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Bifurcation: One, two or dedicated stents?

Bernard Chevalier, MD, FESC, FACC, FSCAI
ICPS Massy
France



- In the last five years , I received research grants or speaker fees or I am/was consultant for: Abbott Vascular, Asahi, Astra Zeneca, AVI, Boston Scientific, Biotronik, Colibri, Cook, Cordis, Daichi-Sankyo, Eli-Lilly, Iroko, Medtronic, Terumo. I am currently minor shareholder & general manager of CERC (CRO)



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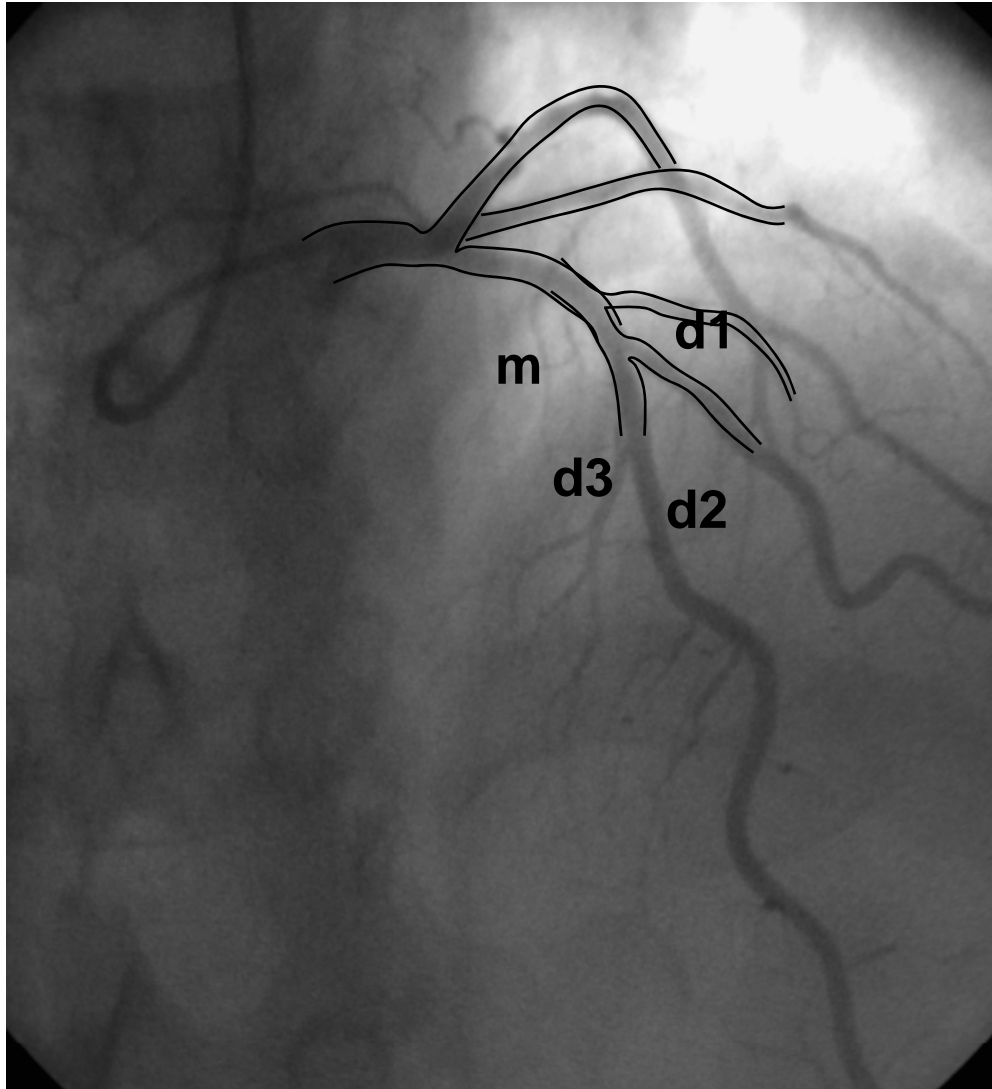
Anatomy

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GÉNÉRALE
DE SANTÉ

Structure-function scaling laws of vascular trees



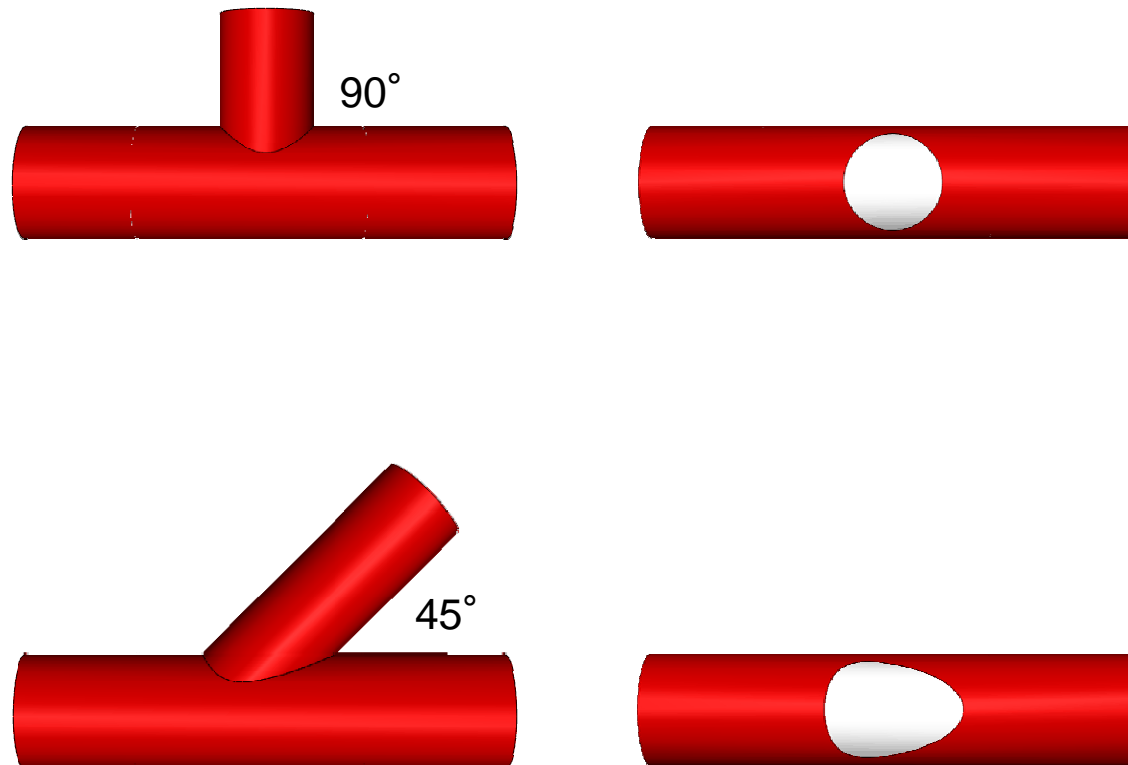
$$D_{\text{mother}}^3 = D_{\text{daughter 1}}^3 + D_{\text{daughter 2}}^3 + \dots$$

Murray's law

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

G. Finet

Angle versus ostium shape





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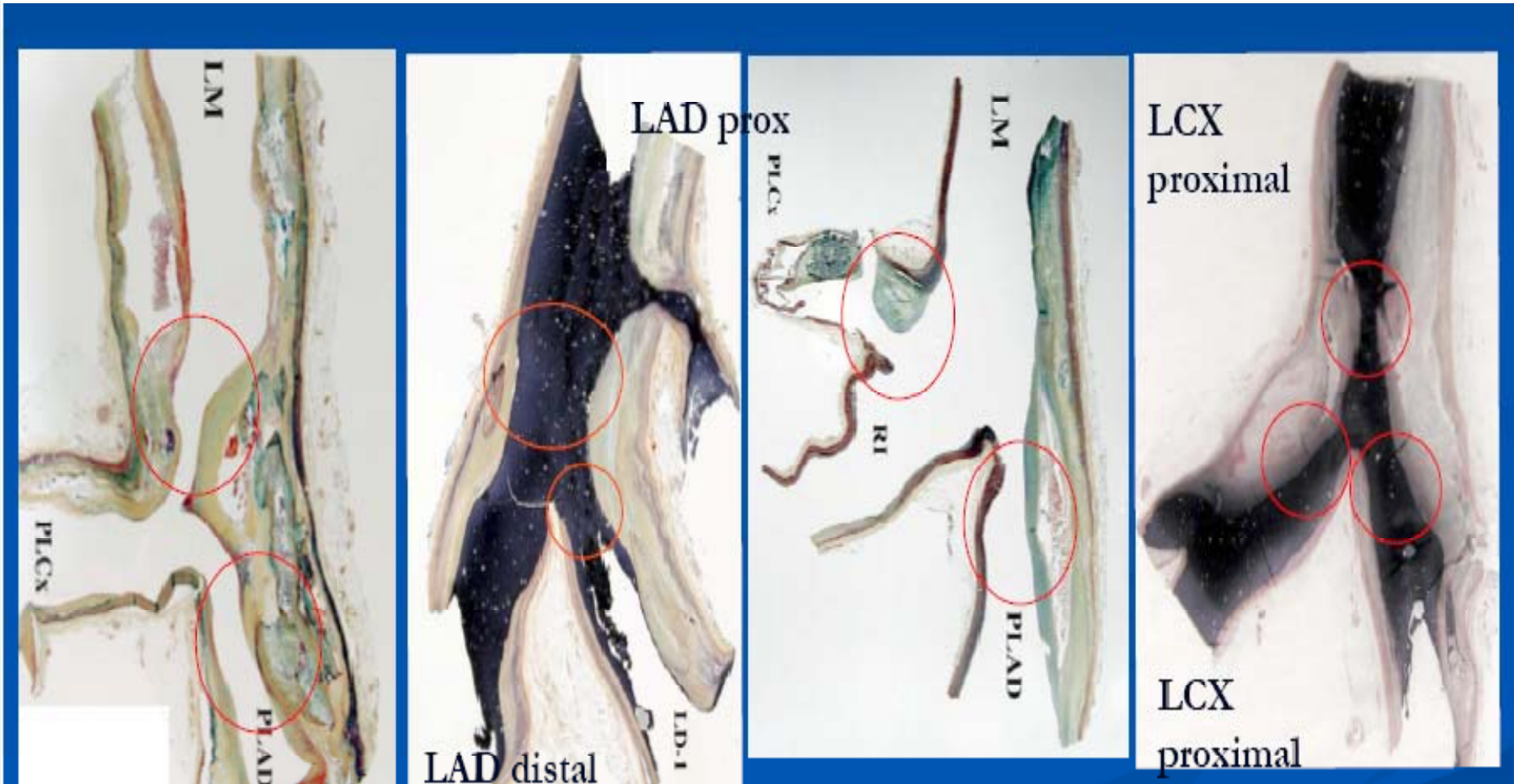
Pathology

