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Protection of side branch is essential in treating bifurcation lesions: overview

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Coronary Bifurcation Lesions

- >20% of all existing coronary lesions
- ~10% of routinely treated coronary lesions
- Frequently observed in high risk patients (UA or AMI)
- Poor outcome compared to non-bifurcated lesions (high incidence of TVR, high restenosis rate)
- DES fatigue to provide as great results as in standard stenting
- One of the few remaining areas where patients may be referred to CABG

Bifurcation Stenting
NHLBI Dynamic Registry

PCI TREATMENT	Bifurcation N =321	No-bifurcation N = 2115	P-value
PTCA	23.1%	26.5%	NS
PTCA+DCA	6.9%	4.4%	NS
PTCA+Stent	55.8%	59.9%	NS
PTCA+DCA+Stent	10.3%	7.0%	NS
OUTCOME			
Angiographic success	86%	93.5%	<0.001
Side branch occlusion	7.3%	2.3%	<0.001
In-hospital MACE	7.2%	5.0%	<0.001
1-year MACE	32.1%	25.7%	<0.05

Al Suwaidi et al, Am J Cardiol 2001

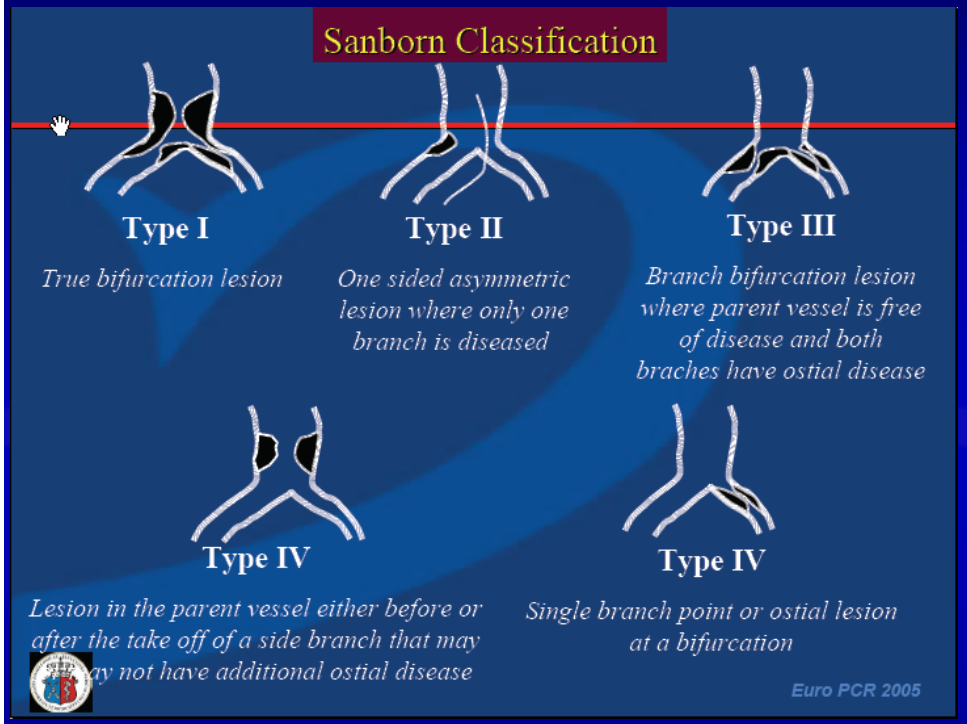
PRESTO Trial: MACE @ 9 Months According to Bifurcation or Nonbifurcation Lesions

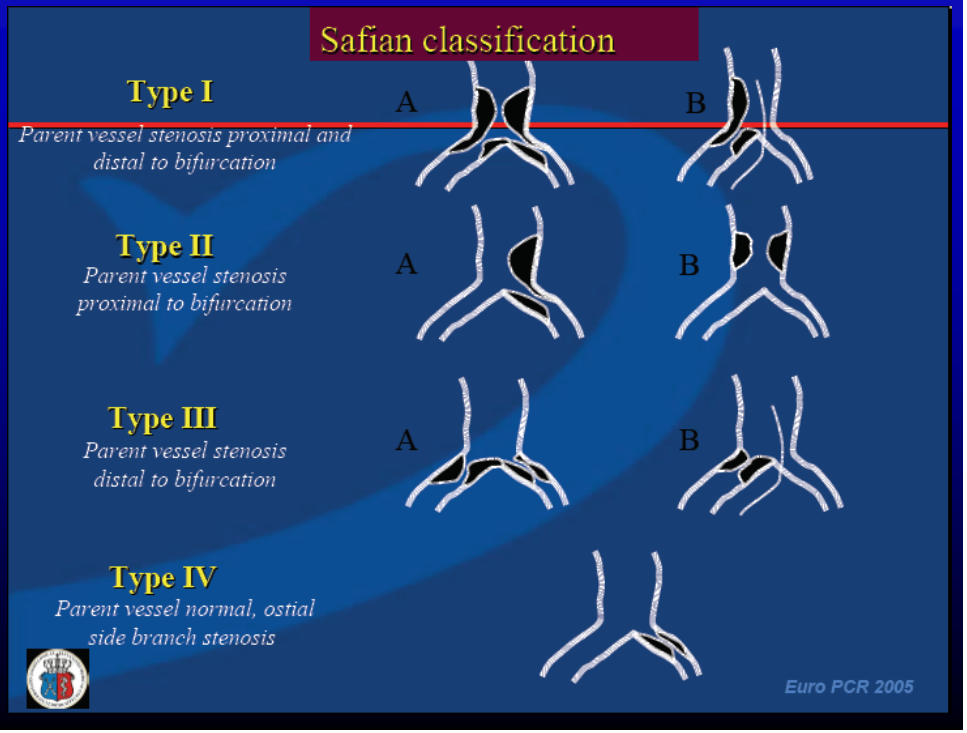
Variable/Event	Nonbifurcation Lesions (n = 10,068)	One or More Bifurcation Lesion (n = 1,412)	p Value
Death, MI, or TVR	1,499 (15)	256 (18)	0.002
Death or MI	247 (2)	29 (2)	0.36
Death	119 (1)	13 (1)	0.39
MI	141 (1)	17 (1)	0.55

Numbers in parentheses are percentages of the total.
CABG = coronary artery bypass grafting; MI = myocardial infarction; PTCA = percutaneous transluminal coronary angioplasty; TVR = target vessel revascularization.

