bifurcation Techniques







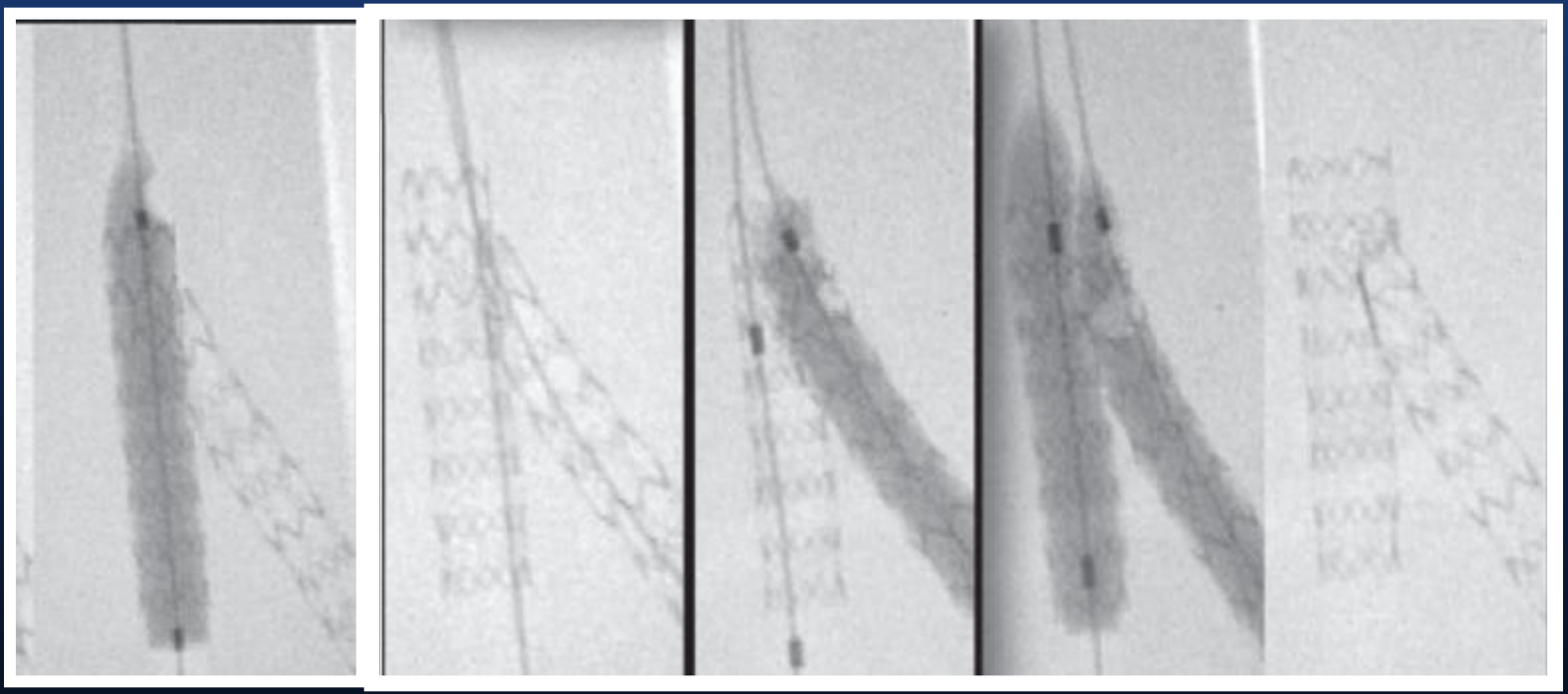
DK Crush Illustration



- 1-2 mm of SB stent positioned in MV (proximal SB stent marker on MB wire or SB just covers proximal edge of ostim)
- The SB stent is deployed & stent balloon withdrawn slightly with high RBP inflation (flares proximal stent) – then angiogram to make sure no distal dissection
- The SB is crushed by a MV balloon then rewire and kiss (extra kiss)

c/o J. Hermiller, adapted from Ormiston JACC Intv 2008

DK Crush Illustration



- Deploy Main Branch Stent
- Rewire SB (for 2nd kiss)
- SB – high pressure dilatation NC balloon (1st step of kissing balloon inflation)
- Final kissing balloon inflation