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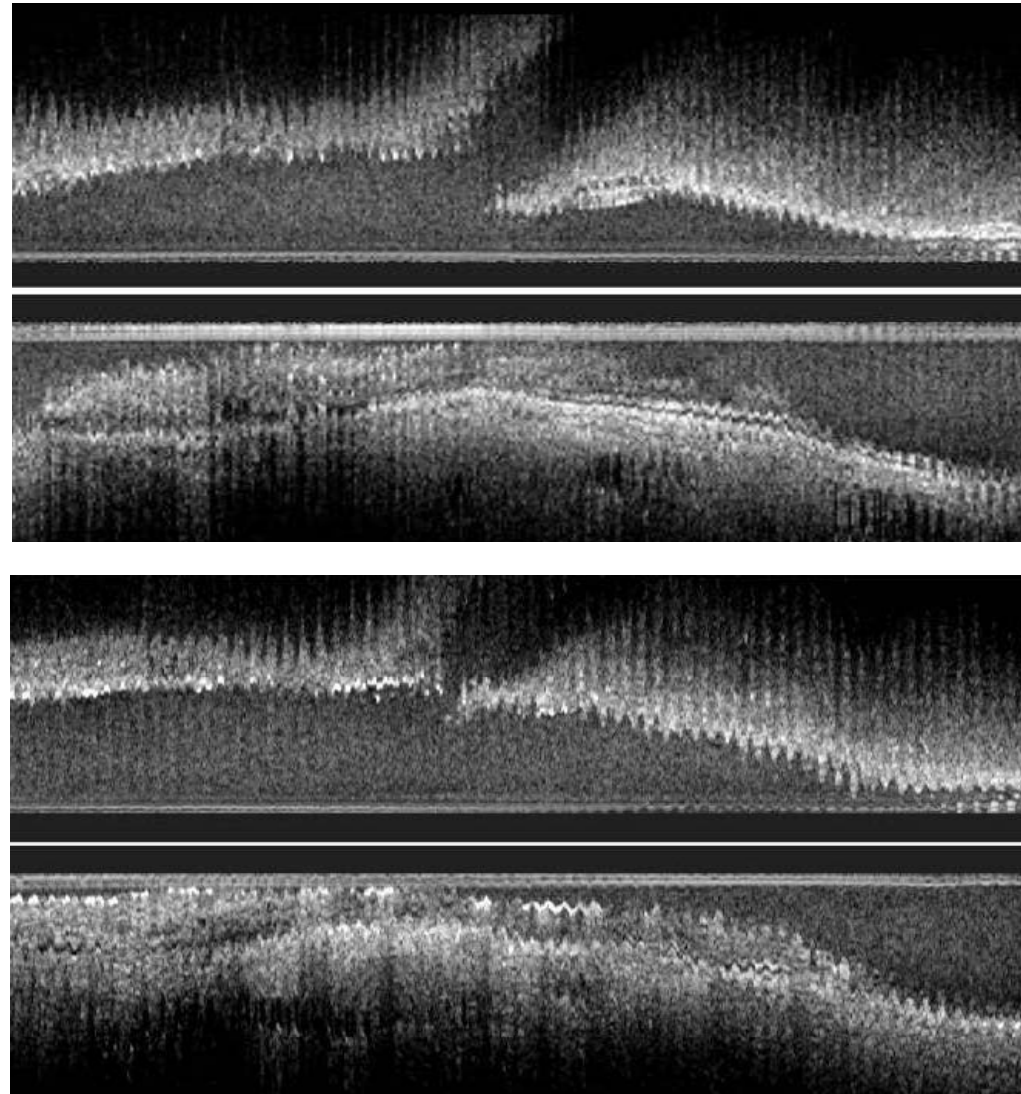


GÉNÉRALE
DE SANTÉ

Lumen vs Plaque



No plaque at carena means carena shifting !



Side Branch Lesion is Short

	Bestent ¹ TULIPE ²		Sirolimus ₃	Sirolimus ₄
Patients (n)	105	187	85	47
Reference (mm)	2.7±0.4	2.3±0.5	2.1±0.3	2.1±0.5
Lesion length (mm)	5.6±4.2	3.7±3.3	5.3±4.2	4.5±3.0
Stenosis SB (%)	49±37	52±17	52±19	42±23

¹ Gobeil et al, Am J Cardiol 2001, ² Lefèvre et al, Am J Cardiol 2003 (abst. supp.)

³ Colombo et al, Circulation 2004; 109: 1244-9, Sengotuel et al, JACC 2004 (abst.supp.)

Practical key points I

- Pre-intervention assessment:
 - Diameters
 - Angle
 - Plaque distribution (taking into account limitations of 2D angio imaging)
 - Decide which one is the distal side branch
- Mandatory to include these parameters as well as the global context of the patient in strategy making process

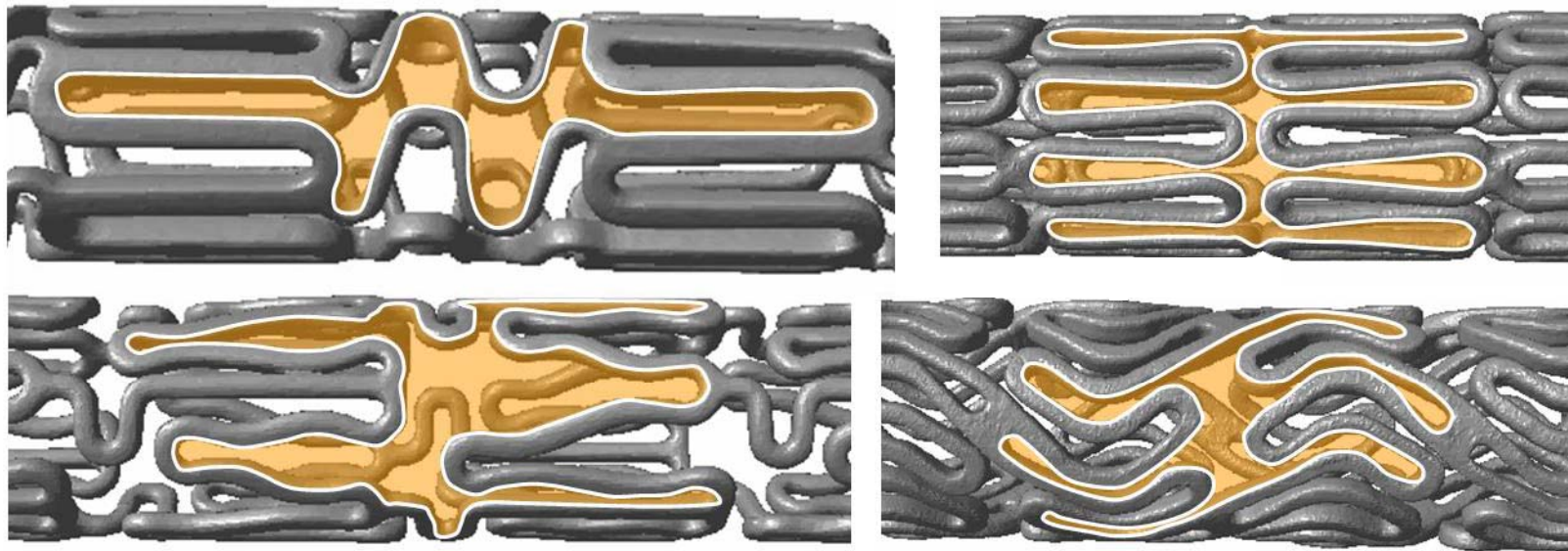


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Stent selection



Size of stent cell



Comparison of drug-eluting stent cell size using micro-CT: important data for bifurcation stent selection