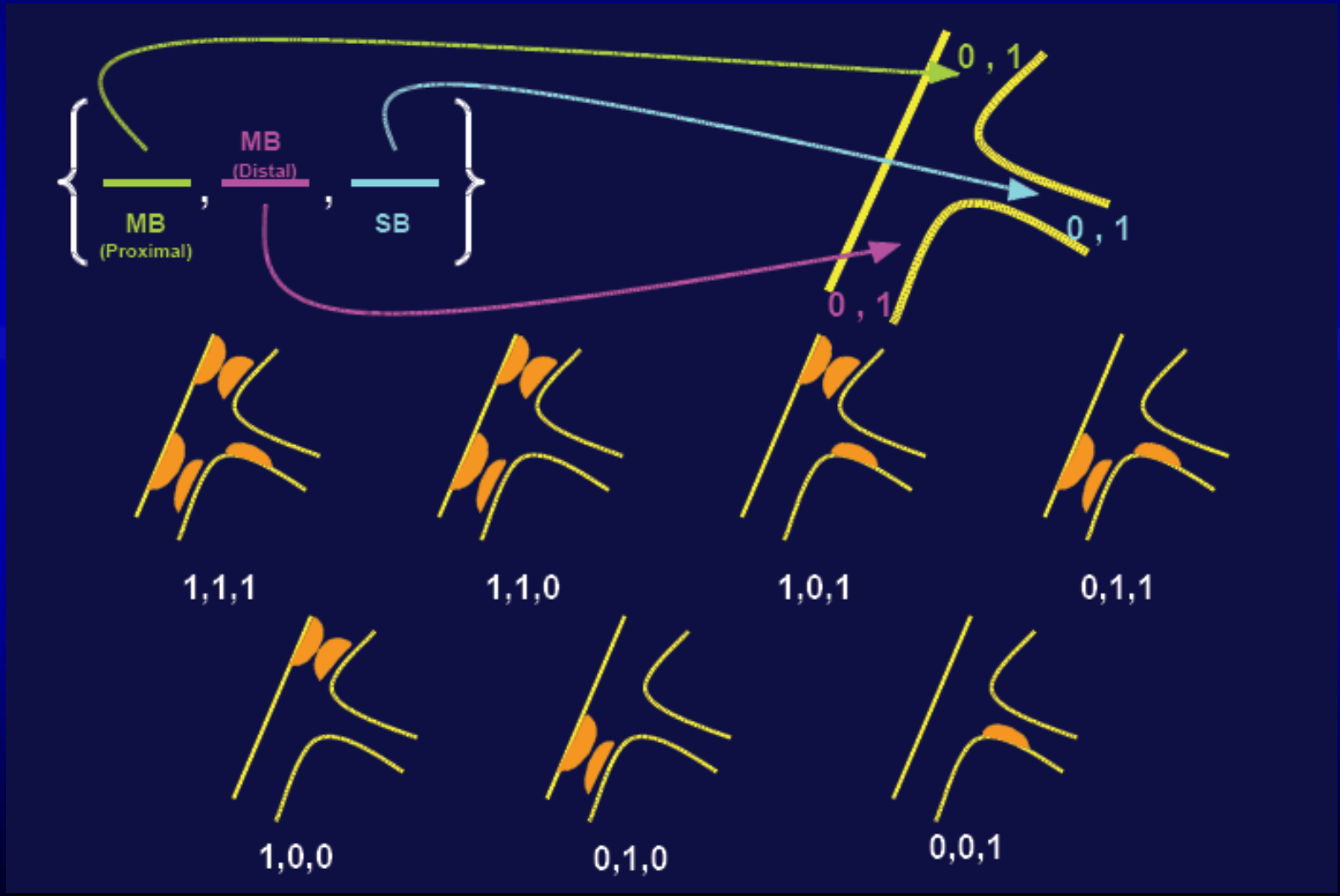
Garot P, et al; JACC 2005;46:606-612

Classification of Bifurcation Lesions



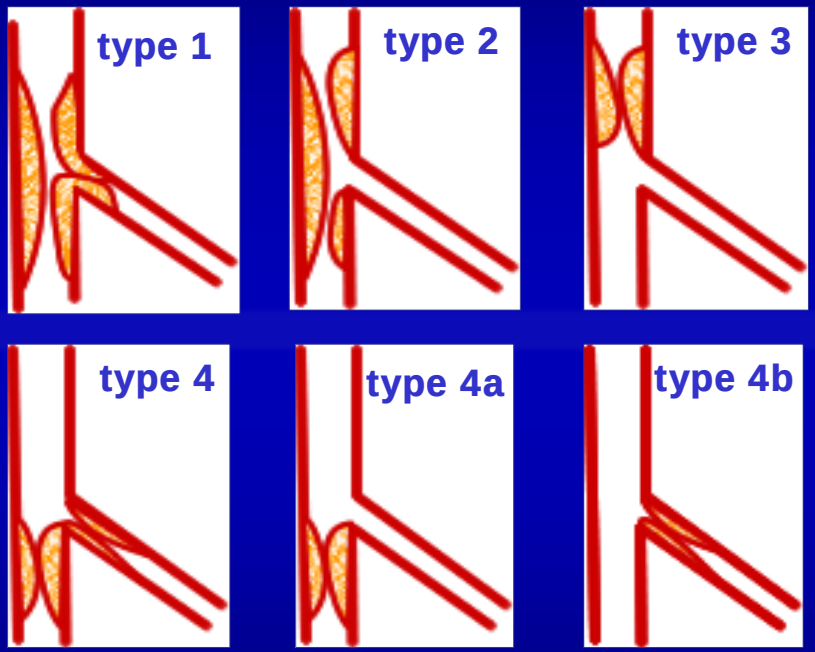


Medina Classification



Classification of Bifurcation Lesions

Morphology

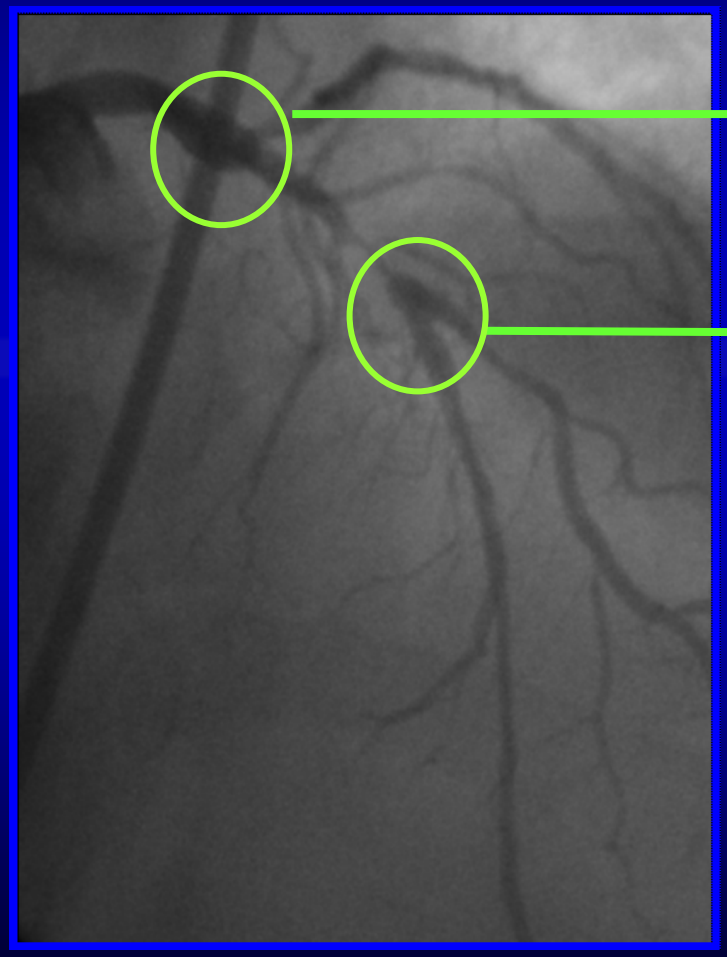


Type 1: true bifurcation lesions

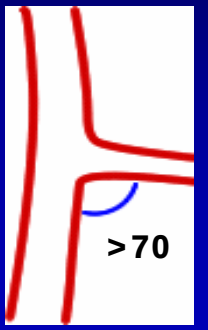
Types 2-4: pseudo-bifurcational lesions

Lefevre T et al, Catheter Cardiovasc Interv 2000

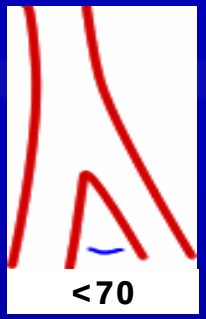
Classification by the Angle of Bifurcation Lesions between MB and SB



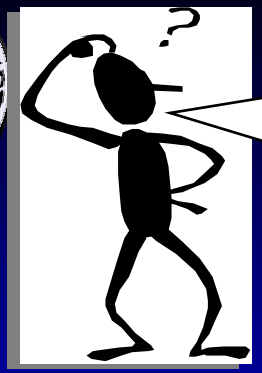
T shape



Y shape



SB access:	easy	difficult
Plaque shift:	more	less



Does The Side Branch Need Wire Protection?

Which is the risk of closure while treating the main branch (severity of ostial involvement and angle of origin)?

What is the size of the side branch?

Side Branch Occlusion during PCI

- Generally clinical sequelae are transient chest pain and ST-T wave changes
- A small percentage of patients develop Q-wave infarction or require emergency surgery as long as main vessel remain patent
- Non Q-wave myocardial infarction undoubtely occurs frequently (serial systematic evaluation of enzymes not available)

Risk of Acute Side Branch Occlusion

	Occlusion rate (%)
Side branch with minimal disease	< 4
Side branch with significant disease	> 27

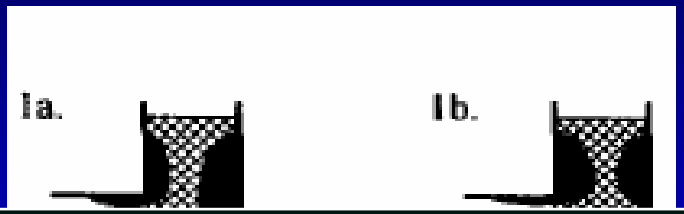
Meier B et al. Am J Cardiol 1984; 53: 10-4

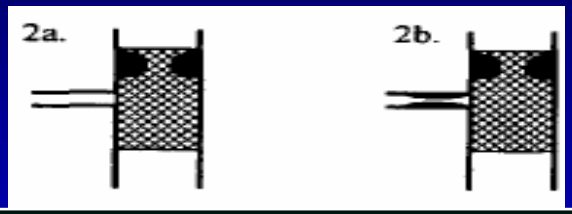
Incidence and Predictors of Side Branch Occlusion Following Stenting

	Occlusion	No occlusion	P value
Patients (n)	10	156	-
Calcifications (%)	0	16	NS
Lesion eccentricity (%)			
Concentric	0	12.9	
Excentric IPSI	80	49	0.143
Excentric Contro	20	38.1	
Angle >70° (T shape)	140° ± 19°	137° ± 26°	NS
Angle <70° (Y shape)	42° ± 22°	60° ± 22°	0.033
Stenosis main branch (%)	58±10	62±12	NS
side branch (%)	46±20	38±21	NS
Jailed guide wire technique (%)	80	91	NS

Y. Louvard, T. Lefèvre et al, TCT 2004

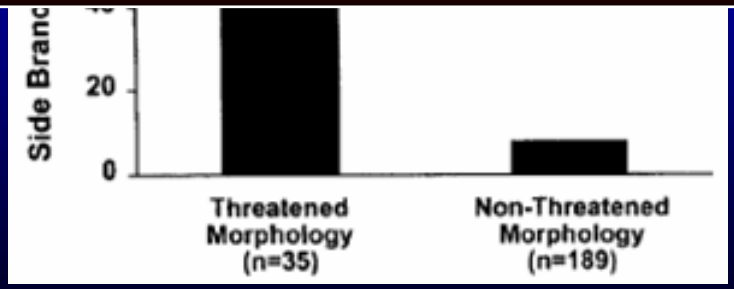
Incidence and Predictors of Side Branch Occlusion Following Stenting



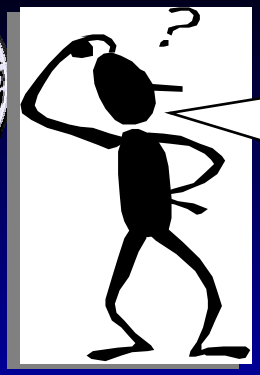


Thus, nonthreathened side branch of a small size should not be wired!!!

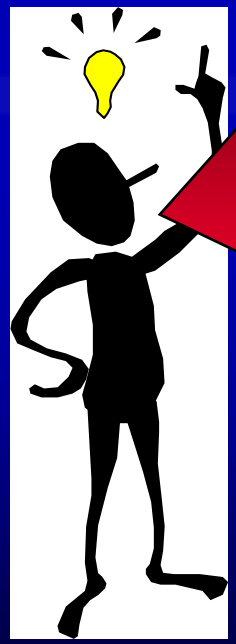
Side branch >2.0 mm that are at risk of closure should be protected!!!



Aliabadi et al, Am J Cardiol 1997

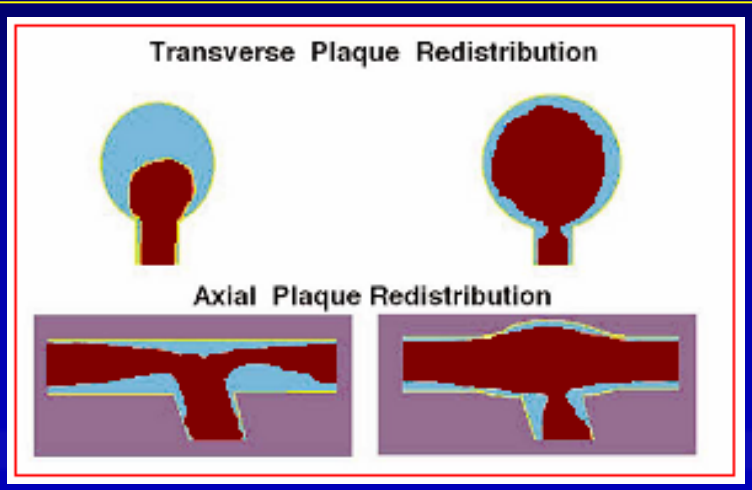


Does The Side Branch Need Balloon Dilatation?

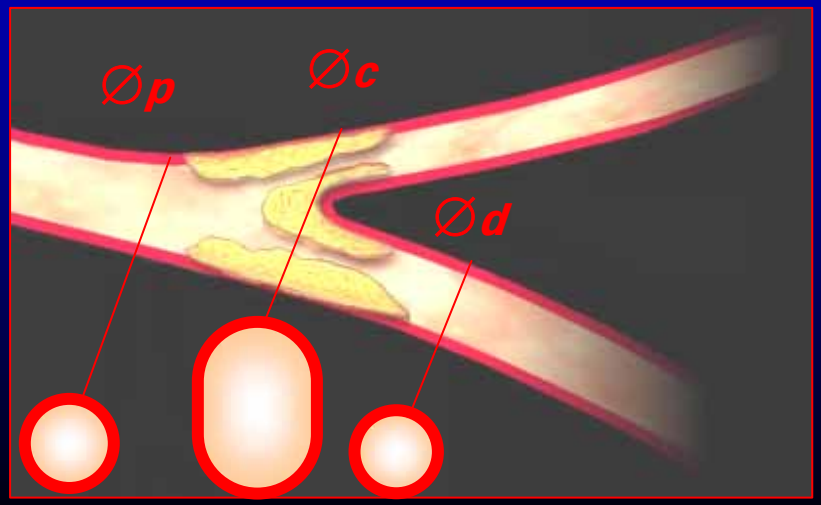


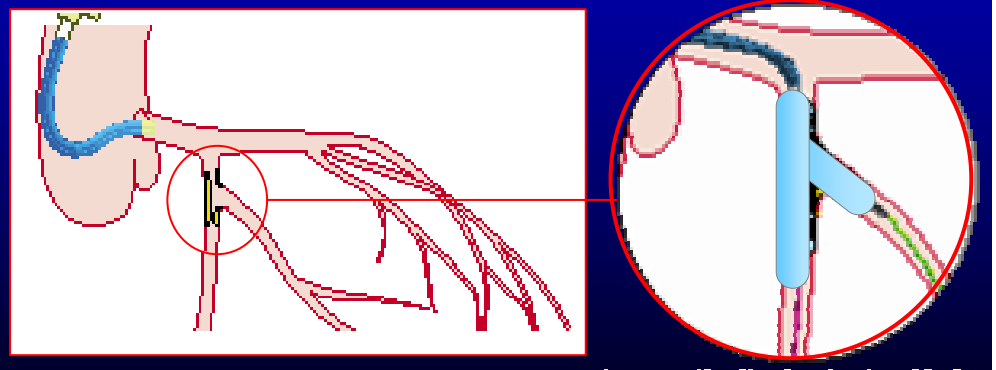
…if the side branch is ≥ 2.5 mm in diameter
with ostial disease or at risk of plaque shift elective balloon dilatation with or without kissing balloon is advised…
……. but remember no oversized balloon in the side branch to prevent dissection!!!

