Left Main and bifurcation PCI

Left Main PCI: Which 2 stent technique ?

Y. Louvard, ICPS, Massy, Quincy, Générale de Santé, France

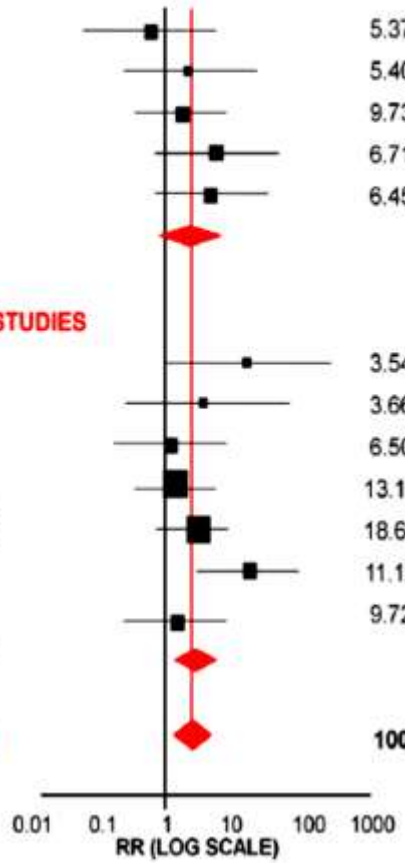
20th CARDIOVASCULAR SUMMIT
TCTAP 2015
APRIL 28-MAY 1, 2015
COEX, SEOUL, KOREA

Why attempt to reduce the stent number in non-LM bifurcations ?

Late Thrombosis After 2 Versus 1 DES in the Treatment of Coronary Bifurcations. Meta-analysis of Randomized and Observational Studies

A DES Thrombosis

Study	Year	DDS	SDS	Weight*	RR (random) 95% CI
RANDOMIZED, CONTROLLED TRIALS					
NORDIC	2008	1/196	2/199	5.37%	0.50 (0.04–5.55)
Ferenc et al.	2008	2/101	1/101	5.40%	2.00 (0.18–21.71)
CACTUS	2009	3/177	2/173	9.73%	1.46 (0.24–8.66)
BBC-ONE	2010	5/249	1/248	6.71%	4.97 (0.58–42.31)
DK-CRUSH-II	2011	4/185	1/185	6.45%	4.00 (0.45–35.44)
META-ANALYSIS		**15/908**	**7/906**		**2.01 (0.77–5.23)**
Cochrane Q: 2.46 (p: 0.651) I^2: 0%					
NONRANDOMIZED, OBSERVATIONAL STUDIES					
Ge et al.	2007	3/57	0/117	3.54%	14.24 (0.74–271.13)
Di Mario et al.	2007	4/109	0/38	3.66%	3.19 (0.17–57.92)
ARTS II	2007	1/61	4/263	6.50%	1.07 (0.12–9.47)
COBIS	2010	2/292	9/1376	13.17%	1.04 (0.22–4.82)
J-CYPHER	2011	3/263	10/1870	18.64%	2.13 (0.59–7.70)
J-PMS	2011	4/37	2/263	11.12%	14.21 (2.69–74.92)
Assali et al.	2011	2/141	3/260	9.72%	1.23 (0.21–7.27)
META-ANALYSIS		**19/960**	**27/4187**		**2.55 (1.13–5.78)**
Cochrane Q: 8.06 (p: 0.234) I^2: 25.57%					
META-ANALYSIS		**34/1868**	**35/5093**	**100%**	**2.31 (1.33–4.03)**
Cochrane Q: 10.65 (p: 0.473) I^2: 0%					

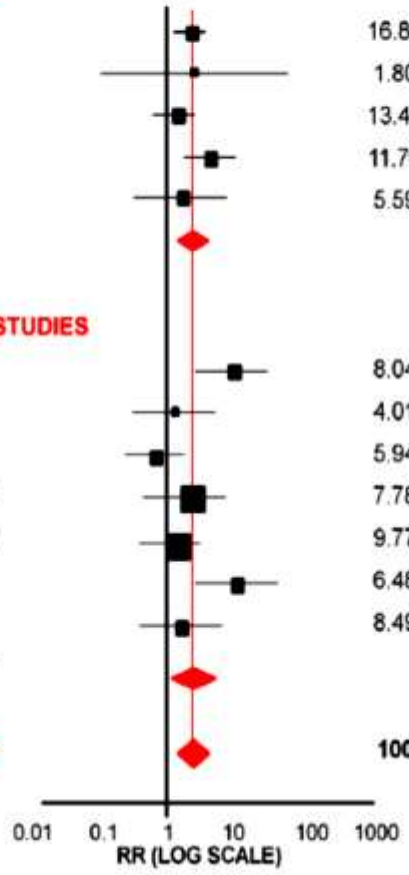


Zimarino J Am Coll Cardiol Intv 2013

Late Thrombosis After 2 Versus 1 DES in the Treatment of Coronary Bifurcations. Meta-analysis of Randomized and Observational Studies