Peter Mortier^{1*}, MEng; Denis Van Loo², MEng; Matthieu De Beule¹, PhD; Patrick Segers¹, PhD; Yves Taeymans³, MD, PhD; Pascal Verdonck¹, PhD; Benedict Verheghe¹, PhD

1. Institute Biomedical Technology (IBiTech), Ghent University, Ghent, Belgium; 2. Centre of X-ray Tomography (UGCT), Ghent University, Ghent, Belgium; 3. Department of Cardiology, Ghent University Hospital, Ghent, Belgium

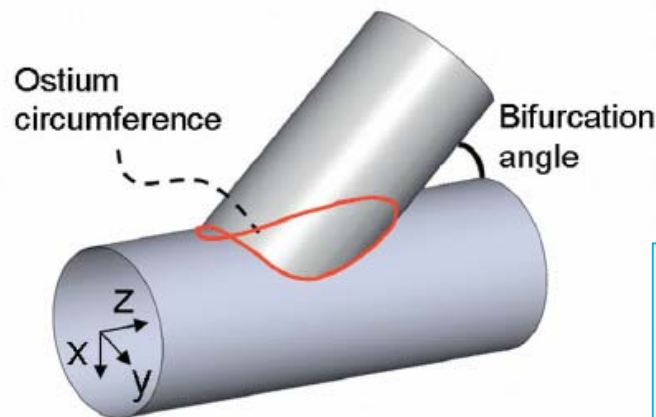
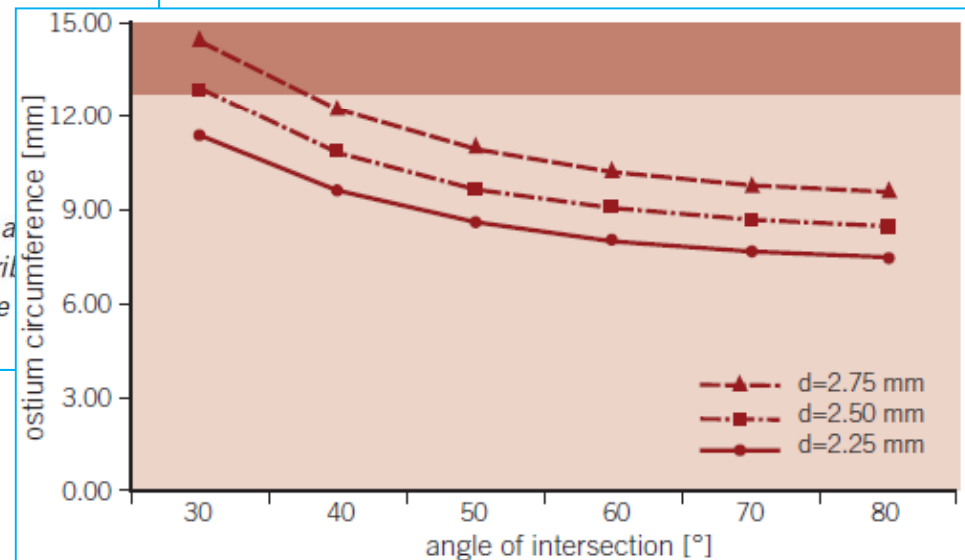
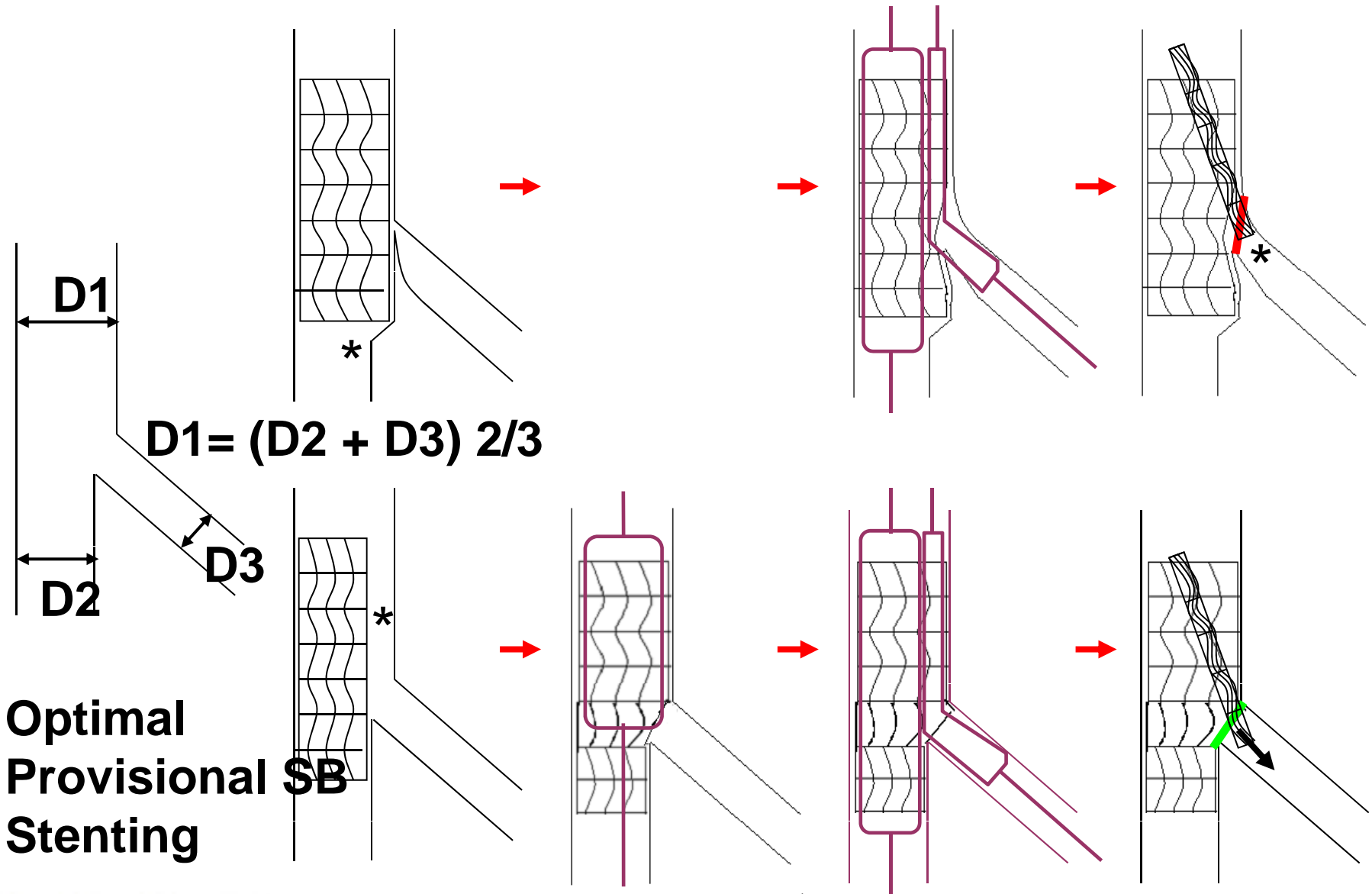


Figure 2. The size of the ostium depends on the bifurcation angle and the side and main branch diameters. The ostium is described by a three-dimensional curve from which the circumference is calculated.

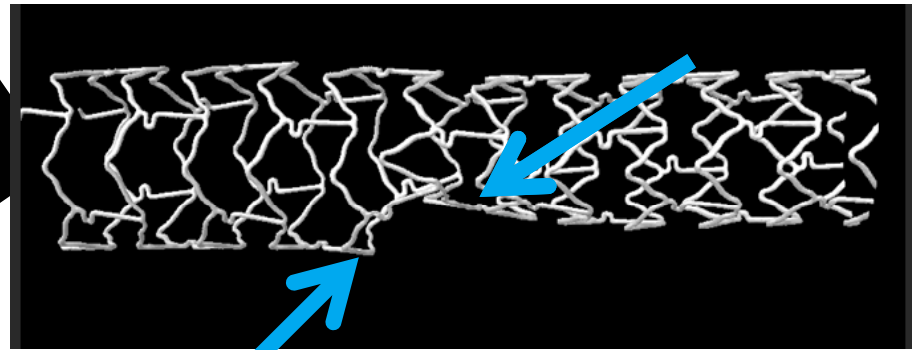
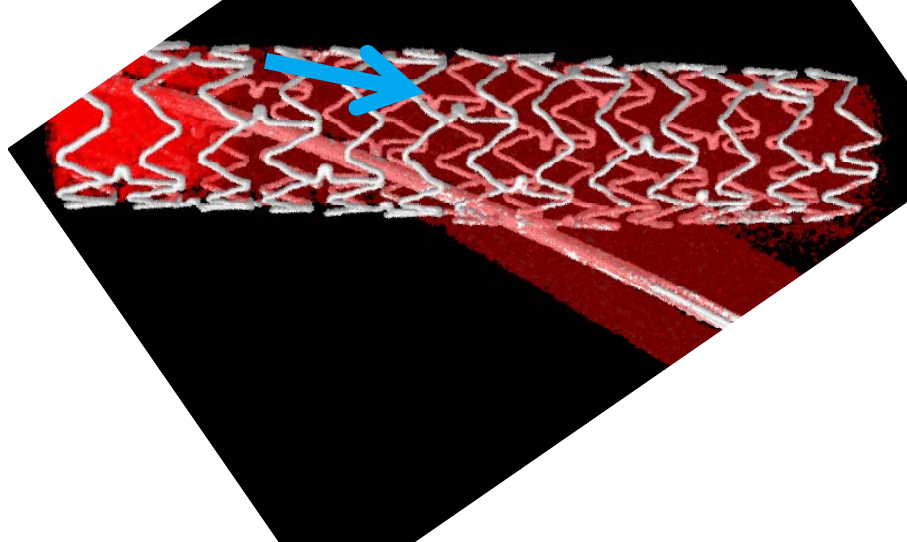