Common Approaches to Bifurcation Lesions: the Role of Kissing Balloon



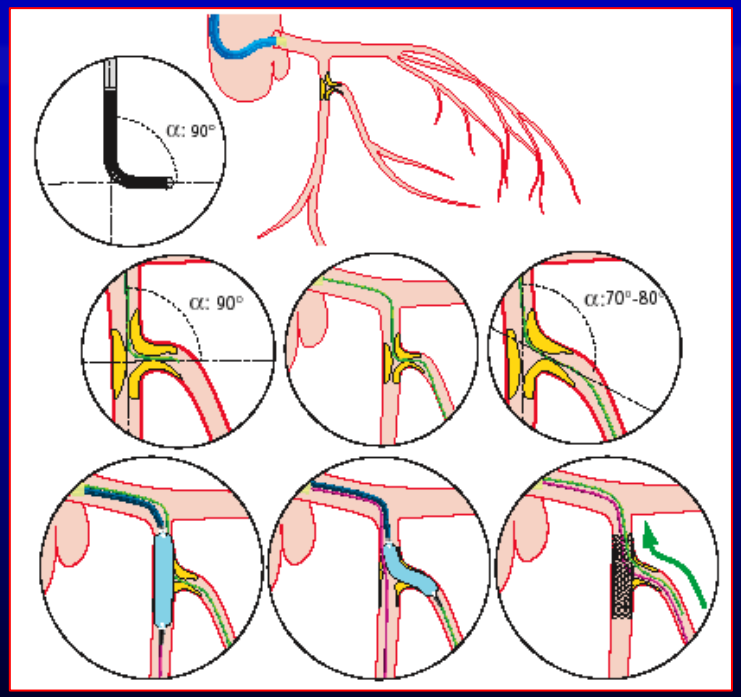
Pre-dilatation *with Kissing Balloon* it avoids closure of side branch (or main vessel) by plaque shift





Common Approaches to Bifurcation Lesions: the Role of Jailed Wire

- Guide wire is left inside the side branch during main vessel stenting
- Side branch guide wire is jailed between main vessel stent struts and main vessel wall



- Used in T shaped Bifurcations in order to favorably modify the angle between the two vessels thus facilitating side branch re-wiring
- Helps to maintain side branch patency
- In case of side branch closure assures side branch traceability by radiopaque distal wire

Jailed Wire Effect on Proximal Main Branch/Side Branch Angle

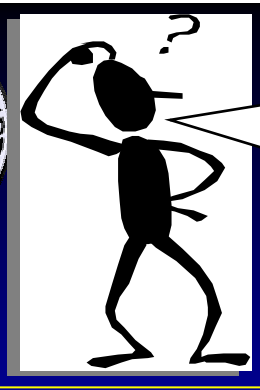
	Baseline	Wiring	° modification	p value
Angle A > 120° (%)	77	87	-	<0.02
Angle A (°)	149±17	160±18	+ 11	<0.001
Angle A ≤ 120° (%)	23	13	-	<0.02
Angle A (°)	107±11	140±19	**+ 33**	<0.001

Y. Louvard, T. Lefèvre TCT 2003

Angiographic Predictors of Side Branch Success (Lesion <50% by QCA)

Age (years)	66±11 vs 57±8	p=0.0007
Larger MB reference (mm)	3.1±0.4 vs 2.8±0.3	p=0.0085
Larger SB reference (mm)	2.5±0.5 vs 2.2±0.3	p=0.0413
Kissing balloon (%)	98.1 vs 76.5	p=0.0019
"Jailed wire technique" (%)	92.9 vs 71.4	p=0.031

T. Lefèvre, Y. Louvard, unpublished



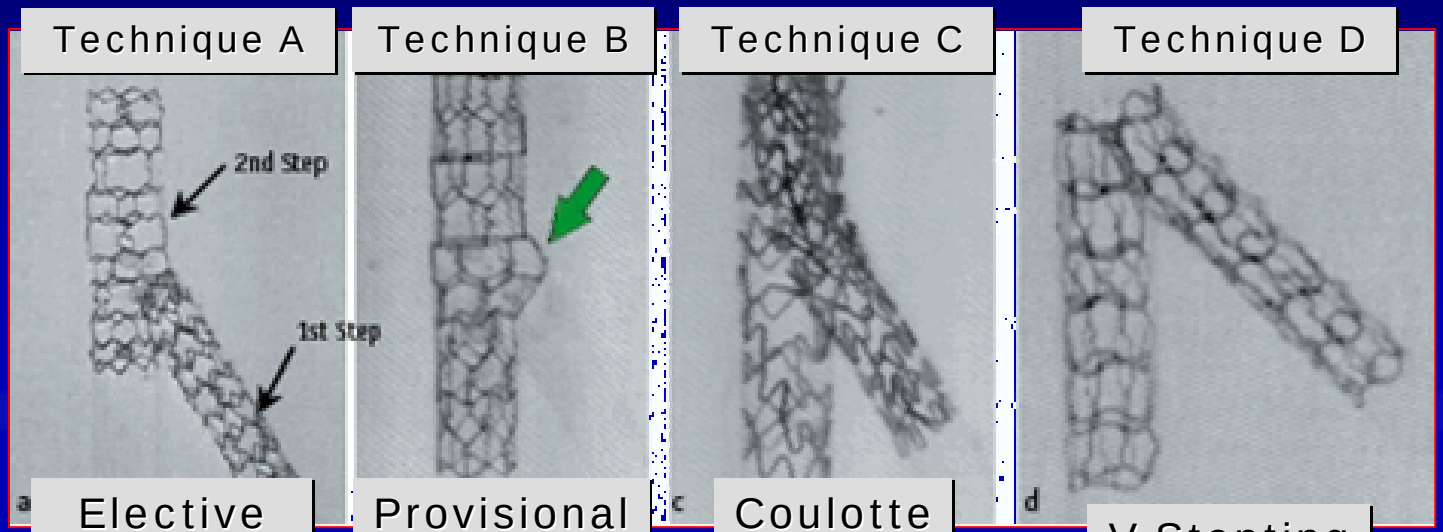
Does The Side Branch Need Protection by a Stent?

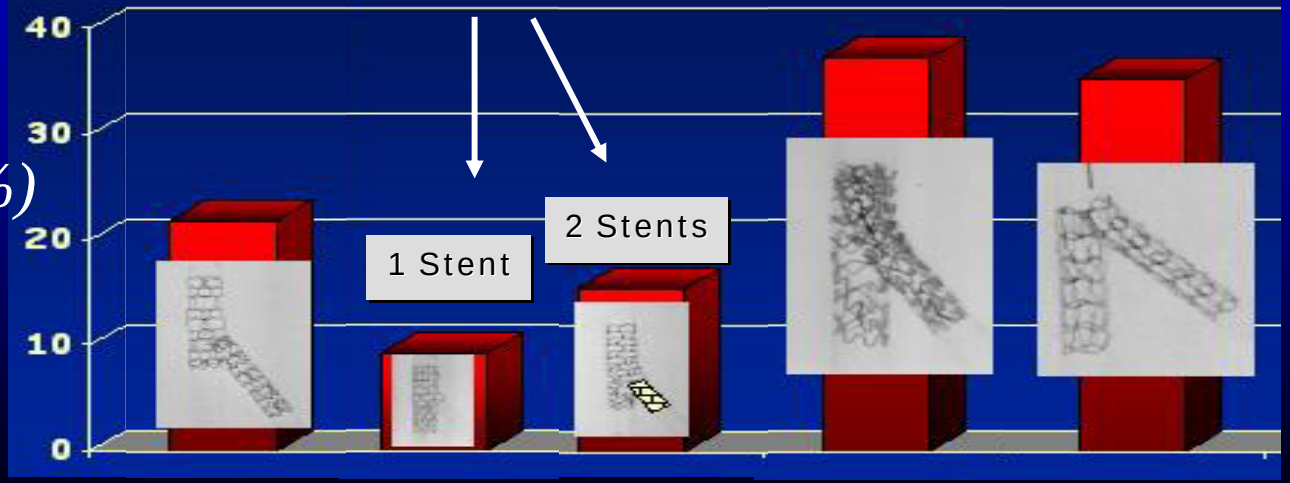
- **Is the side branch a large vessel?**
- **Does the side branch comes out from the main with an acute angle?**
- **Does the ostium or the proximal segment of the side branch have a significant narrowing?**
- **Is the side branch very difficult to be wired?**
- **Is the patient a very high risk patient and the side branch appears relatively important?**
- **Is the main branch severely narrowed with a lot of plaque burden?**

If the answer is YES Antonio Colombo's suggestion is that the operator will lean more towards two stents

… sometimes a decision should be made only following predilatation of the main branch and of the side branch!

Common Approach to Bifurcation Lesions With Stents



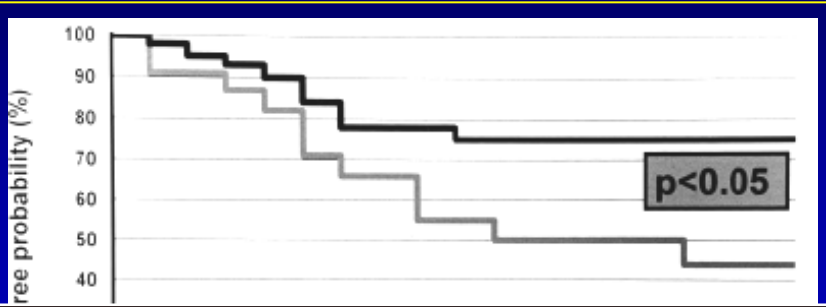


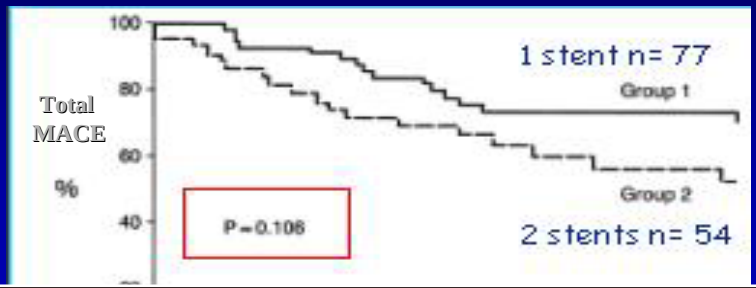
TVR (%)

Sengotuvel, Lefevre, Louvard et al

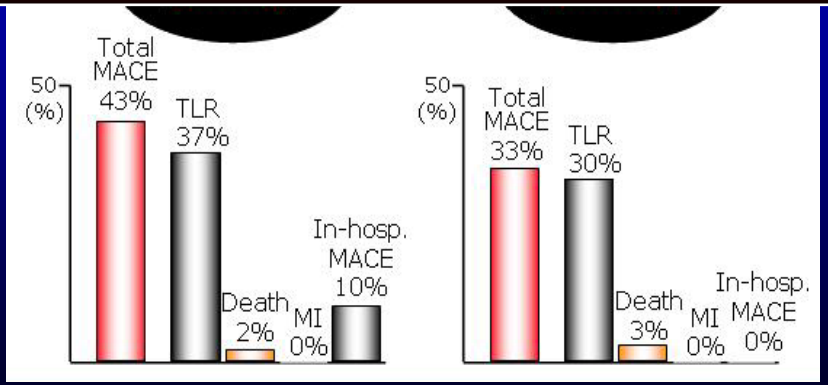
ACC 2004

1 Stent vs 2 Stent in the Bare Metal Stent Era (1994-2002)





No advantages of complex vs simpler strategy!