c/o J. Hermiller, adapted from Ormiston JACC Intv 2008

Example of Double Kiss Crush

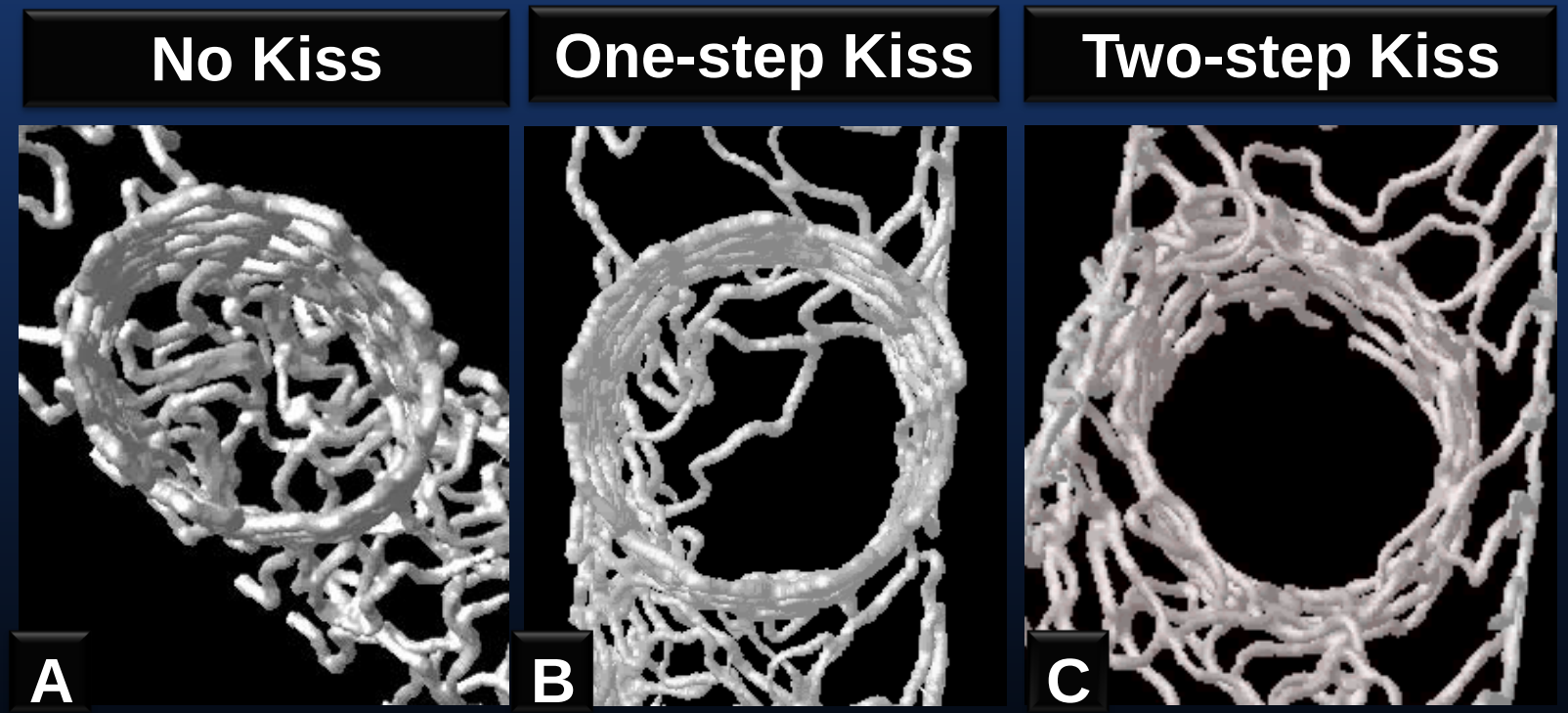
Example of Culotte

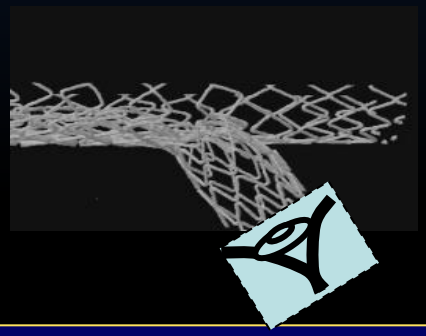
Example of Culotte and Provisional stenting

Example of Culotte with Tryton

Example of Provisional Stenting

A Second Kiss: Two Step



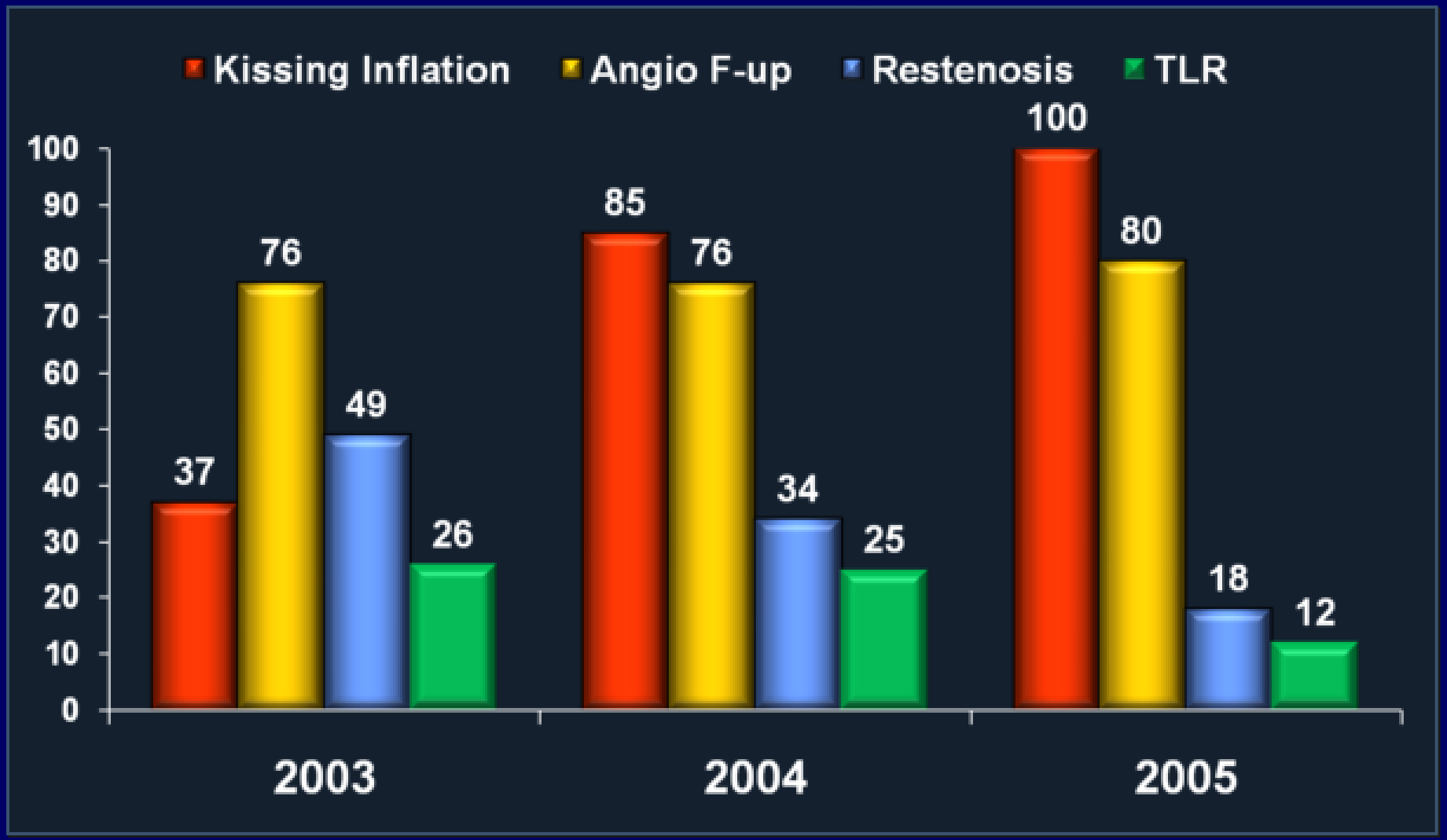


Slide courtesy of John Ormiston

Technical Factors that May be Important in Reducing Restenosis & TLR when 2 Stents Implanted in Bifurcations