Sizing MB stent: Proximal optimisation technique (POT)

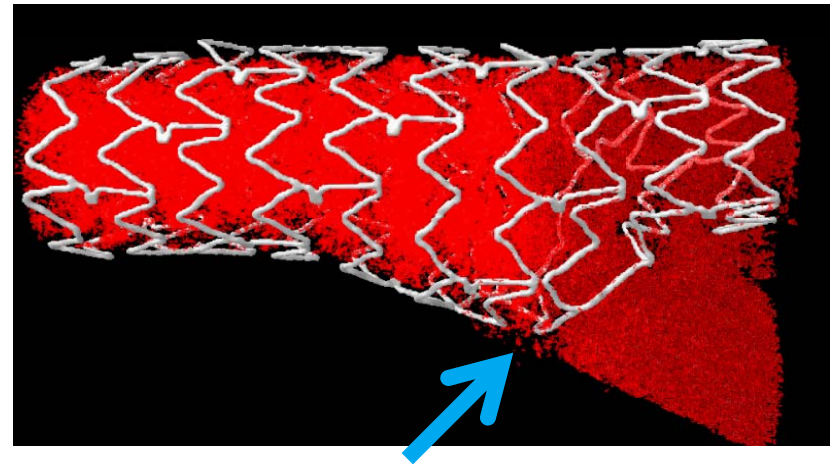
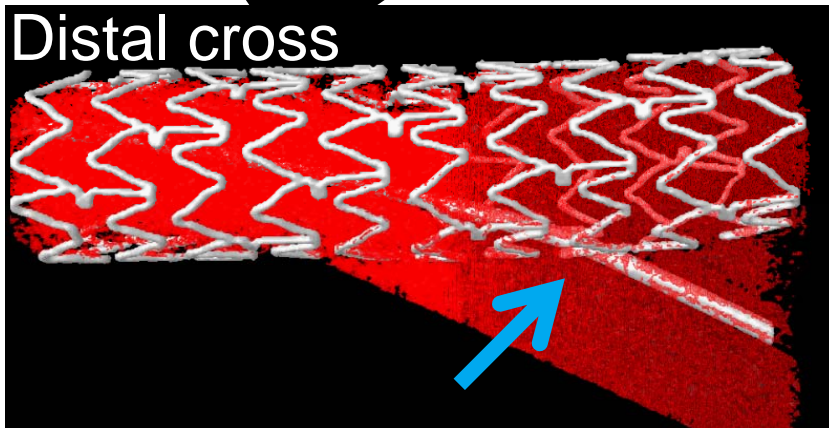


Proximal vs Distal Strut

Proximal cross



Distal cross





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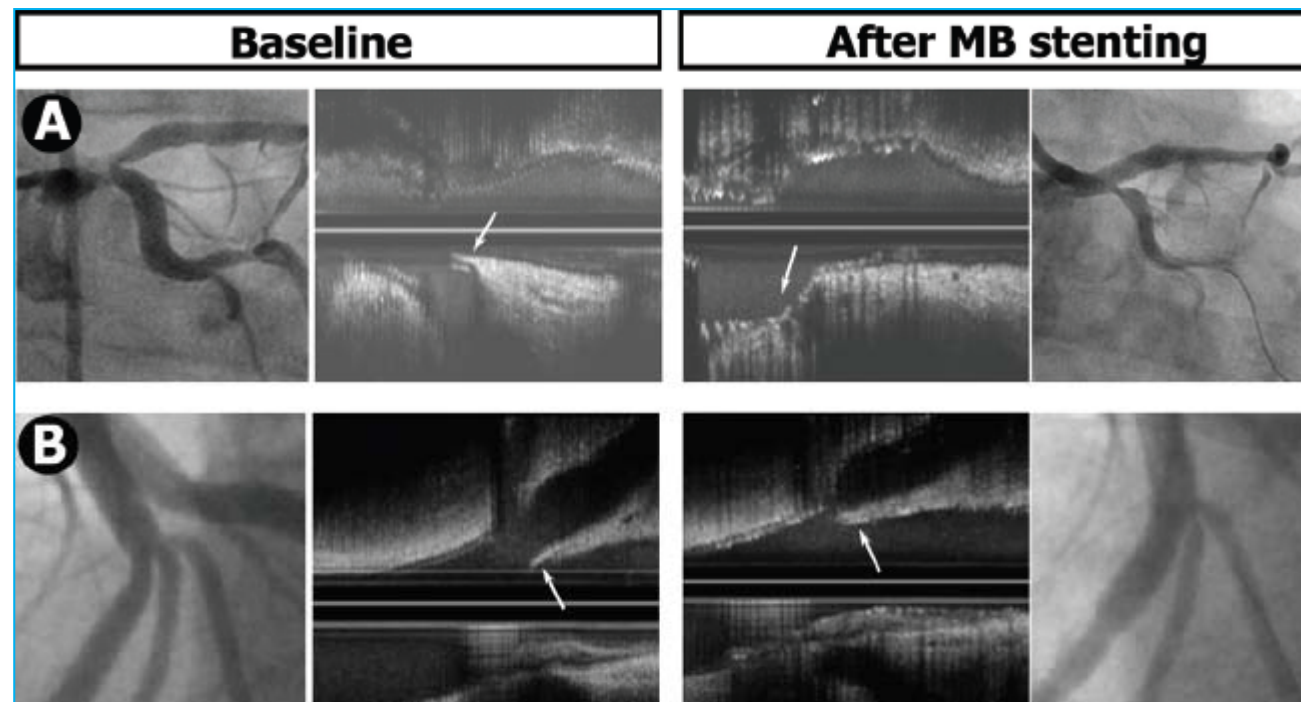
SB worsening



Predictors of ostial side branch damage during provisional stenting of coronary bifurcation lesions not involving the side branch origin: an ultrasonographic study

Javier Suárez de Lezo^{1*}, MD, PhD; Alfonso Medina², MD, PhD; Pedro Martín², MD, PhD; José Novoa², MD; José Suárez de Lezo¹, MD, PhD; Manuel Pan¹, MD, PhD; Eduardo Caballero², MD, PhD; Francisco Melián², MD, PhD; Francisco Mazuelos¹, MD PhD; Verónica Quevedo², MD

1. Department of Cardiology, Reina Sofia Hospital, University of Córdoba (IMIBIC), Córdoba, Spain 2. Dr. Negrin Hospital, Department of Cardiology, University of Las Palmas, Las Palmas de Gran Canaria, Spain



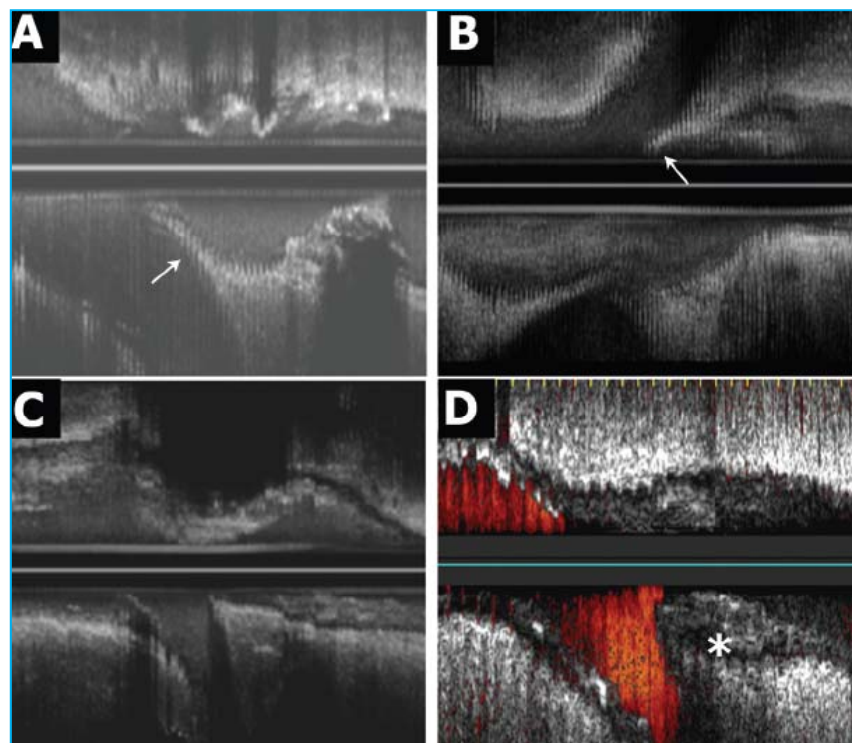


Table 4. Predictors of SB damage.