Yamashita et al, JACC 2000

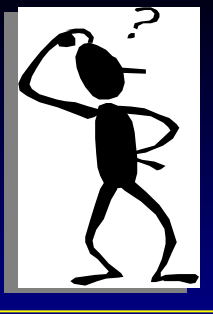
Procedural success (%)	97.9	97.3	99.2	NS
MACE at 30 days	1 (MI)	0	0	
Angiographic restenosis				
Both vessels (%)	27.8	25.8	*12.5	p<0.05
Parent vessel (%)	18.2	15.7	12.0	NS

*p<0.05 Single stenting vs Y-stenting and T-stenting
MACE: Major Adverse Cardiac Event (death/CABG/MI)
TLR: Target Lesion Revascularization

"St. of both Vx offers no advantage over st. one parent V in term of immediate and long-term results".

Nakamura et al, AHA 2002

Does The Side Branch Need a Stent?

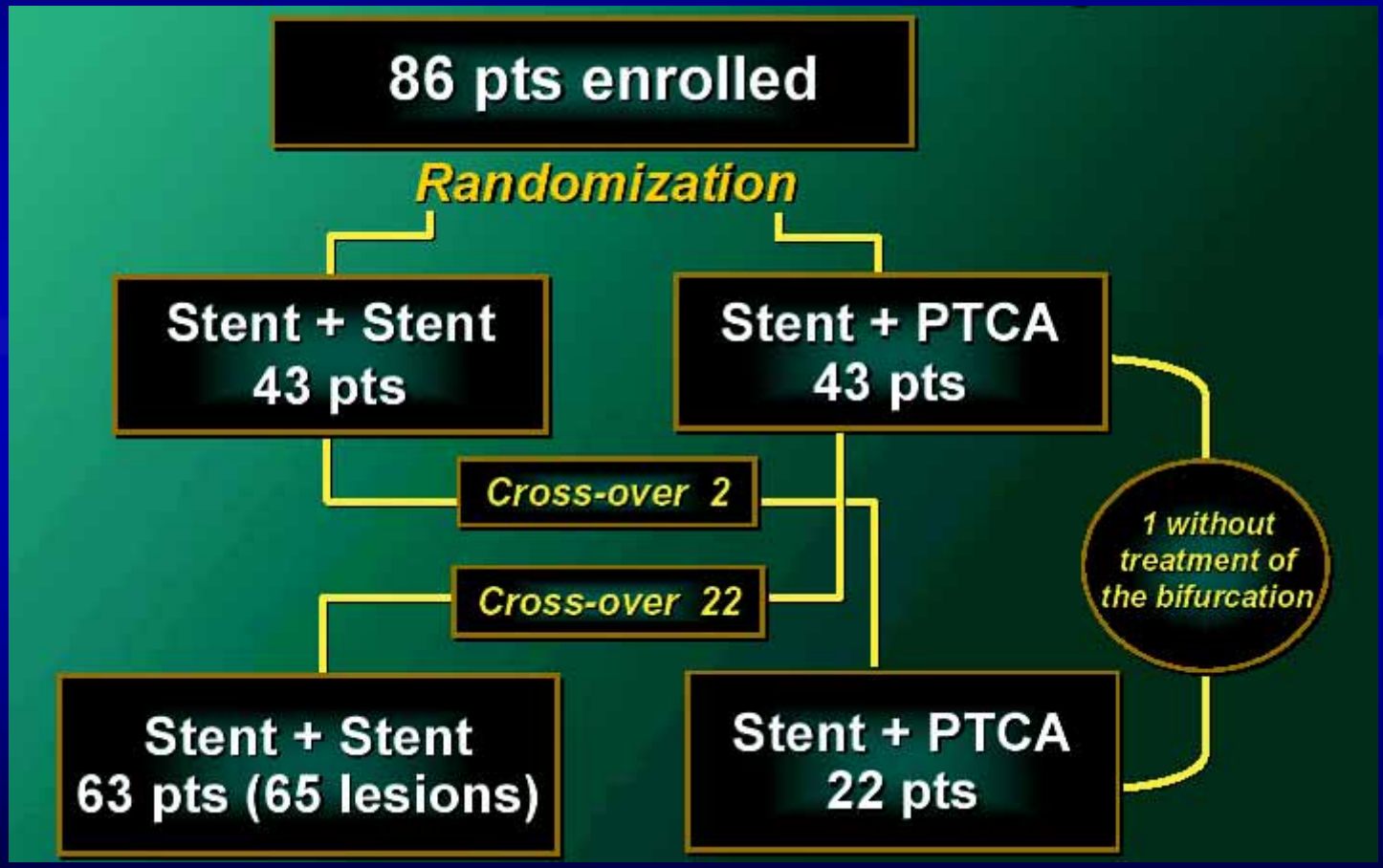


common thinking in BMS era

… *if side branch is ≥ 2.7 mm in diameter* elective stent implantation of both the main branch and the side branch should be performed!

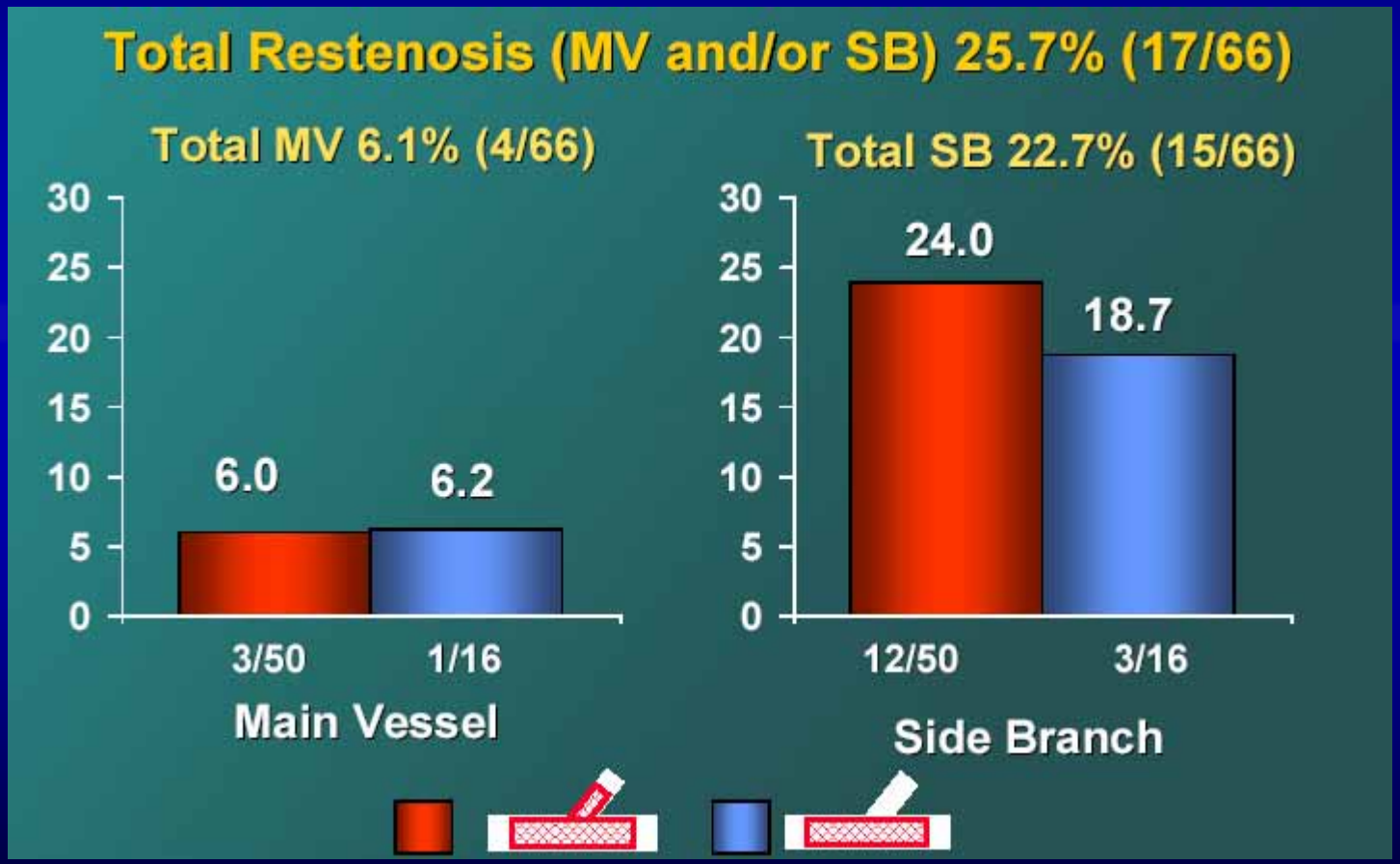
… *if side branch is < 2.7 mm in diameter* single stent implantation of the main vessel followed by side branch dilatation may be advised!