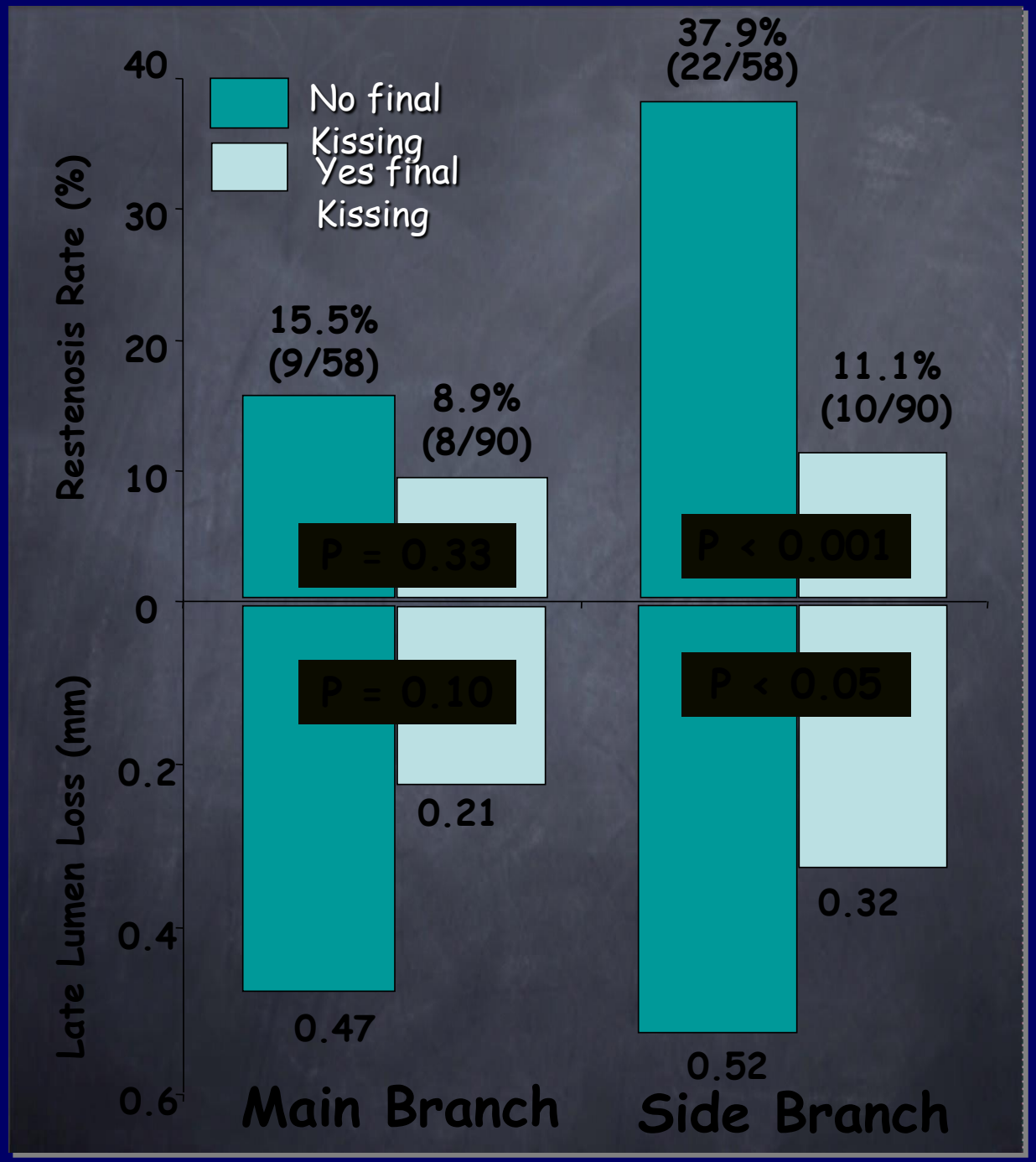
- High pressure side branch inflation
- 2-step Kiss: Pre-FKI side branch dilatation
- Use of low-compliant balloons
- Less protrusion of SB stent into MB (mini-crush)
- IVUS-guided stenting

Optimal Performance of 2 Stent Techniques Important in Reducing Event Rates



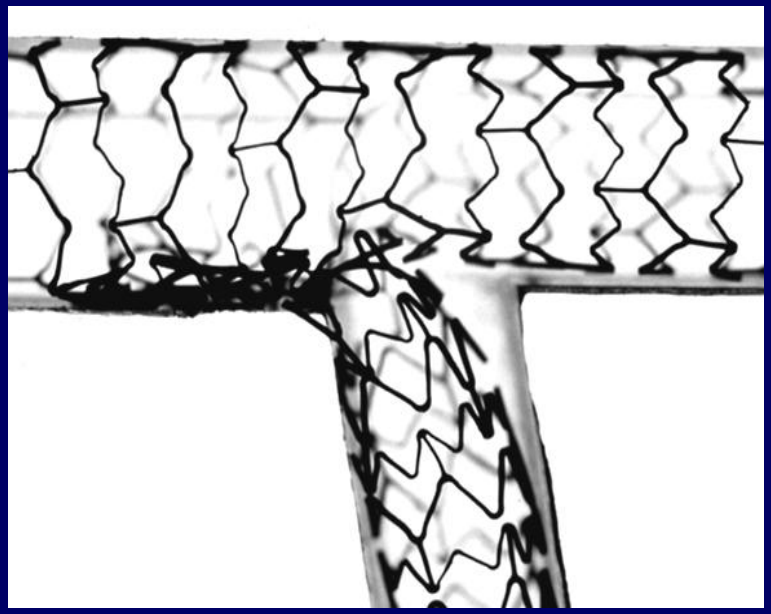
Impact of learning curve in Technique; TCT 2006

Result with Crush stenting according to performance of final kiss: restenosis and late loss are significantly reduced for the side branch.