	SB damage (n=51)	No SB damage (n=59)	<i>p</i>
Bifurcation angle, °±SD	60±32	63±28	0.1
MB diameter, mm±SD	3.35±0.4	3.48±0.6	0.7
SB diameter, mm±SD	2.78±0.5	2.86±0.3	0.5
Stent diameter, mm±SD	3.1±0.3	3.1±0.4	0.8
MB stenosis, %±SD	70±10	76±11	0.3
Plaque length, mm±SD	17.1±8.4	17.8±8.2	0.5
EEM area in carina, mm ² ±SD	11.8±4.2	12.2±3.3	0.2
Plaque burden in proximal reference, mm±SD	31±13	29±14	0.3
Plaque burden in distal reference, mm±SD	24±14	26±12	0.3
Plaque burden in MLA, %±SD	71±13	75±10	0.3
Plaque burden in carina region, %±SD	56±15	59±16	0.3
Plaque in carina, n	8	19	<0.05
Eyebrow sign, n	41	10	<0.01

MB: main branch; SB: side branch; MLA: minimal lumen area; EEM: external elastic membrane; SD: standard deviation

Practical key points II

- During interventions:
 - Select appropriate working views
 - Do not overestimate the severity of SB stenosis and its clinical impact
 - Never compromise main branch result because of « cosmetic » SB result
 - Respect the natural anatomy ?

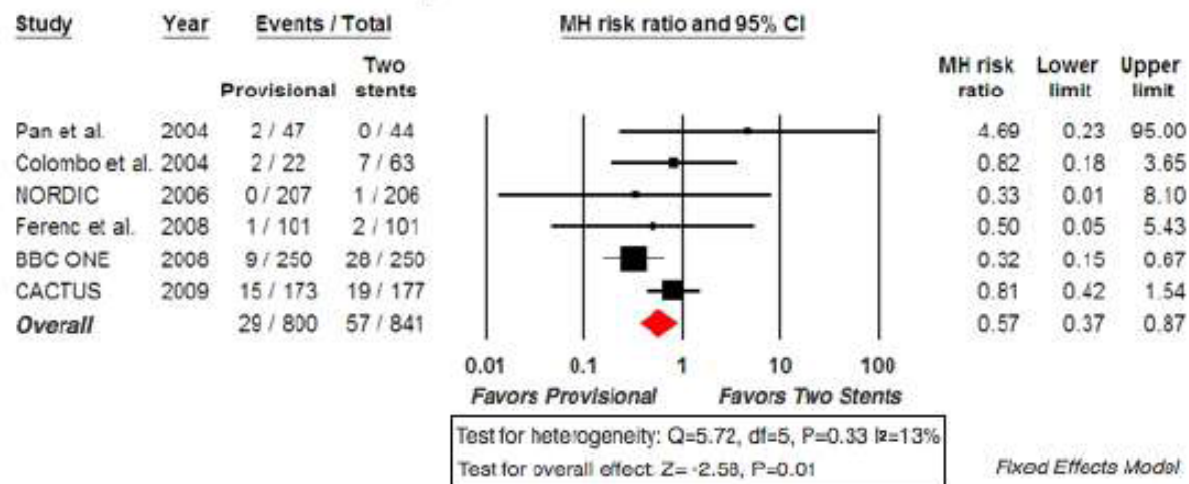
Two stents? One stent?

Limitation of the 2 Stents Techniques

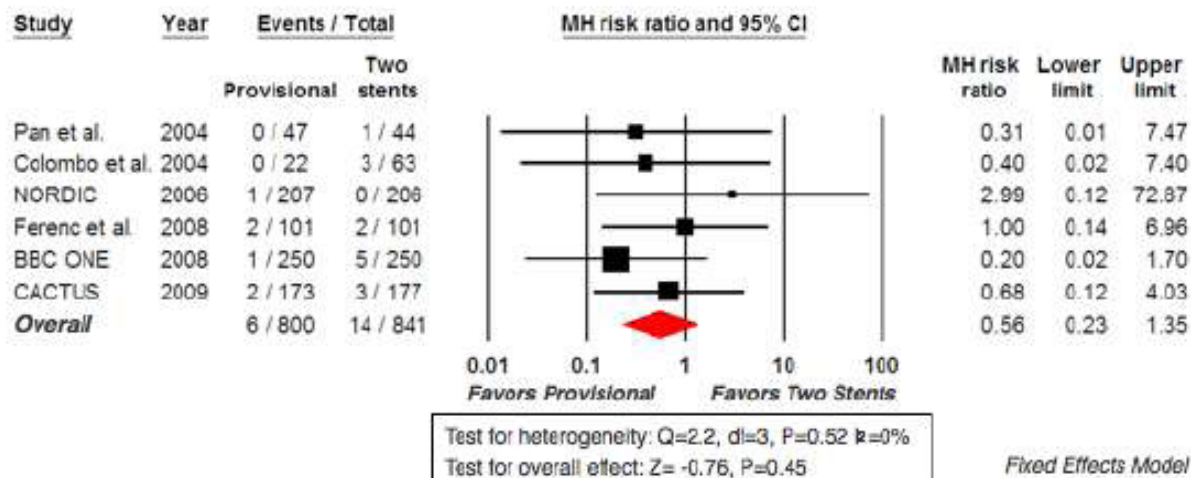
- ✓ Wire management more difficult
- ✓ Final kiss more difficult
- ✓ Overlap (delayed endothelialisation, stagnation)
- ✓ Stent not fully apposed
- ✓ Rheology not optimal

	M Main prox. first	A Main Accross side first	D Distal first	S Side branch first
1st stent	 PM stenting	 MB stenting across SB	 DM stenting Provisional SKS	 SB ostial stenting
After balloon	 Skirt	 MB stenting + SB balloon MB stenting + kissing		 SB minicrush SB crush
2 stents	 Skirt + DM Skirt + SB	 Elective T stenting Internal crush Culotte TAP	 V stenting SKS	 Syst. T Stenting Minicrush Crush
3 stents	 Extended V		 Trouser legs and seat	

B. Myocardial Infarction



E. Stent Thrombosis



C.

TLR

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 / 260	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: $Z= -0.49$, $P=0.63$

0.01 0.1 1 10 100
 Favors Provisional Favors Two Stents

Fixed Effects Model

D.

Side Branch Restenosis

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	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 / 101	13 / 101		0.69	0.31	1.55
CACTUS	2009	22 / 150	20 / 152		1.11	0.64	1.96
Overall		65 / 470	67 / 508		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

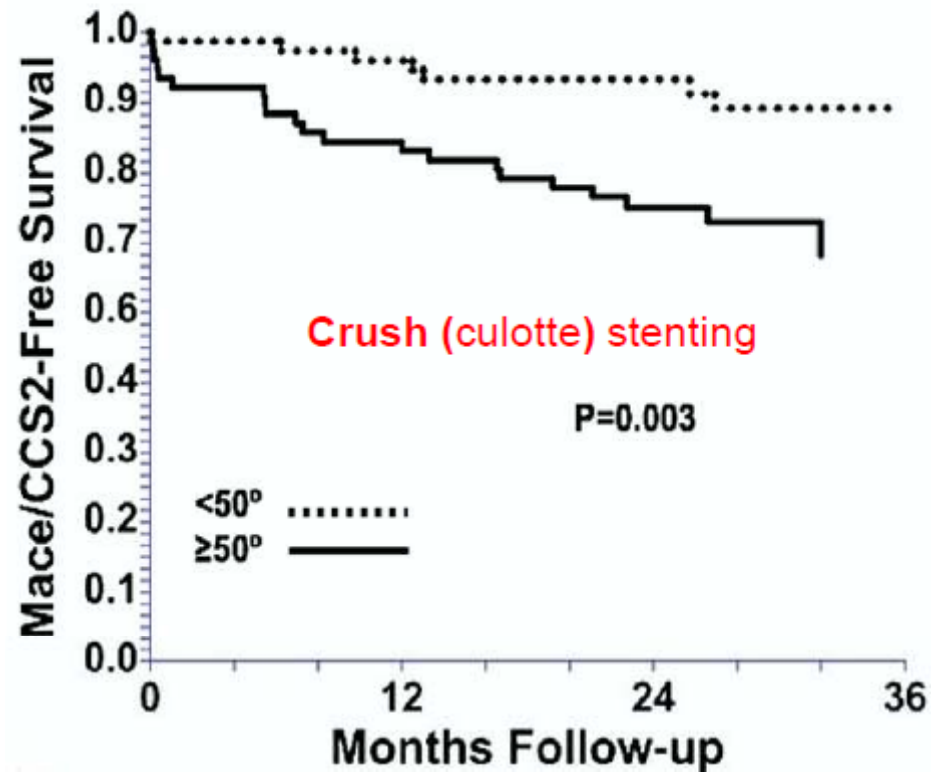
NORDIC II

Rate of main vessel and/or side branch
in-stent diameter stenosis >50%
at 8 months follow-up



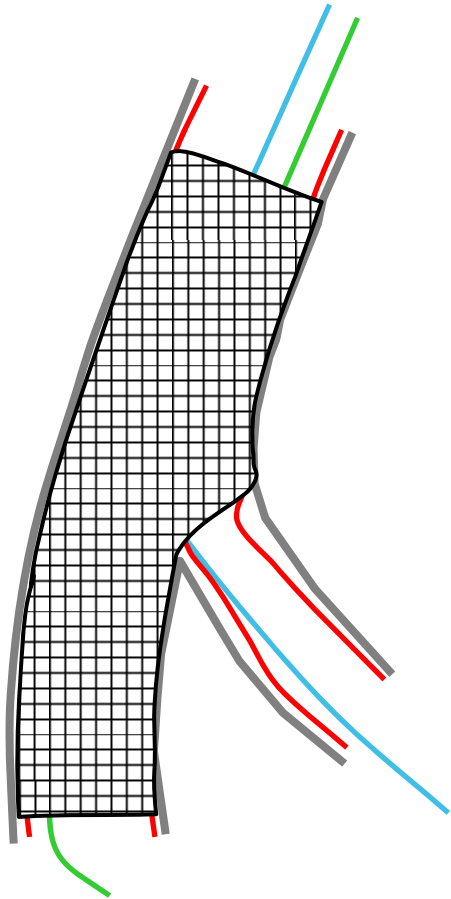
P. Gunnes, TCT 2007

Culotte in T shape?