Randomized Study to Evaluate SES Implantation at Bifurcation



Colombo et al, Circulation 2004

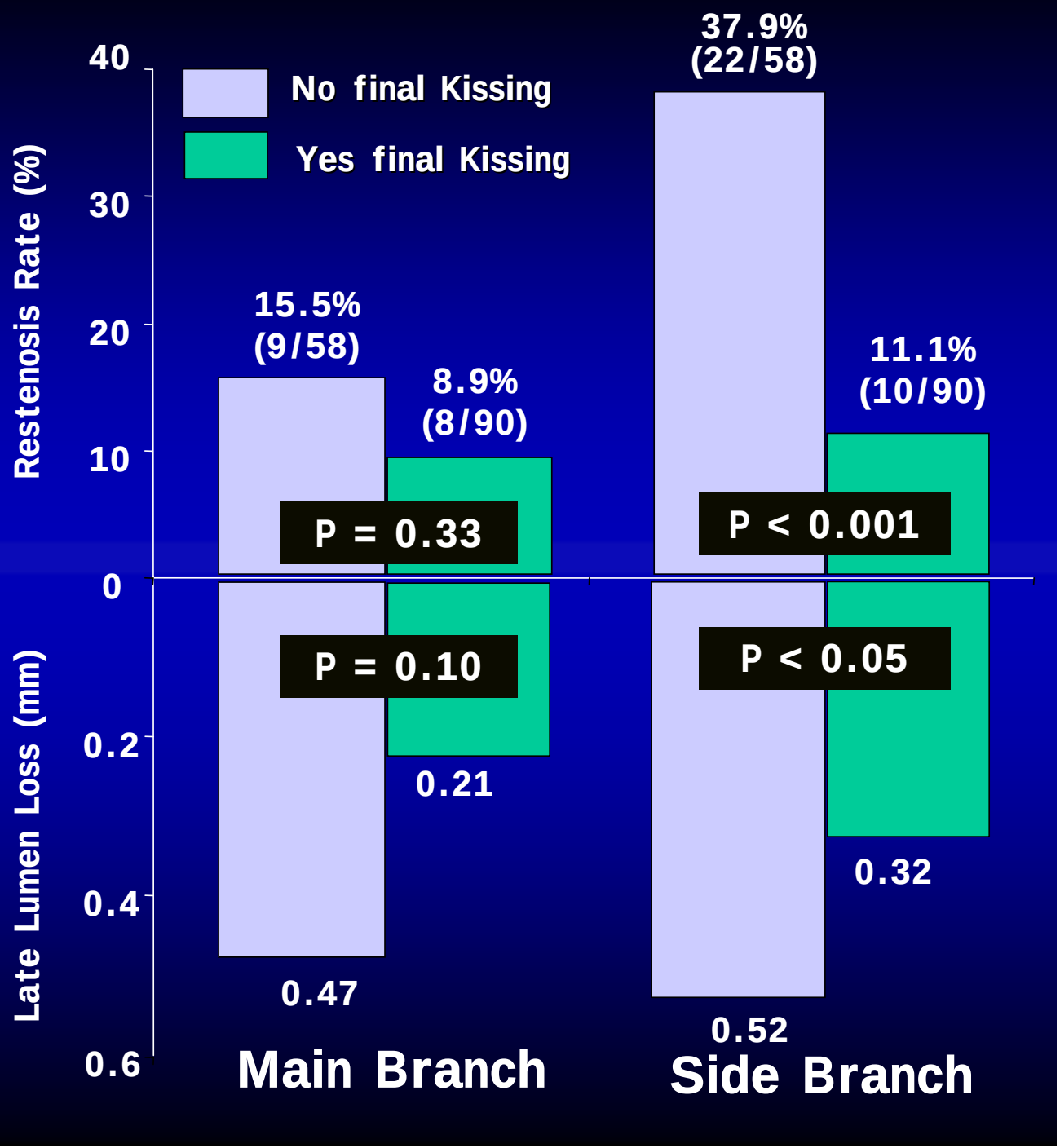
Randomized Study to Evaluate SES Implantation at Bifurcation



Colombo et al, Circulation 2004

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

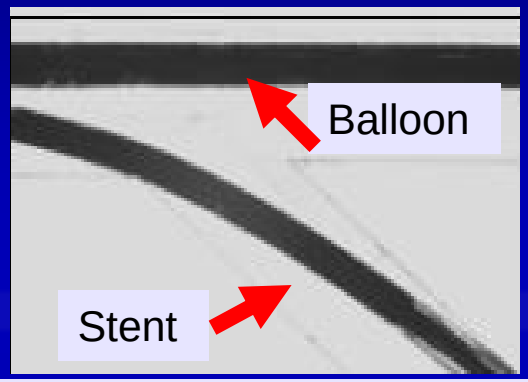
Ge et al. JACC 2005

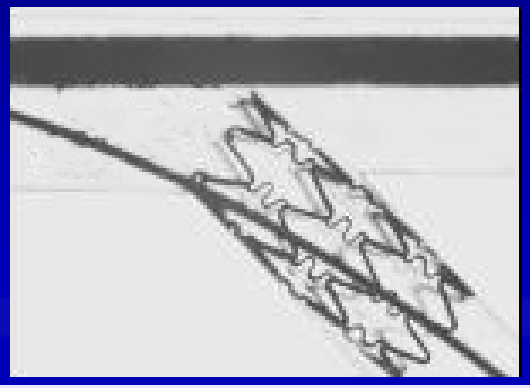


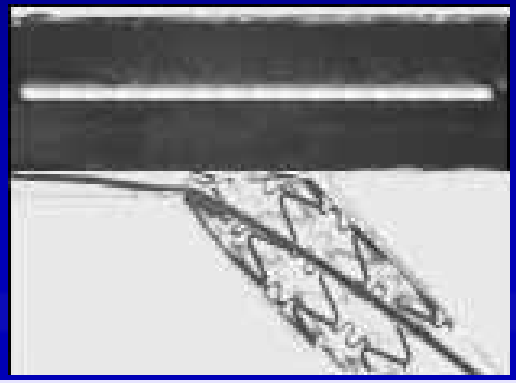
Crush Technique in the DES era

- **Standard Crush (external crush):** 7F, two stents in position together, side branch inflated first, main branch stent crushes side branch
- **Reverse Crush (internal crush):** used when provisional stenting requires another stent in the side branch: 6F, main branch stent deployed first, side branch stent is crushed against the main vessel stent with a balloon
- **Inverted Crush:** makes recrossing easier and improves side branch coverage: 7F similar to Standard Crush but the side branch stent is positioned more proximally than the main branch stent, the side branch stent will crush the main branch stent
- **Step Crush:** as standard Crush but can be done with 6F. Advance and deploy stent in side branch

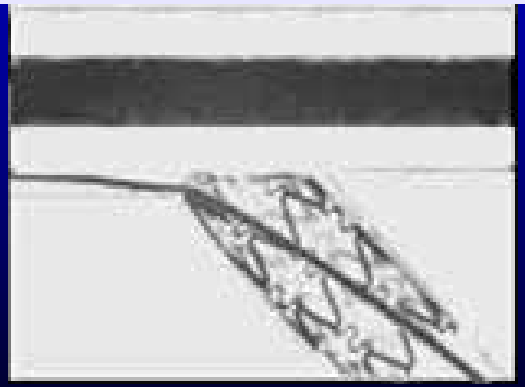
The “Modified Crush” Technique

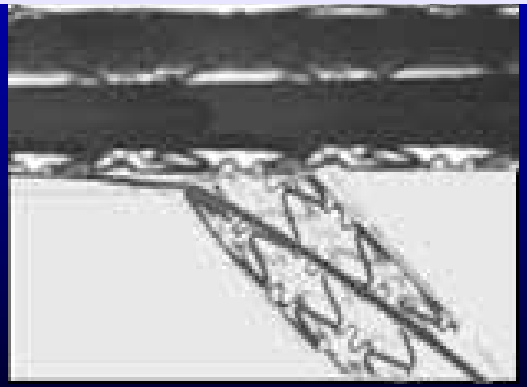




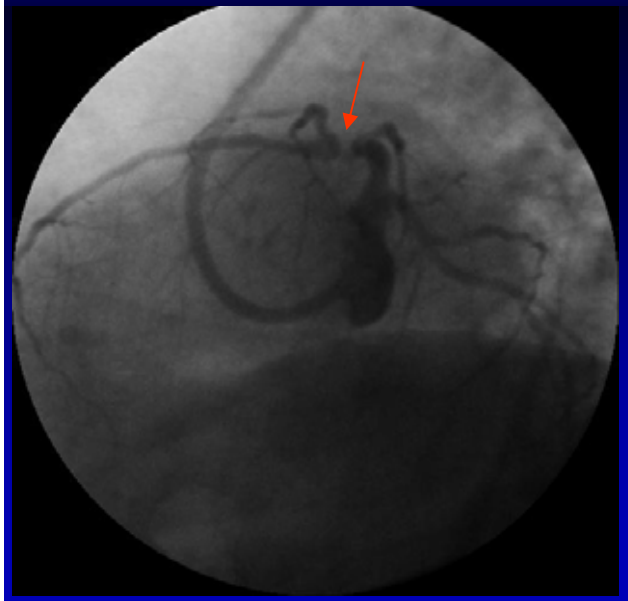


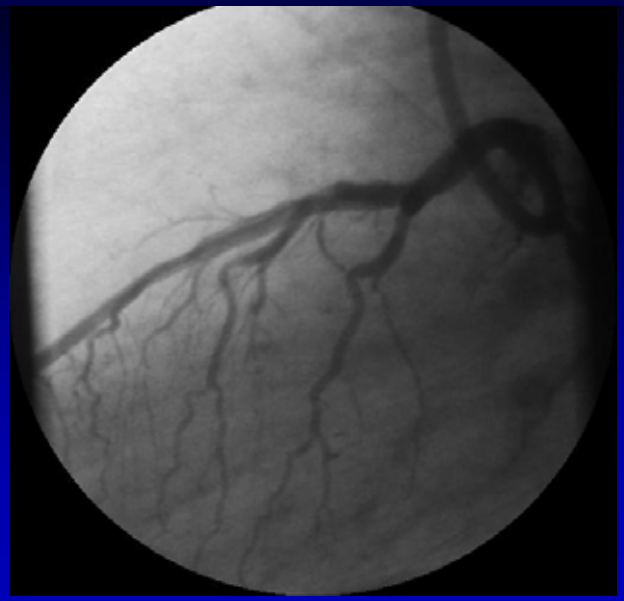
Post dilatation with kissing balloon is performed
(a 3rd guide wire may be employed)





Modified Crush in a Trifurcation Lesion

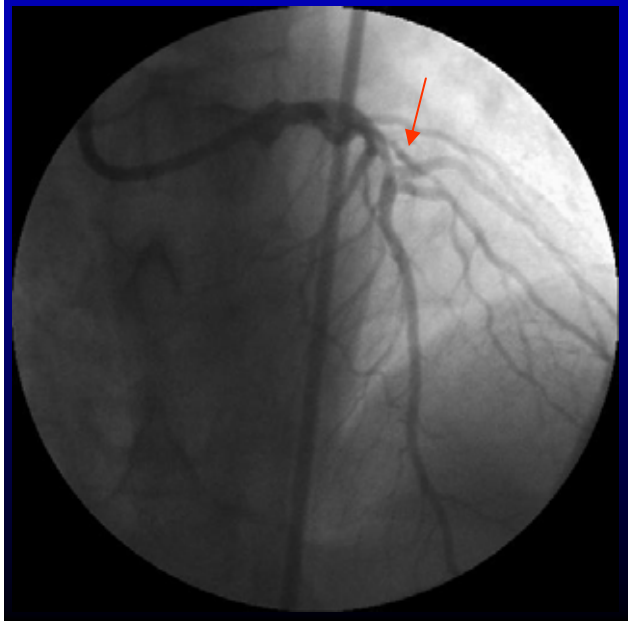


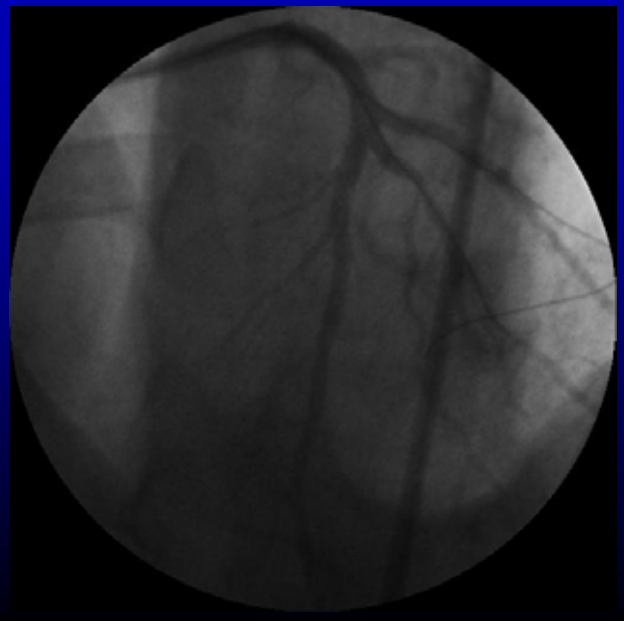


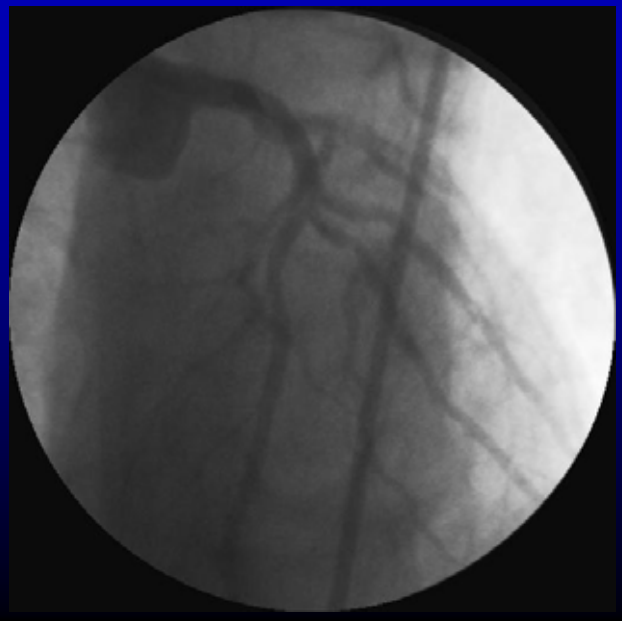
PRE

POST

6 mo ANGIO FU







Procedural, in-hospital, 30-day and 8-month FU Results

Galassi AR, Buchbinder M, Colombo A et al Catheter Cardiovasc Interv 2006 (abstr)