Colombo
Circulation 2004;109:1244-9

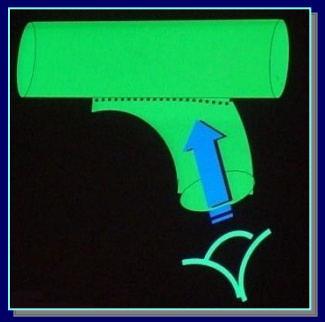
Need for high pressure side branch inflation and kissing



J. Ormiston (Crush)

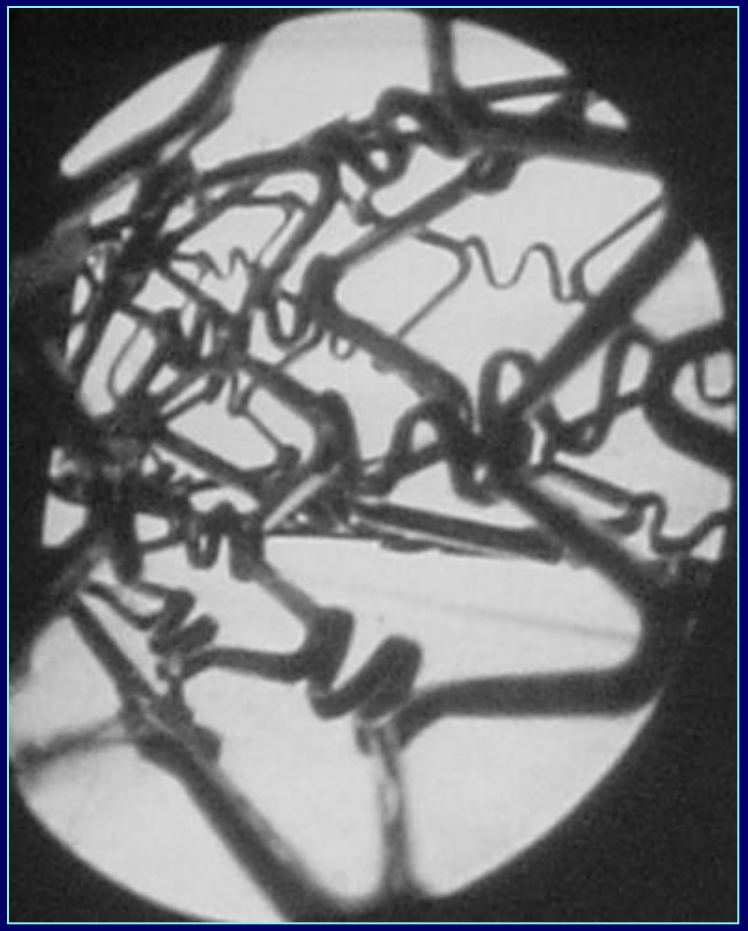
Ormiston JA CCI 1999;47:258-64

Treatment of Bifurcational lesions

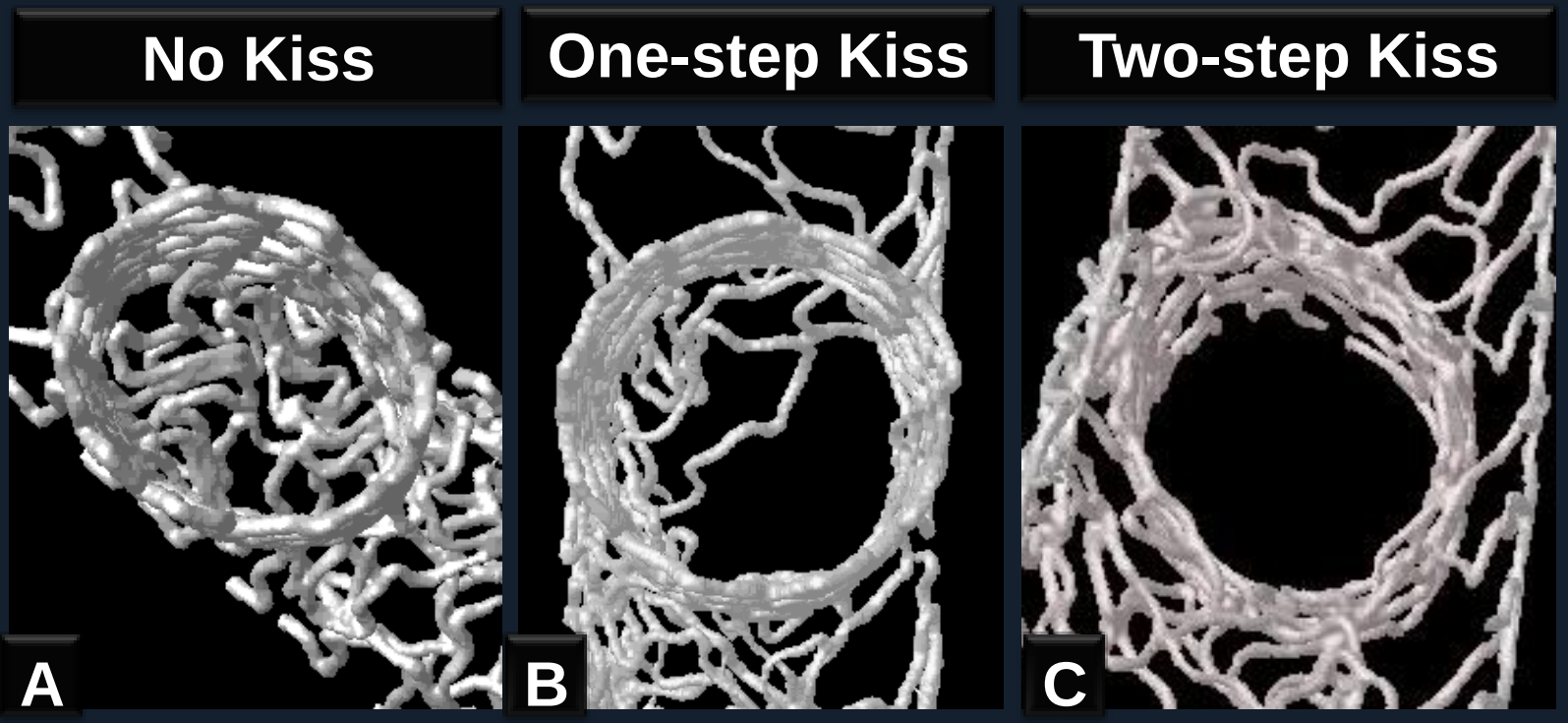


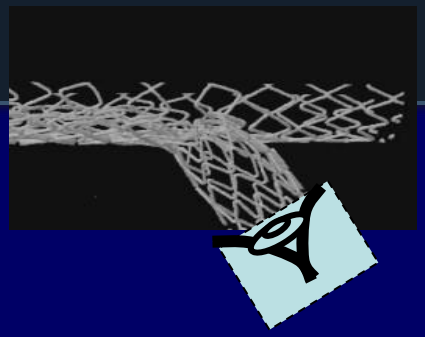
After Crush

After Kissing



2-Step Kiss





Slide courtesy of John Ormiston

Independent risk factors for major adverse cardiac event and target lesion revascularization (1691 non LM bifurcations)

	Hazard ratio (95% confidence interval)	*P*
MACE		
Final kissing ballooning	2.01 (1.29-3.13)	0.002
Use of paclitaxel-eluting stent	1.98 (1.34-2.92)	0.001
Stent length in the main vessel	1.02 (1.001-1.03)	0.03
TLR		
Final kissing ballooning	3.09 (1.84-5.16)	<0.001
Use of paclitaxel-eluting stent	2.28 (1.45-3.59)	<0.001
Stent length in the main vessel	1.02 (1.01-1.04)	0.01