Collins

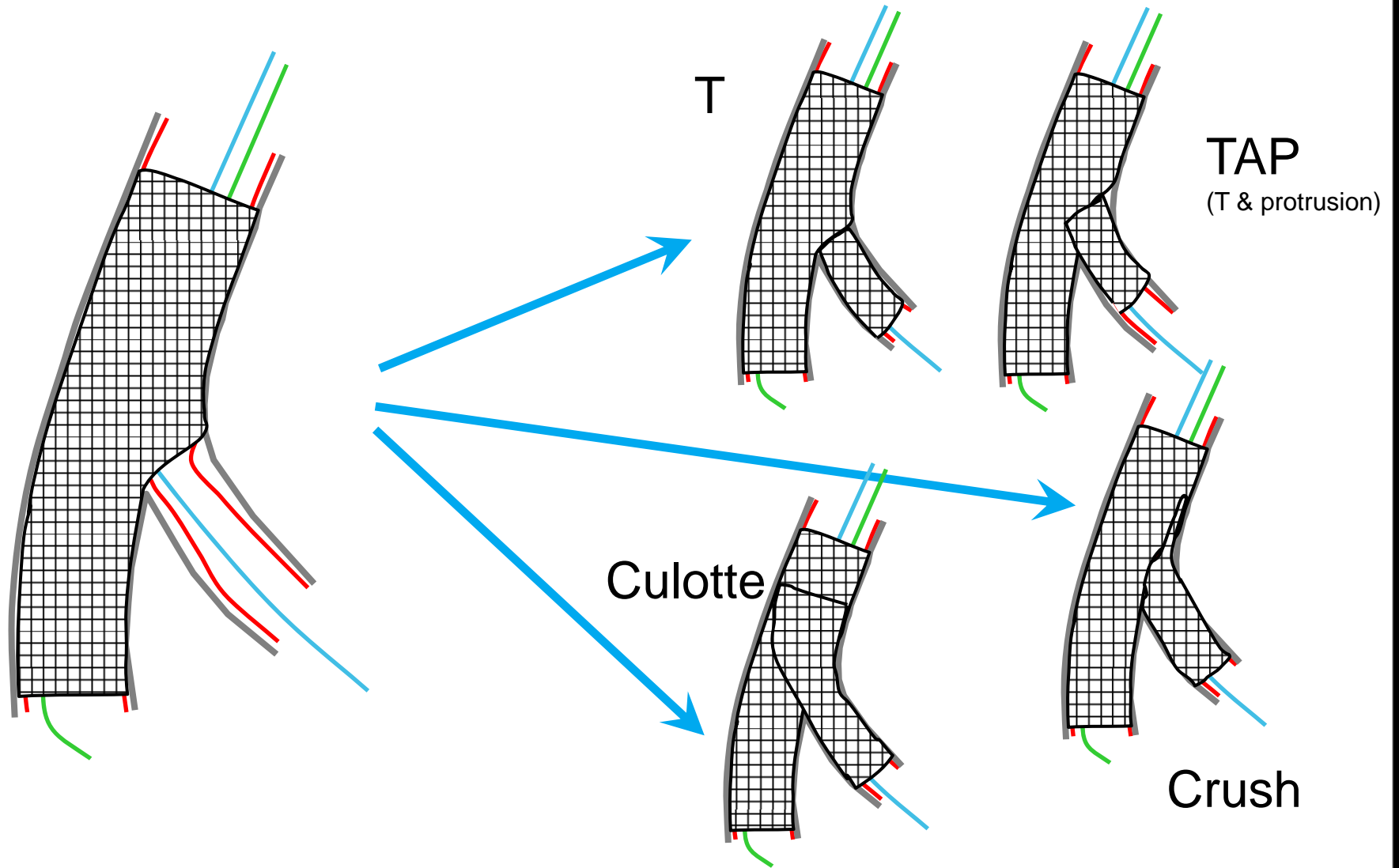
Provisional Side Branch Stenting



Advantages

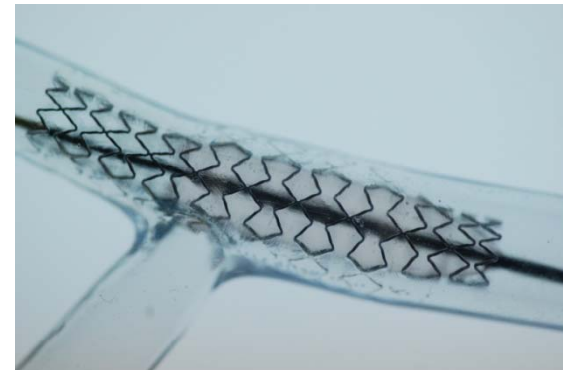
- ✓ Can be standardized
- ✓ Few tips and tricks
- ✓ One stent in > 80% of cases
- ✓ Kissing balloon easy
- ✓ Good efficacy and safety profile

Provisional Side Branch Stenting

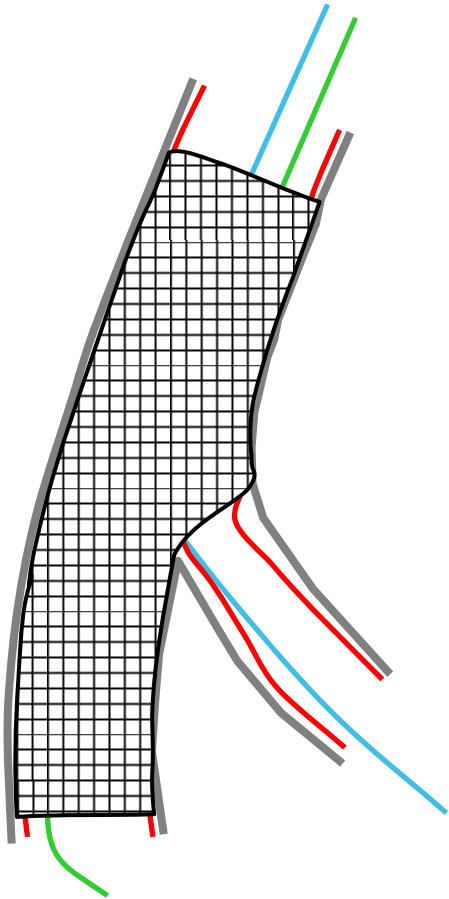


Important tips & tricks

- ✓ 6 French at least
- ✓ Diameters +angle evaluation & choice of SB
- ✓ Jailed wire as landmark
- ✓ No ballooning on SB
- ✓ Choose main stent on distal MB reference
- ✓ POT before wire exchange
- ✓ Recross distal cell
- ✓ Kissing with NC balloons
- ✓ High threshold for second stenting



Provisional Side Branch Stenting



Limitations ?

- ✓ Access through stent struts



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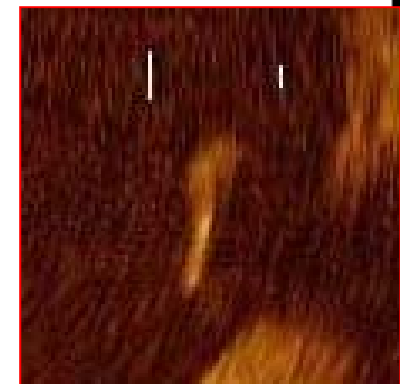
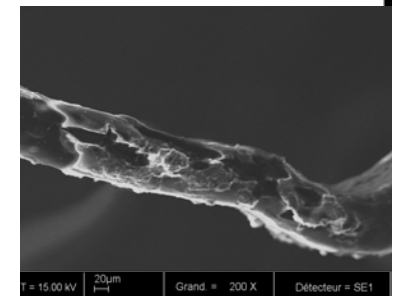
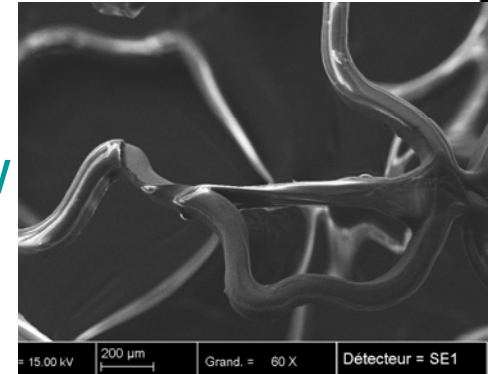
Is there a room for improvement?

(How could you achieve better
results using dedicated stents?)



Pro dedicated stents

- Rheology
 - Strut at the edge of SB ostium creates low shear stress
 - Strut in the middle of SB ostium creates high and low shear stress areas which are very close
- Limitations of non dedicated stents
 - Access to SB
 - Huge polymer injury limits DES efficacy (dark side of kiss?)