	Immediate and 30-Day pts 45/45	*8-month pts 45/45, lesions 52/52*
Non-Q MI (%)	0	1/45 (2,2)
Q-MI (%)	0	0
Death (%)	0	0
Re-PTCA (%)	0	7/45 (15.5)
TLR (%)	0	6/45 (13.3)
TBR (%)	0	3/52 (5.7)
Acute thrombosis (%)	0	.....
Subacute thrombosis (%)	0	.....
Late thrombosis (%)	.....	1/45 (2,2)
Main branch restenosis (%)	0	5/52 (9.6)
Side branch restenosis (%)	0	1/52 (1.9)
CABG (%)	0	0
Total MACE (%)	0	7/45 (15.5)

QCA Angiographic Findings (52 lesions)

Galassi AR, Buchbinder M, Colombo A et al Catheter Cardiovasc Interv 2006 (abstr)

MAIN BRANCH			
	Pre-procedure	Post-procedure	Angio follow up
Lesion lenght (mm ± DS)	16,59 ± 9,45	4,60 ± 2,25	6,00 ± 2,71
RVD (mm ± DS)	2,69 ± 0 ,48	2,81 ± 0,45	2,79 ± 0,50
MLD (mm ± DS)	0,90 ± 0,55	2,21 ± 0,49	2 ± 0,64
DS (% ± DS)	68 ± 17,81	22 ± 10	29,38 ± 16,74
SIDE BRANCH			
	Pre-procedure	Post-procedure	Angio follow up
Lesion lenght (mm ± DS)	7,84 ± 7 ,59	2,86 ± 1,32	3,97 ± 3,12
RVD (mm ± DS)	2,29 ± 0 ,33	2,30 ± 0,47	2,28 ± 0,40
MLD (mm ± DS)	1,12 ± 0,47	1,91 ± 0,45	1,64 ± 0,48
DS (% ± DS)	51,8 ± 19,26	17,4 ± 8,79	27,84 ± 16,82

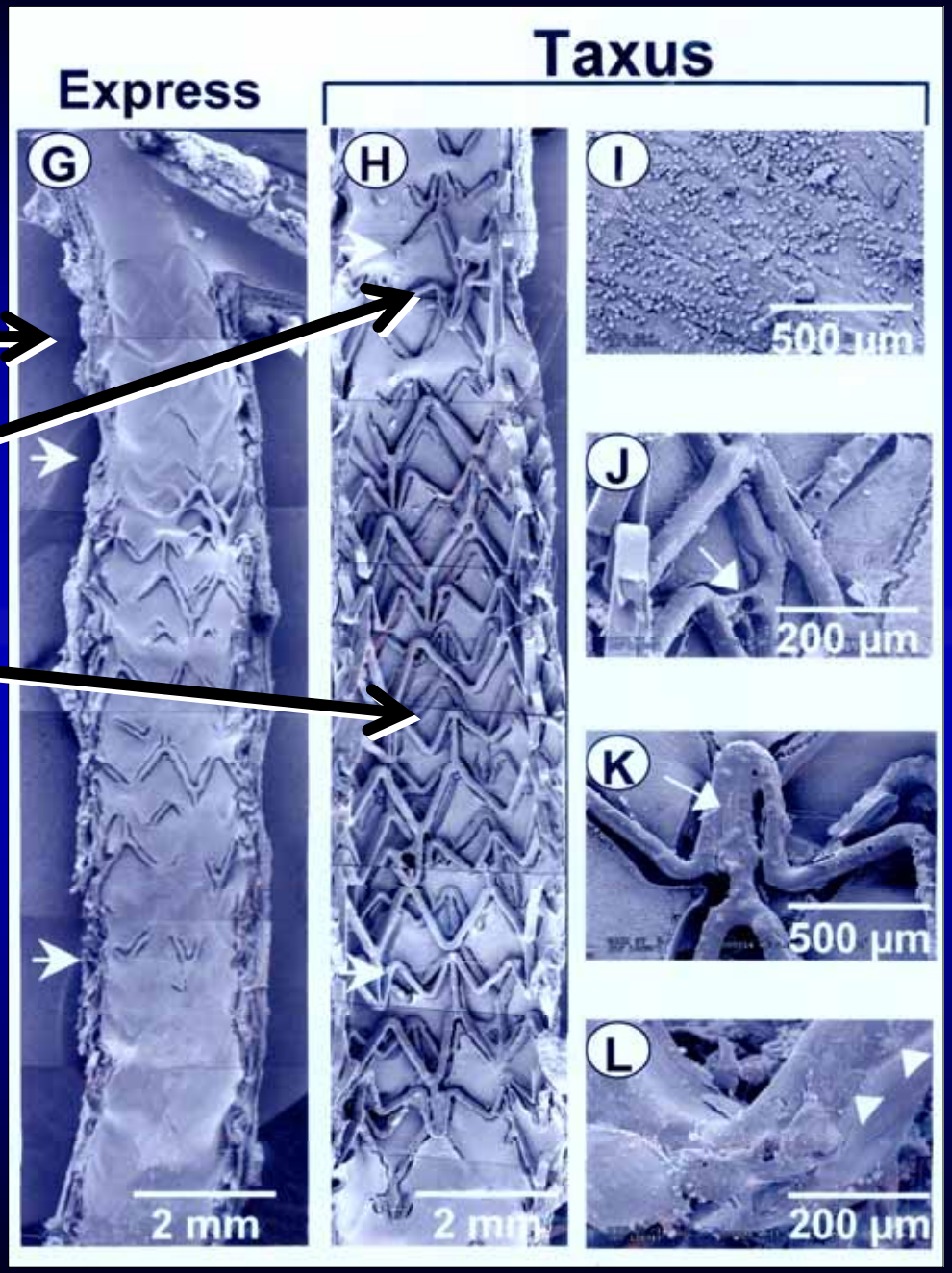
Recent Studies With DES

	RVD MainBranch SideBranch	Technique	Restenosis Rate		
			Total	Main	Side
Colombo A et al, Circulation 2004	2,60 ± 0,40 2,10 ± 0,30	Provisional Vs. T-, V-stenting and Crush	19 % 27,5 %	4,8 % 5,7 %	14,2 % 21,8 %
Tanabe K et al, Am J Cardiol 2004	2,64 ± N/A 1,99 ± N/A	T stenting Culotte V stenting Crush	22,7 %	9,1 %	19,6 %
Ge L et al., JACC 2005	2,81 ± 0,58 2,44 ± 0,58	Crush FKB Crush NoFKB	20 % 53,4 %	8,9 % 15,5 %	11,1 % 37,9 %
Galassi AR, Buchbinder M, Colombo A et al Catheter Cardiovasc Interv 2006 (abstr)	2,69 ± 0,48 2,28 ± 0,22	Modified crush	13,4 %	9,6 %	2,2 %

Endothelialization was complete after single or overlapping BMS

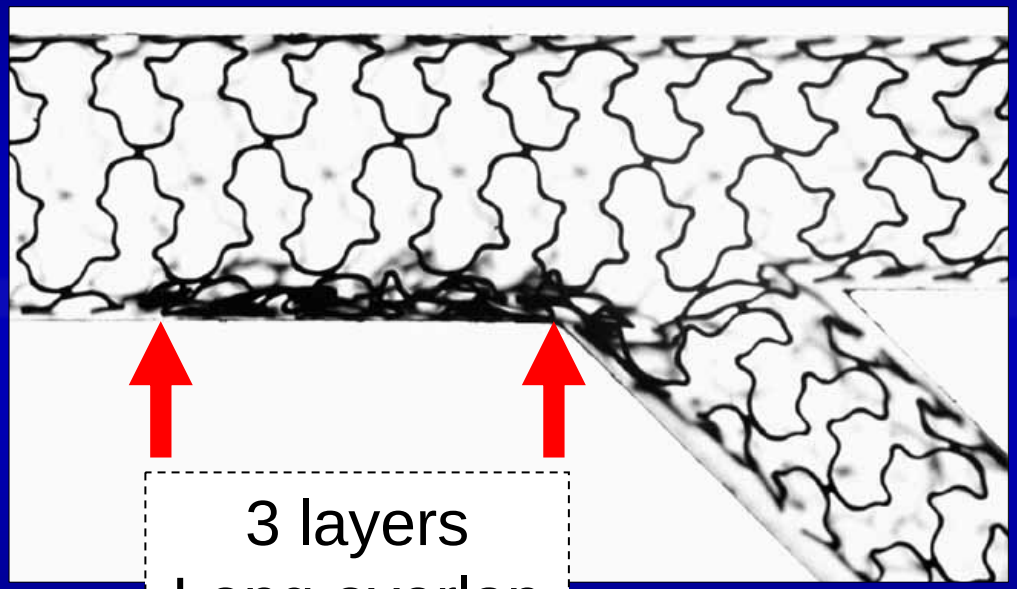
- ❑Reduced with single layer DES
- ❑Further reduced by overlapping DES

Does overlapping predispose to SAT?