Stent diameter in the main vessel	0.42 (0.20-0.89)	0.02

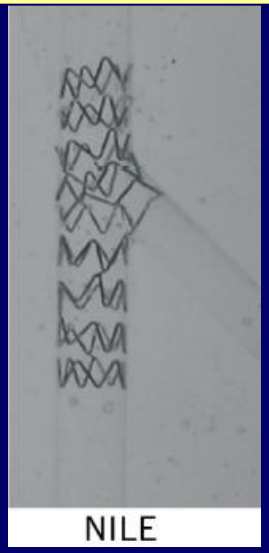
HC Gwon, Circulation

Dedicated Bifurcation Devices

- Dedicated bifurcation stent systems remain limited (EBC)
- Comparative RCTs vs. provisional stenting are lacking (ESC)

1. MB stenting with provisional SB stenting

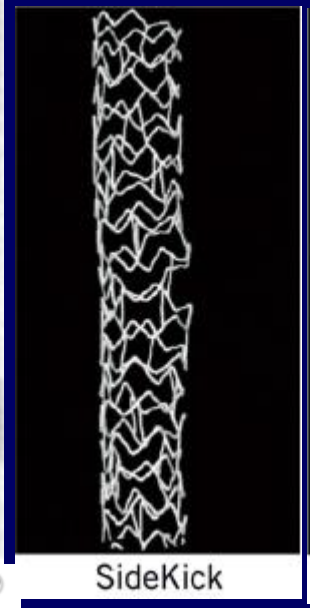

Twin-Rail

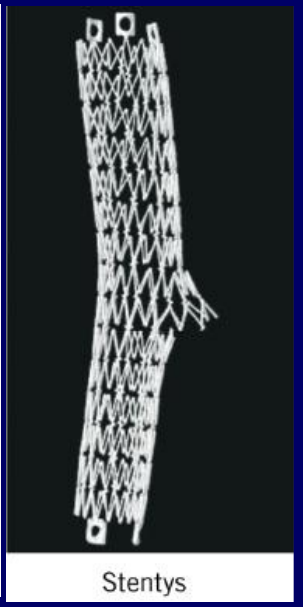

NILE


Petal


Abbott's SB Access DES

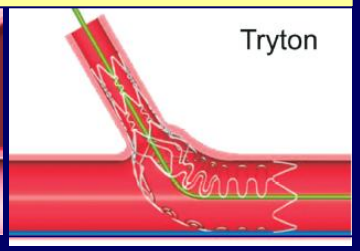

Antares®


SideKick


Stentys

2. Side branch stents

Capella Sideguard



3. Proximal

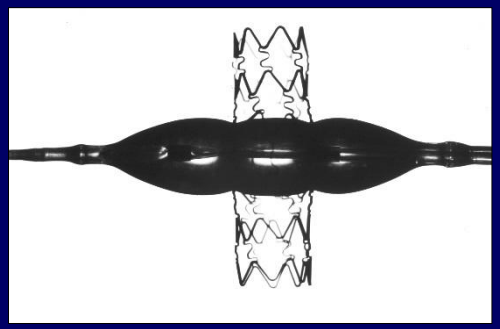

Axxess

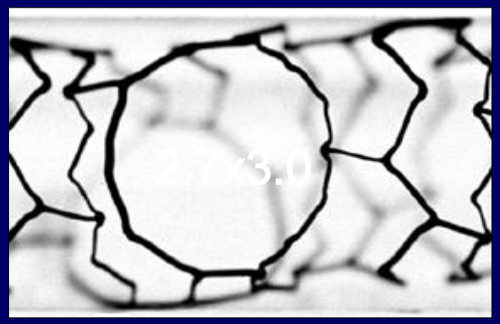
4. Bifurcated stent


Medtronic Y stent

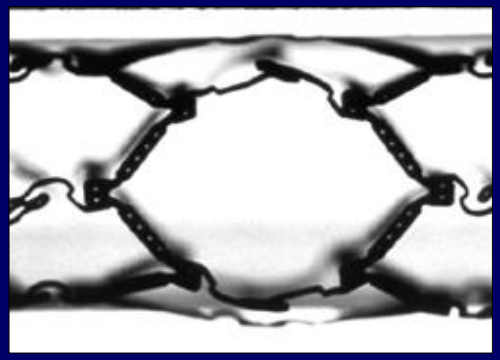
ESC Guidelines - European Heart Journal (2010) 31, 2501–2555
Consensus from 5th EBC meeting. EuroIntervention 2010;6(1):34-8