Dedicated stent-related issues

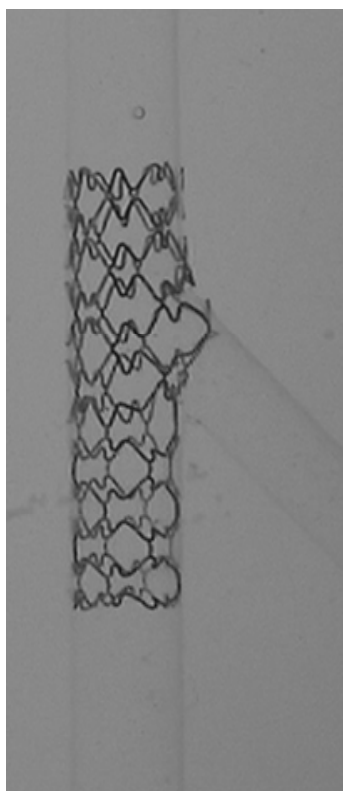
- Multiple steps approach
- Positioning :
 - Longitudinal
 - Rotational
- Conformation to complex/various anatomies
 - Self vs balloon expansion
 - Static vs dynamic conformability
- Validation :
 - Comparator?
 - Primary endpoint? Feasibility vs angio vs DOC

Dedicated Devices

1. MB stenting with provisional SB stenting
2. Side branch stents
3. Proximal bifurcation stenting
4. Bifurcated stents

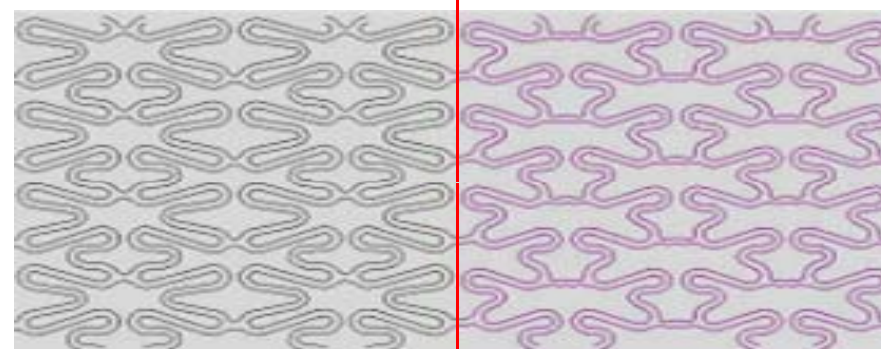
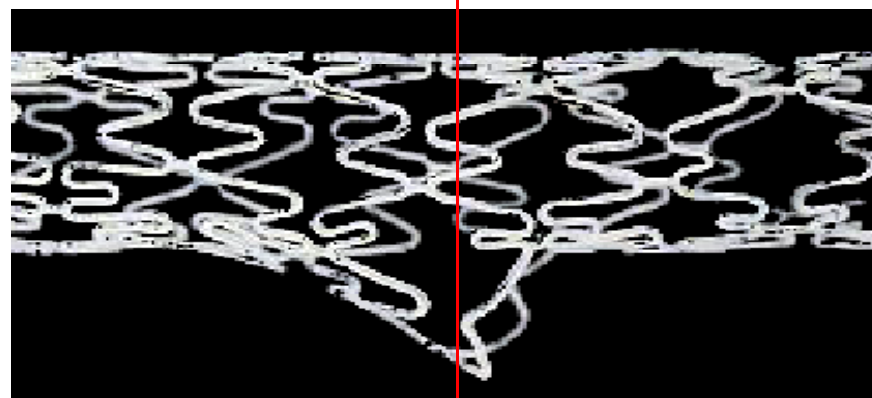
1. MB Stenting With Provisional SB Stenting

Stent pushed on MB and SB wires



Twin Rail

Main Vessel prox. Main Vessel dist.



Dedicated BMS platform

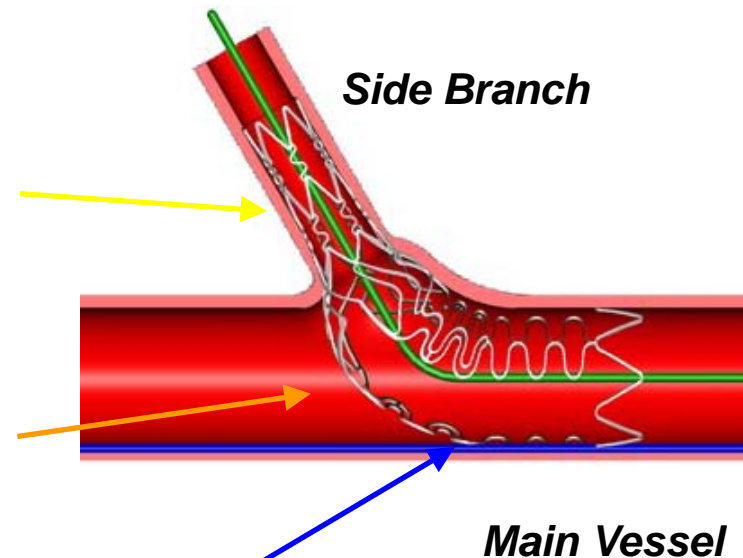
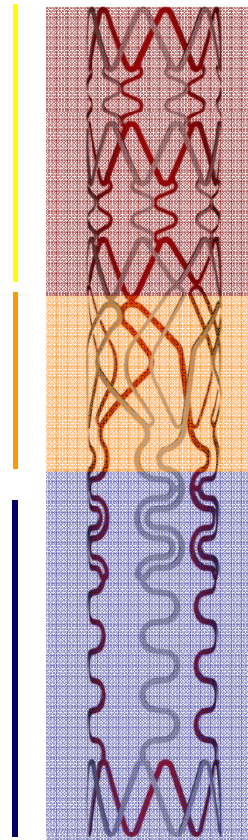
2. Side Branch Stent

Tryton Side Branch Stent

SB Standard Design

Transition Zone Coverage

MB Minimal Coverage



Cobalt Chromium

Strut Thickness:

0.003"