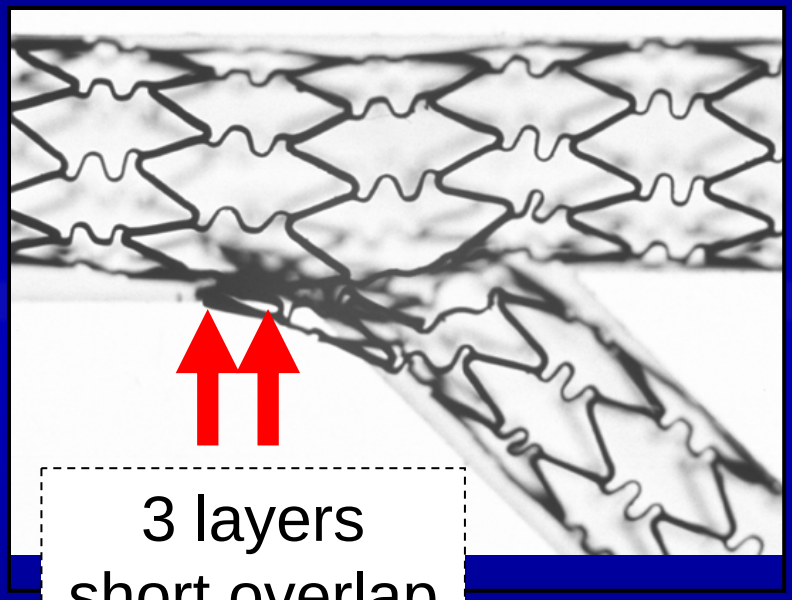


From John A. Ormiston

- The ideal bifurcation stent or strategy should not have multiple layers with current DES
- Or overlap should be limited eg with “crush”



3 layers
Long overlap



3 layers
short overlap

From John A. Ormiston

Appropriate Balloon Sizing for “Kissing” is Important

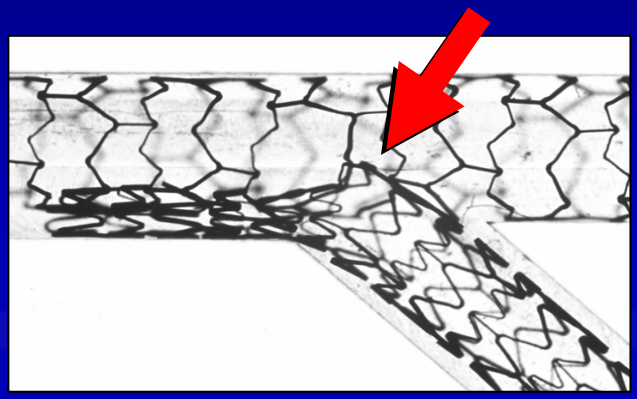
“If you get a crush you should kiss and if you kiss, you should do it well”

Colombo, Editorial CCVI, 2004;63

An undersized “kissing balloon” post-dilatation…..

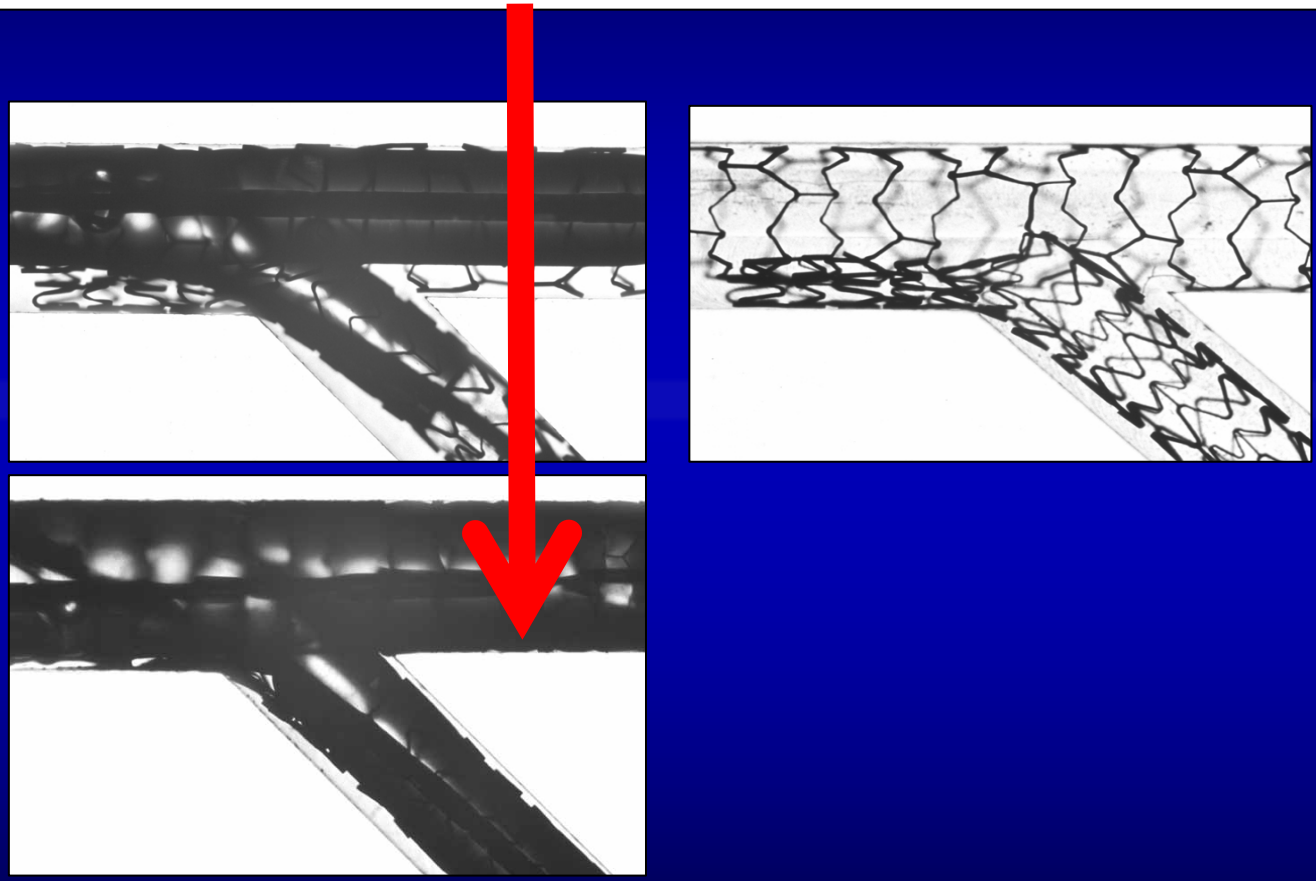
Ormiston CCVI 2004;63:332

.....causes distortion after “crush”



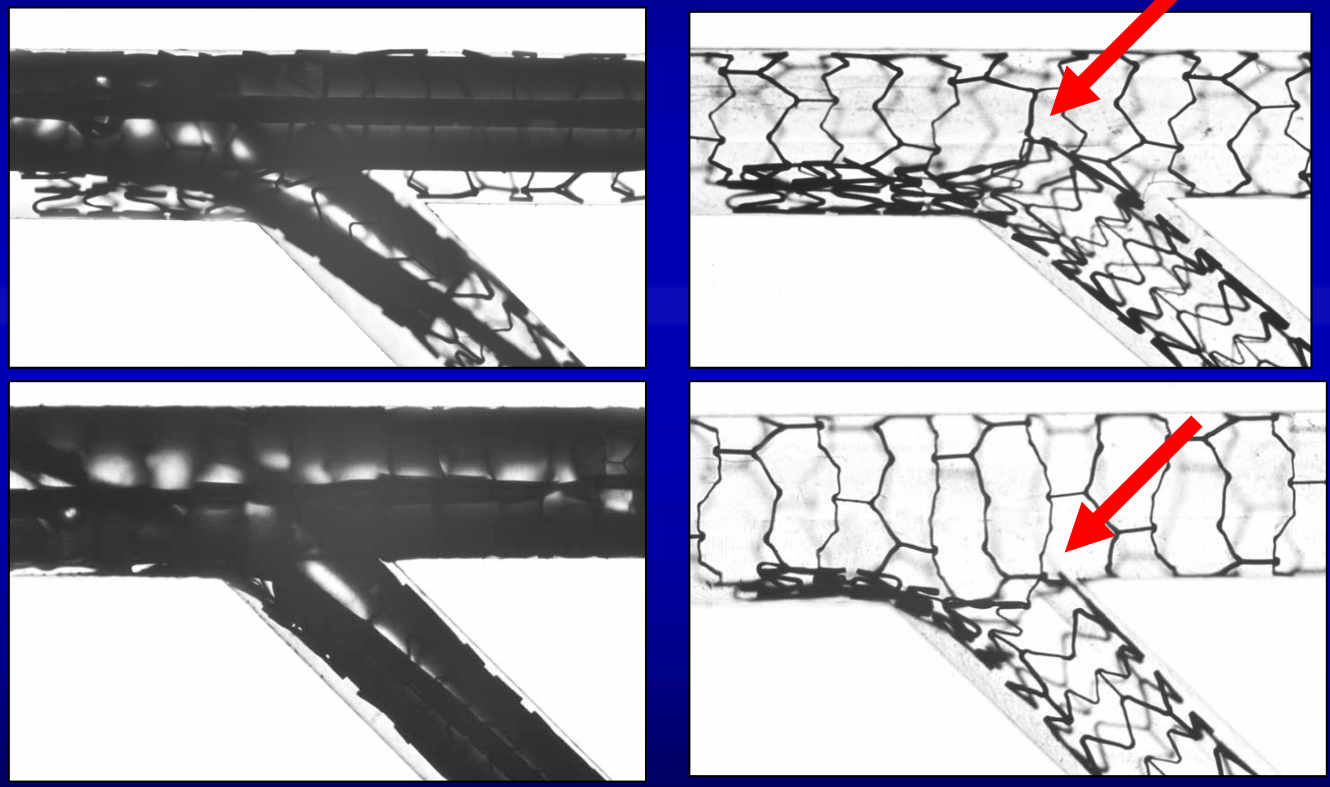
Ormiston CCVI 2004;63:332

An appropriately sized main branch “kissing” balloon……



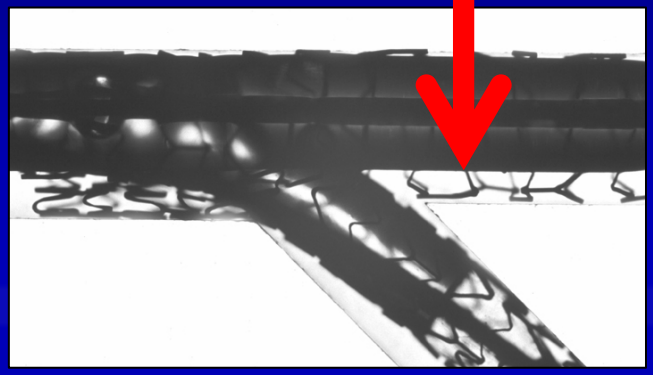
Ormiston CCVI 2004;63:332

…….repairs (or prevents) distortion



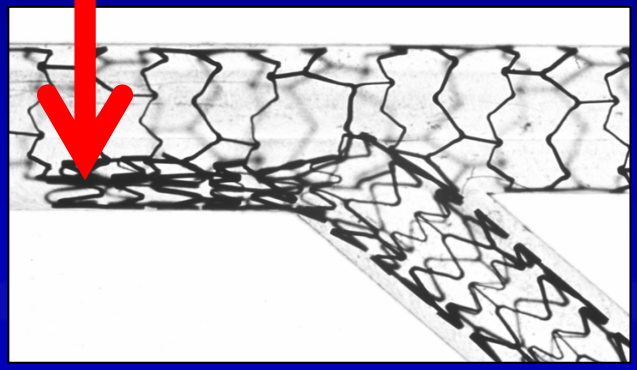
Ormiston CCVI 2004;63:332

In addition, an undersized “kissing balloon” post-dilatation…..