Conventional photos and Cell Size after SB Dilatation with a 4mm Balloon

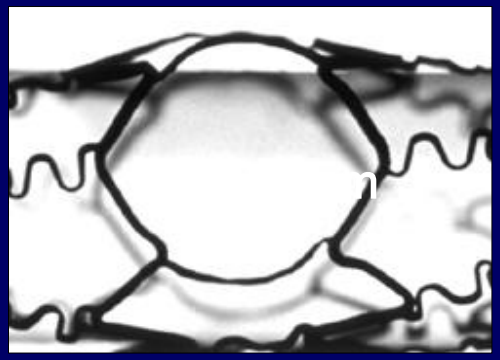




Express

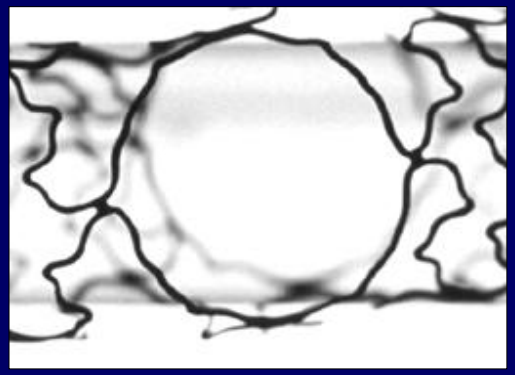


CoStar

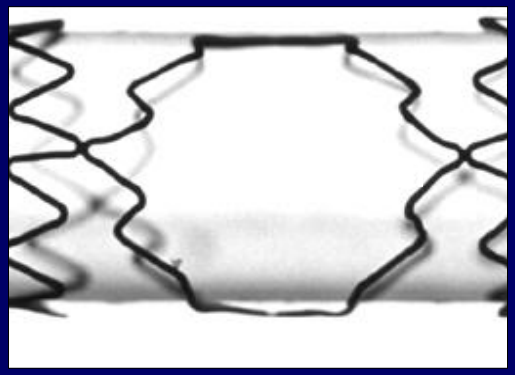


Bx Velocity

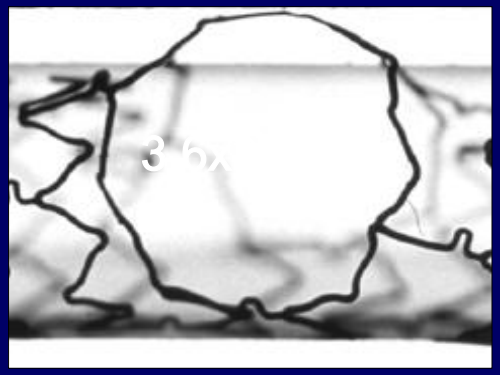
Select



Liberte



Driver



Vision

Ormisto

Randomized Trials using DES and Bifurcations

- **1. Compared to historical studies utilizing bare-metal stents, a remarkable improvement has been achieved in the treatment of bifurcation lesions when 1 (MB) or 2 stents (MB and SB) are implanted**
- **2. The side branch seems to be the weak link in the chain in terms of a higher risk of angiographic restenosis (~20%) and a slightly higher risk of thrombosis when 2 stents are implanted (~3.6% at 9 month f/u)**
- **3. When possible, the placement of a single stent on the MB gives a result similar to that obtained with placement of 2 stents**

Iakavou JAMA 2005:293:2126-30
Ge AJC 2005;95:757-760
Pan M AHJ 2004;148:857-864

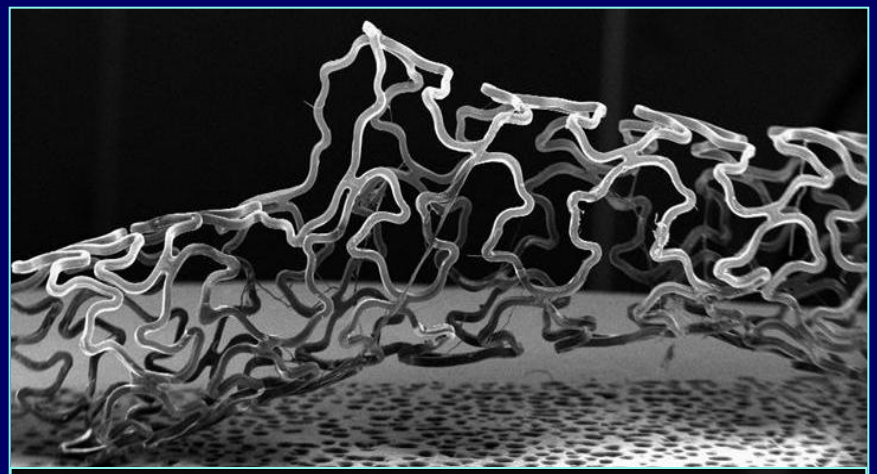
When to Favor a Planned 2 Stent Technique (and Which One)?