Diameter: 2.5 mm

3. Proximal Bifurcation Stenting

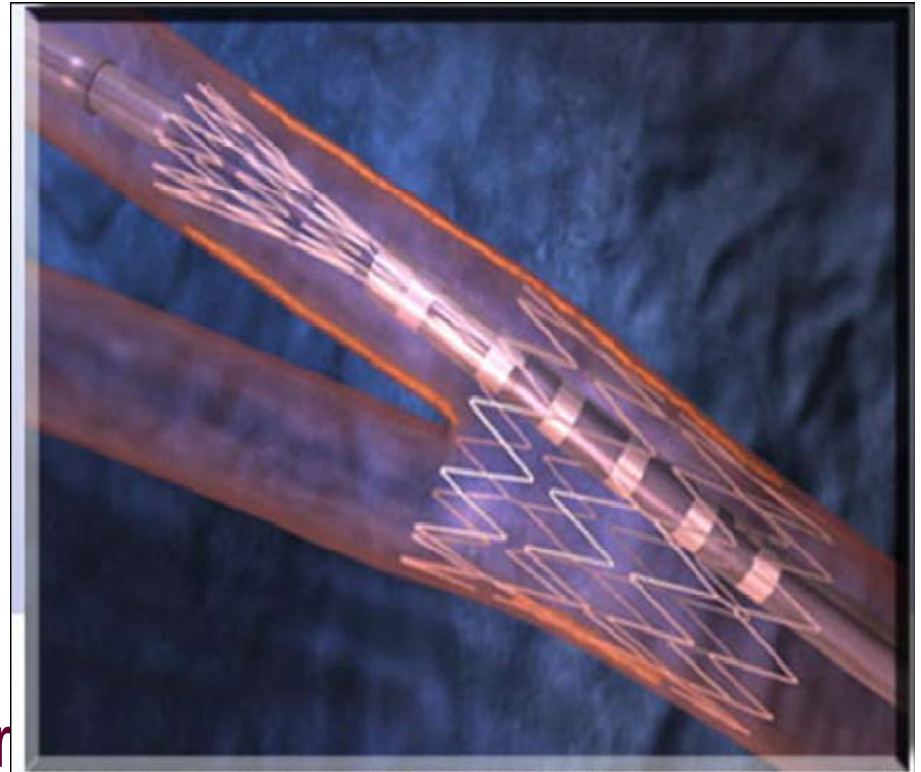
DEVAX Stent

Dedicated Stent and
Delivery system

Self expanding Nitinol alloy

Biolimus A9™

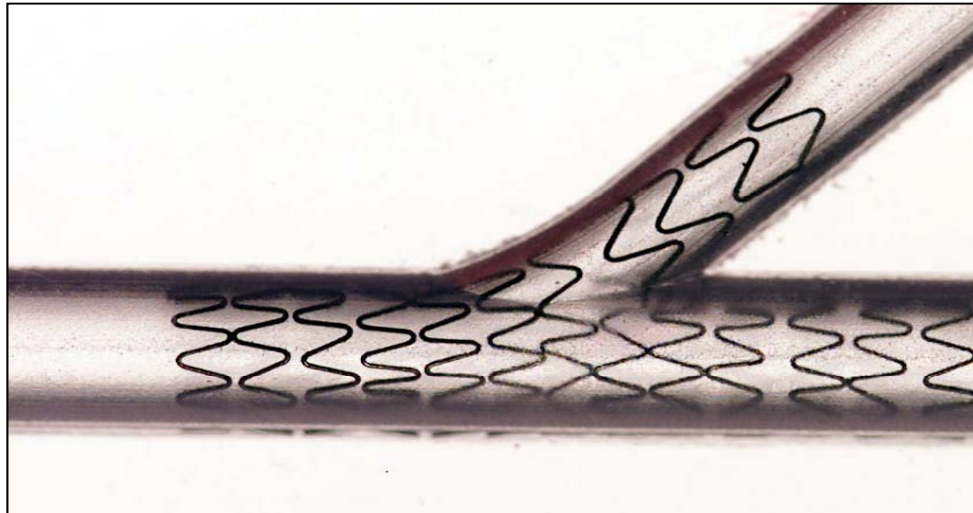
Bioabsorbable PLA polymer



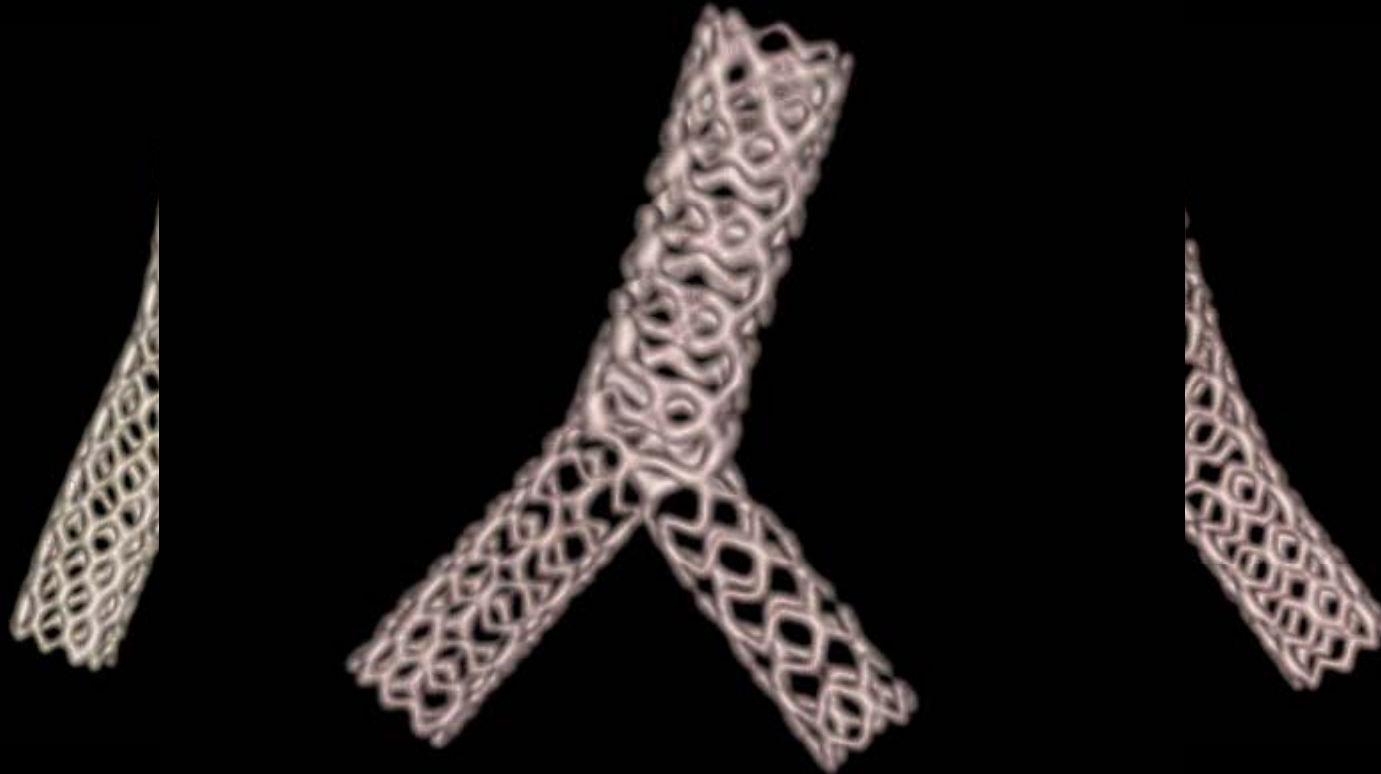
4. Bifurcated Stents

Medtronic Device

Dedicated Stent and
Delivery System

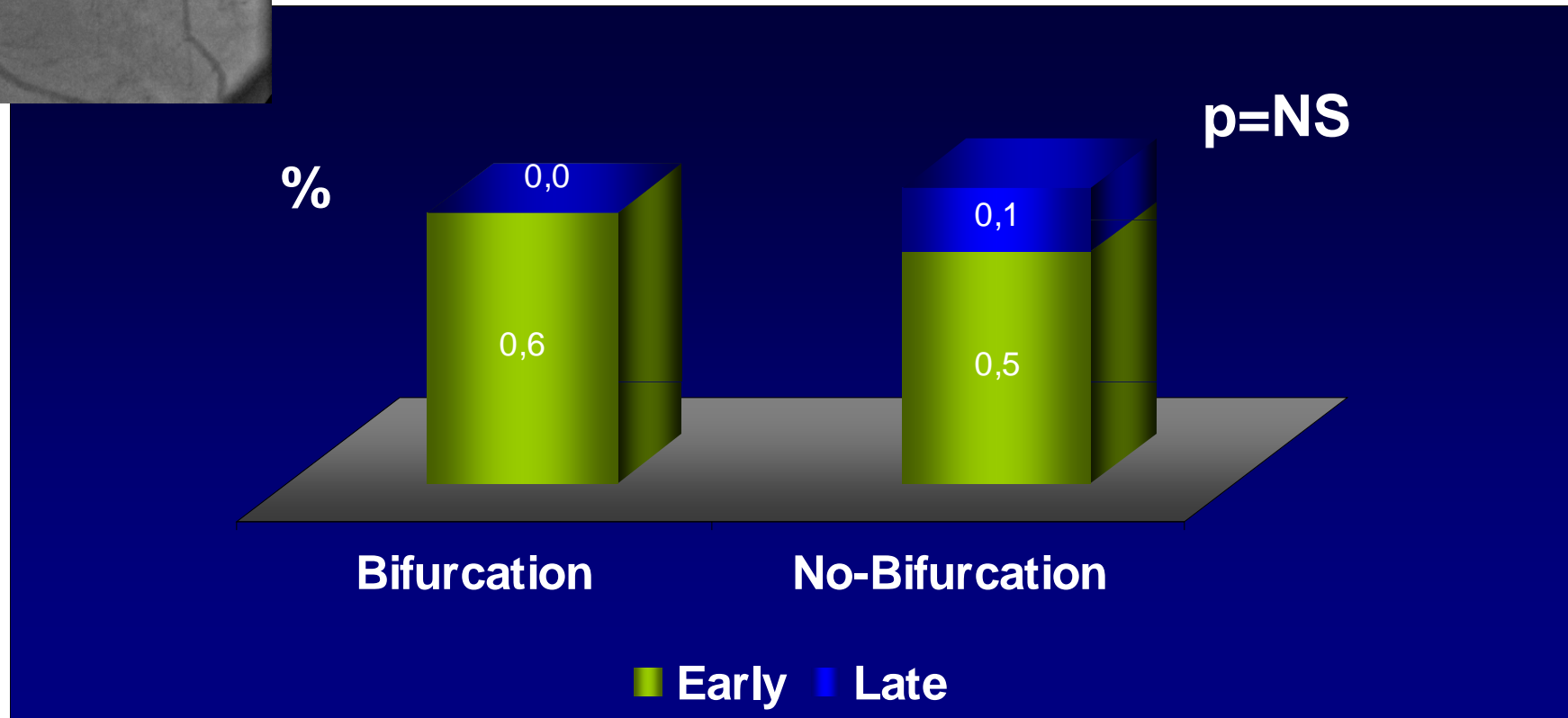
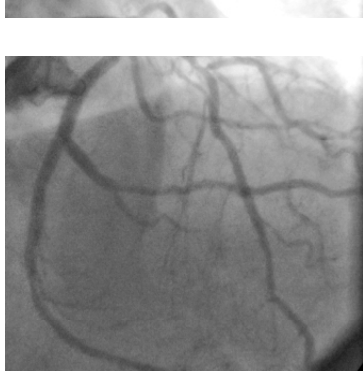


Results of last generation DES in bifurcation



	Bifurcation n=695	No- Bifurcation n=2130	p-value
%			
Cardiac Death	0.6	1.3	0.15
MI	2.3	1.3	0.08
TL-CABG	0.6	0.4	0.50
TL-Re-PCI	2.0	1.6	0.50
TV-Re-PCI, non TL	1.2	1.1	0.84
TLF	4.5	3.4	0.20
MACE	5.3	4.5	0.35

NOBORI II- Bifurcation Study



Conclusions

- Despite the huge variation in bifurcation lesions, thanks to recent trials, the treatment is now relatively standardised
- Single stent strategy is preferred
 - Kissing at operator discretion in single stenting
- Culotte is preferred to crush(Y shape) – T stenting(T shape)
- Recent DES have similar results than in non-bifurcation lesions (role of dedicated stents???)
- Unanswered questions:
 - Threshold for SB interventions (angio? FFR?...)
 - 2 stents in 1.1.1 large bifurcation (EBC II) (like LM...)