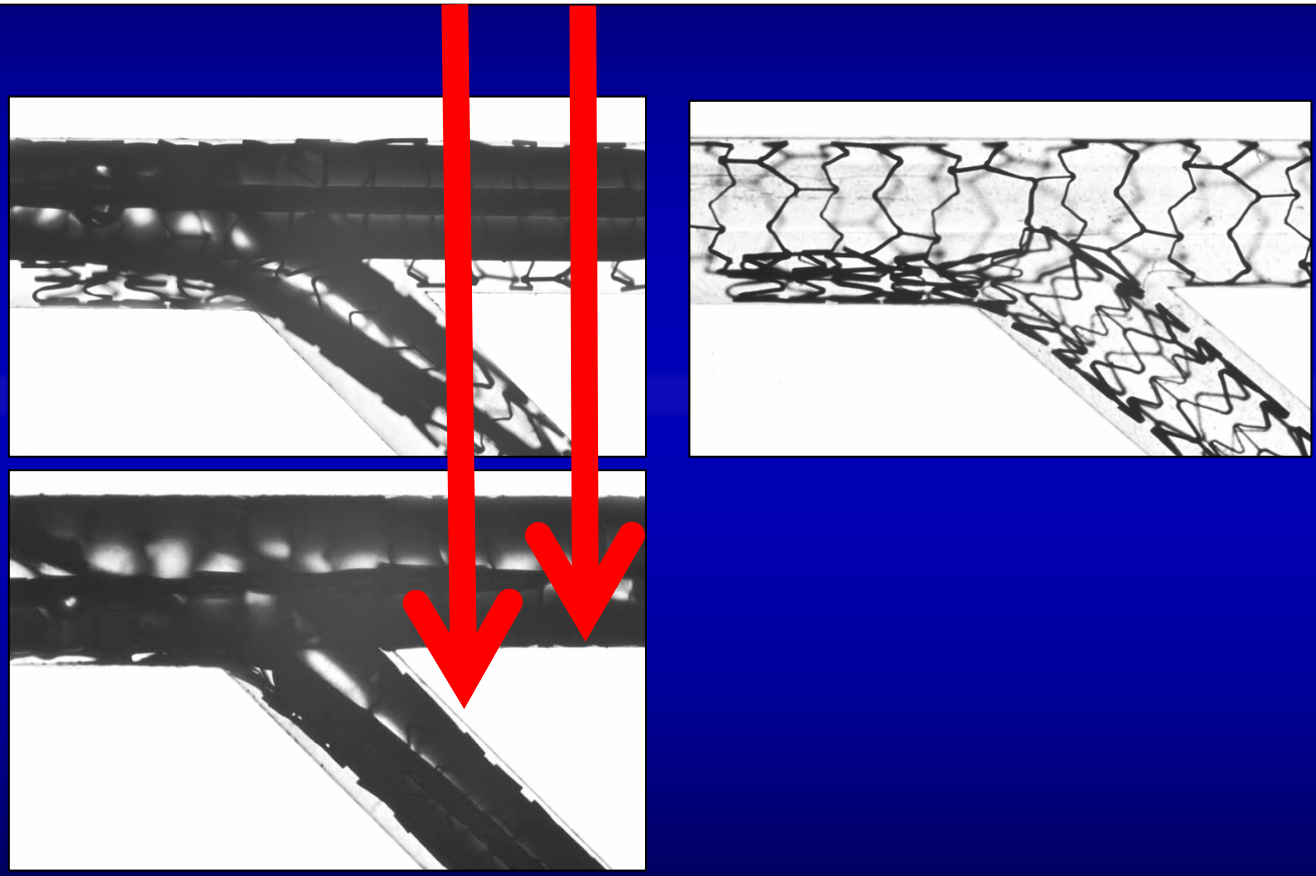
Ormiston CCVI 2004;63:332

……may incompletely crush the side-br stent in the main branch



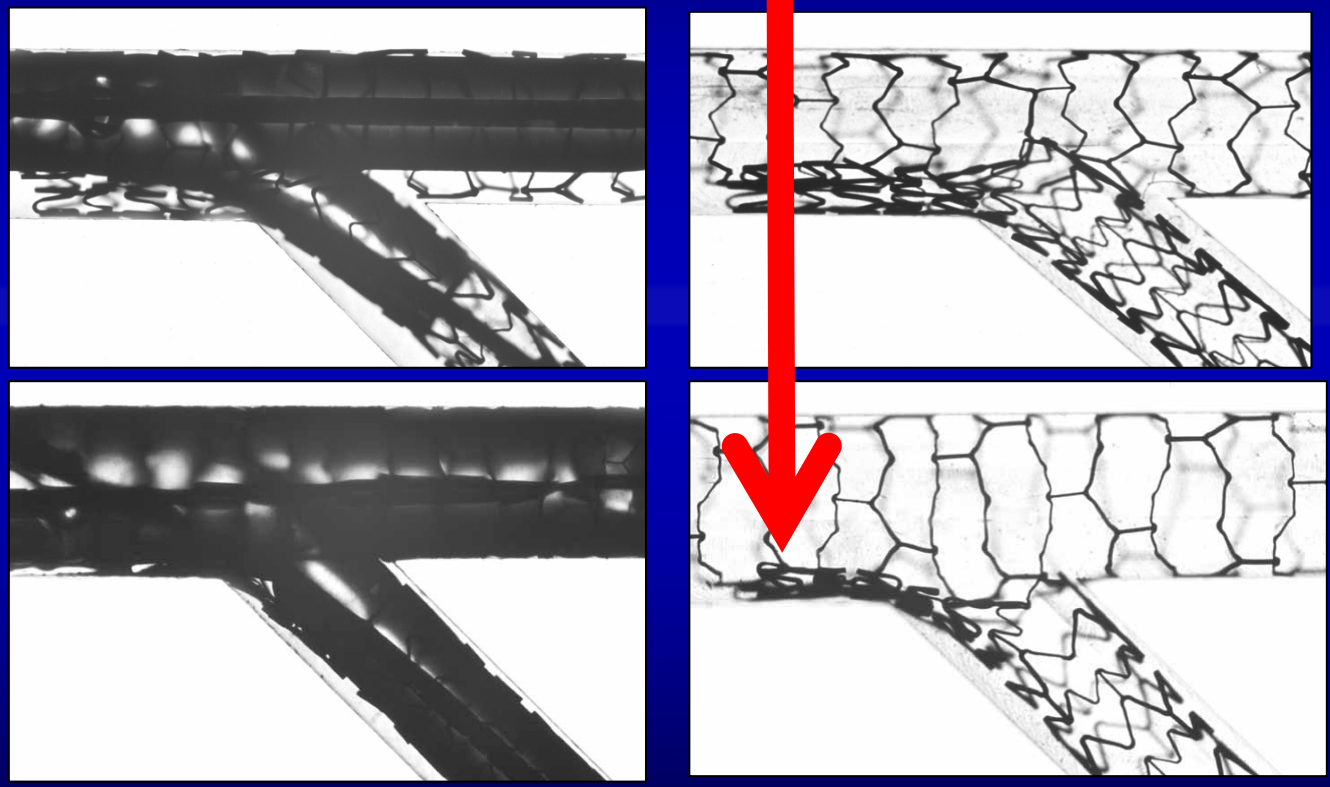
Ormiston CCVI 2004;63:332

Appropriately sized main and side-branch “kissing” balloons……



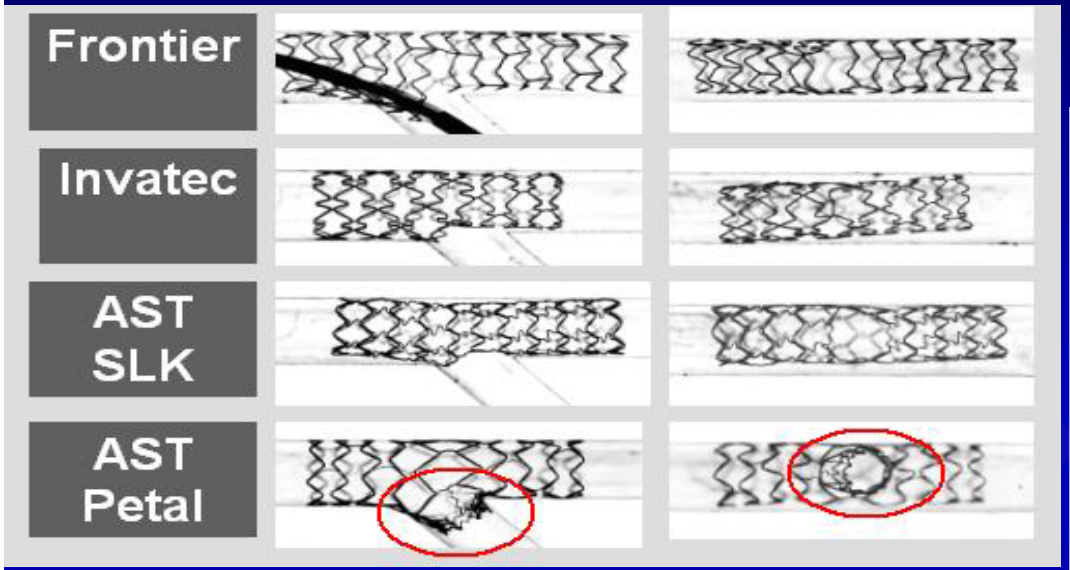
Ormiston CCVI 2004;63:332

….completely crush the side-branch stent

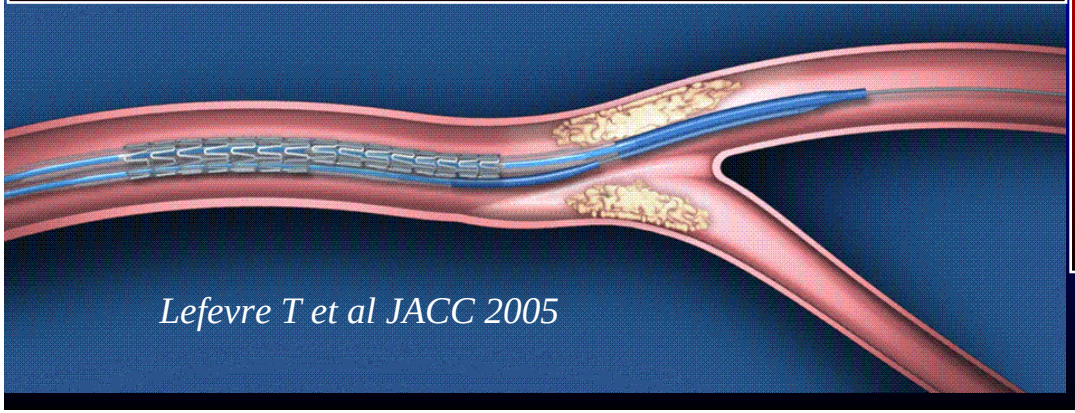


Ormiston CCVI 2004;63:332

Dedicated Bifurcation Stents



FRONTIER Registry Angio @ 6-month: RR 44.8%, TLR 13.3%, MACE 17.1%



Lefevre T et al JACC 2005

Dedicated bifurcation stents may solve problems but introduce new challenges

- ***more difficult to deliver (profile, flexibility, wire wrap)***
- ***more difficult to retrieve into guide***
- ***larger calibre guide needed.***

Summary

- Nonthreathened side branch of a small size should not be wired, but side branch >2.0 mm that are at risk of closure should be protected
- If the side branch is ≥2.5 mm with ostial disease or at risk of plaque shift elective balloon dilatation with or without kissing balloon is advised
- If the side branch is ≤2.7 mm single stent implantation of the main vessel followed by side branch dilatation is advised
- If the side branch is ≥2.7 mm elective stent implantation of both the main and the side branch should be performed

Conclusions - Before the DES Era (I)

- A single stent technique is generally preferred to the double stent technique
- Among the multiple techniques the provisional T-stenting is the preferred one
- Final kissing balloon is always advised

Conclusions - After the DES Era (II)

- A drug-eluting stent in the main branch can substantially lower the restenosis rate…….but Achille's heel still remain the side branch

- If a double-stent technique is used crush,V stenting (SKS) and T-stenting are the preferred ones (the "modified crush" seems a very promising approach…..it need to be tested in randomized study)

- Recent introduction of dedicated bifurcation stent design might improve clinical outcome