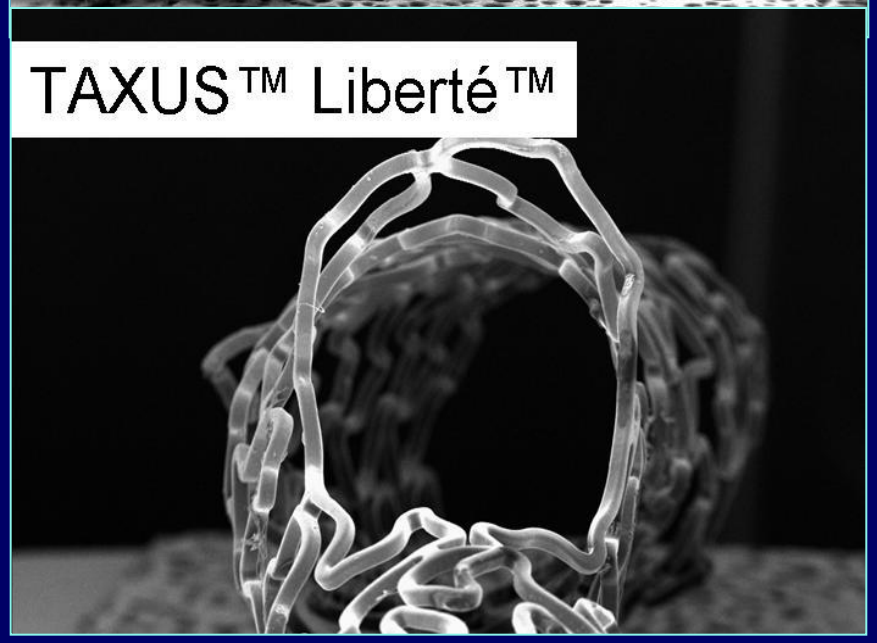
Summary

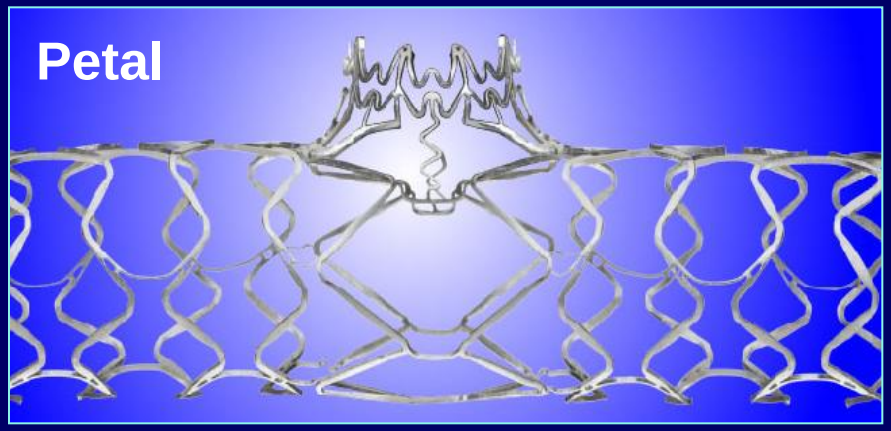
- The goal of PCI in bifurcation lesions is to attain optimal results in the MV and maintain physiologic patency of the SB. Planning of the strategy up front is critical and knowledge of all possible bailout techniques must be kept in mind.
- 4 out of 5 RCTs comparing provisional to 2-stent technique included low-risk bifurcation lesions
- While provisional SB stenting should be the default technique for “low-risk” bifurcations a 2-stent technique may be preferable for “high-risk” or truebifurcations
- Although evidence is lacking as to the superiority of one 2-stent technique versus others its unlikely that any single 2-stent technique would be superior in all bifurcation morphologies. The DK crush technique seems to be most favorable but TAP and Culotte techniques are also excellent options.
- The decision as to which 2-stent technique to use should be driven by bifurcation morphology, operator experience and randomized controlled trials.

Bifurcational Lesion Treatment: BSC Development

Step-by-Step Guide to Crushing, SKS, and More







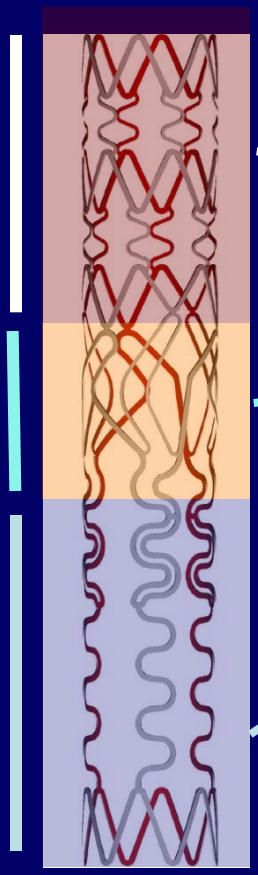
- **Stent Redesign**
  - **Platinum enriched radiopaque stainless steel**
  - **Thinner struts – 0.0032”**
  - **Reduce strut spacing in mid-portion**
- **Translute™ coating with paclitaxel**

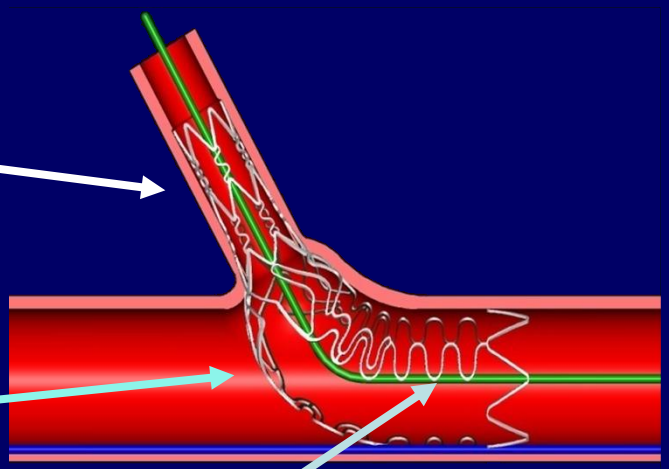
Courtesy of Boston Scientific Corporation

Tryton Sidebranch Stent

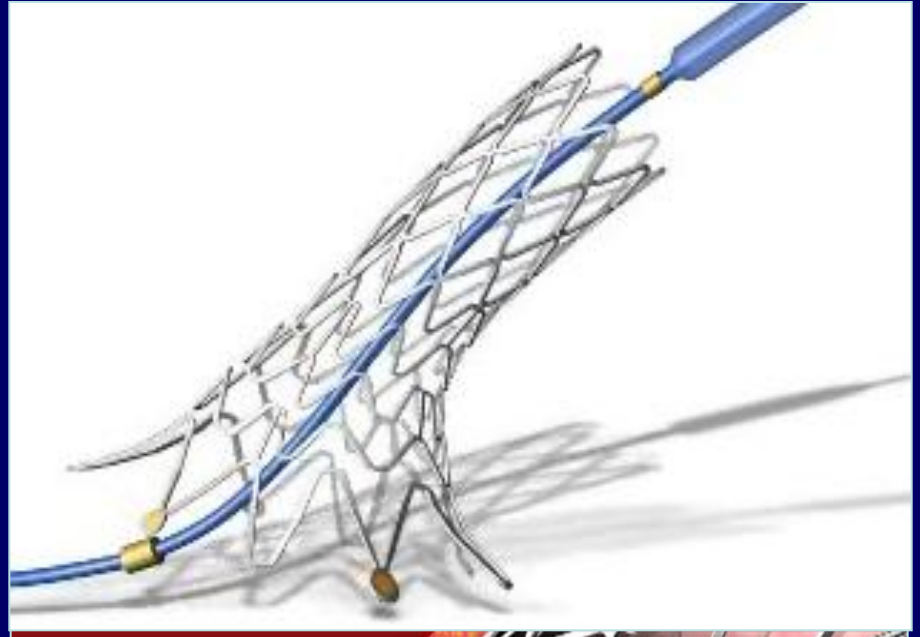
19 mm Stent

- Side Branch Region
  - Standard stent
- Transition Zone
  - Coverage
  - Hoop strength
- Main Vessel Region
  - 3 fronds
    - Minimal coverage
  - Wedding band

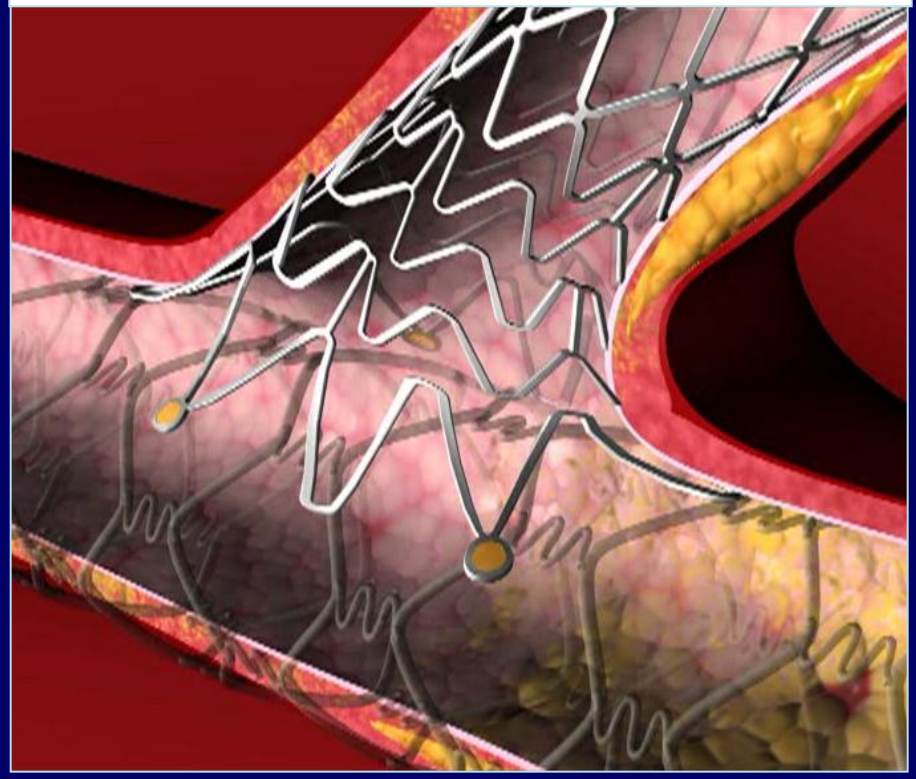


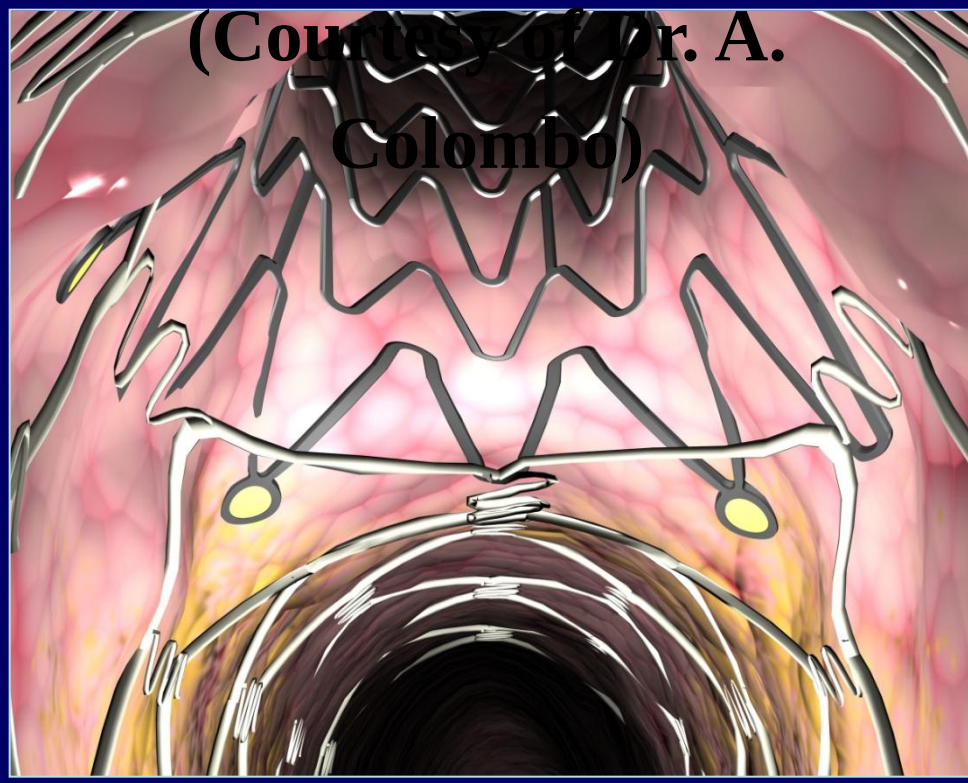


Courtesy of Dr. Aaron Kaplan from Columbia Univ, NY



Dedicated Self-Expanding Stent for Optimal SB Coverage





(Courtesy of Dr. A. Colombo)

Conclusions

Treatment of bifurcation lesions using DES is feasible with very low immediate angiographic complications. One stent should be the first strategy. When 2 stents are needed, the crush stent or 'Y' stent technique with kissing balloon inflation/deflations or V/SKS stenting should be considered depending on location, size and bifurcation classification. Based on early data the "Y" stent technique seems to be a bit safer with lower TLR in the sidebranch but clearly technically it is more challenging.

In complex bifurcations 2 stents should be used as intention to treat.

Low rates of target vessel revascularization have been observed in the main branch. Thrombosis rates are low but not insignificant (larger number of patients needed to make a statement)

Problem of restenosis at the side branch is improved but not fully resolved