C Myocardial Infarction

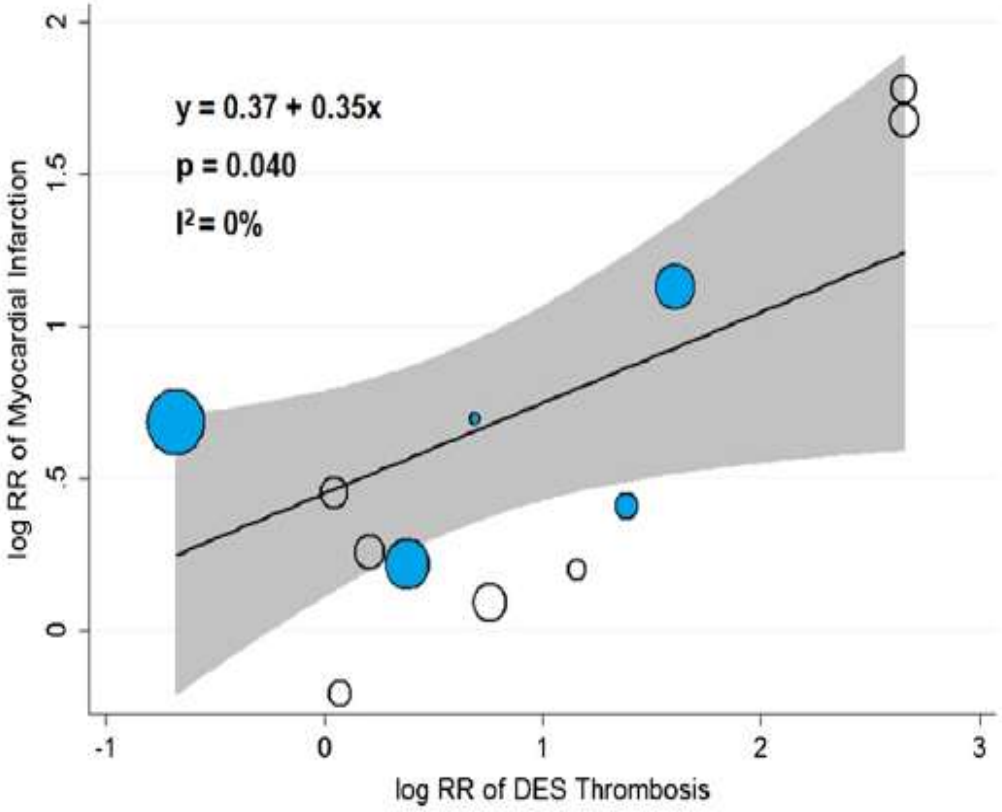
Study	Year	DDS	SDS	DDS better	SDS better	Weight*	RR (random) 95% CI
RANDOMIZED, CONTROLLED TRIALS							
NORDIC	2008	39/196	20/199			16.86%	1.97 (1.19–3.26)
Ferenc et al.	2008	2/101	1/101			1.80%	2.00 (0.18–21.71)
CACTUS	2009	19/177	15/173			13.48%	1.28 (0.65–2.35)
BBC-ONE	2010	28/249	9/248			11.76%	3.09 (1.49–6.43)
DK-CRUSH-II	2011	6/185	4/185			5.59%	1.50 (0.43–5.22)
META-ANALYSIS		**94/908**	**49/906**				**1.88 (1.35–2.62)**
Cochrane Q: 3.59 (p: 0.453) I^2: 0%							
NONRANDOMIZED, OBSERVATIONAL STUDIES							
Ge et al.	2007	13/57	5/117			8.04%	5.33 (1.99–14.24)
Di Mario et al.	2007	7/109	2/38			4.01%	1.22 (0.26–5.62)
ARTS II	2007	3/61	16/263			5.94%	0.80 (0.24–2.68)
COBIS	2010	5/292	15/1376			7.78%	1.57 (0.57–4.28)
J-CYPHER	2011	6/263	39/1870			9.77%	1.09 (0.46–2.55)
J-PMS	2011	5/37	6/263			6.48%	5.92 (1.90–18.44)
Assali et al.	2011	7/141	10/260			8.49%	1.29 (0.50–3.32)
META-ANALYSIS		**43/960**	**93/4187**				**1.85 (1.03–3.32)**
Cochrane Q: 12.79 (p: 0.041) I^2: 53.11%							
META-ANALYSIS		**140/1727**	**142/5093**			**100%**	**1.86 (1.34–2.60)**
Cochrane Q: 16.34 (p: 0.129) I^2: 32.69%							



Zimarino J Am Coll Cardiol Intv 2013

Late Thrombosis After 2 Versus 1 DES in the Treatment of Coronary Bifurcations. Meta-analysis of Randomized and Observational Studies

Association Between Log-Transformed Risk of DES Thrombosis and Myocardial Infarction



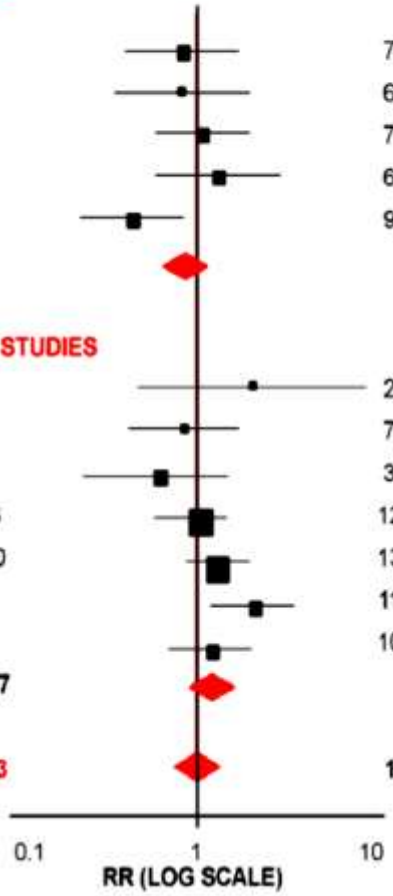
The size of each circle represents the precision of each estimate (the inverse variance of the log RR in the trial), and the line is the best fit for the meta-regression model. Randomized, controlled trials (filled circles); nonrandomized observational studies (open circles).

Zimarino J Am Coll Cardiol Intv 2013

Late Thrombosis After 2 Versus 1 DES in the Treatment of Coronary Bifurcations. Meta-analysis of Randomized and Observational Studies

D TVR

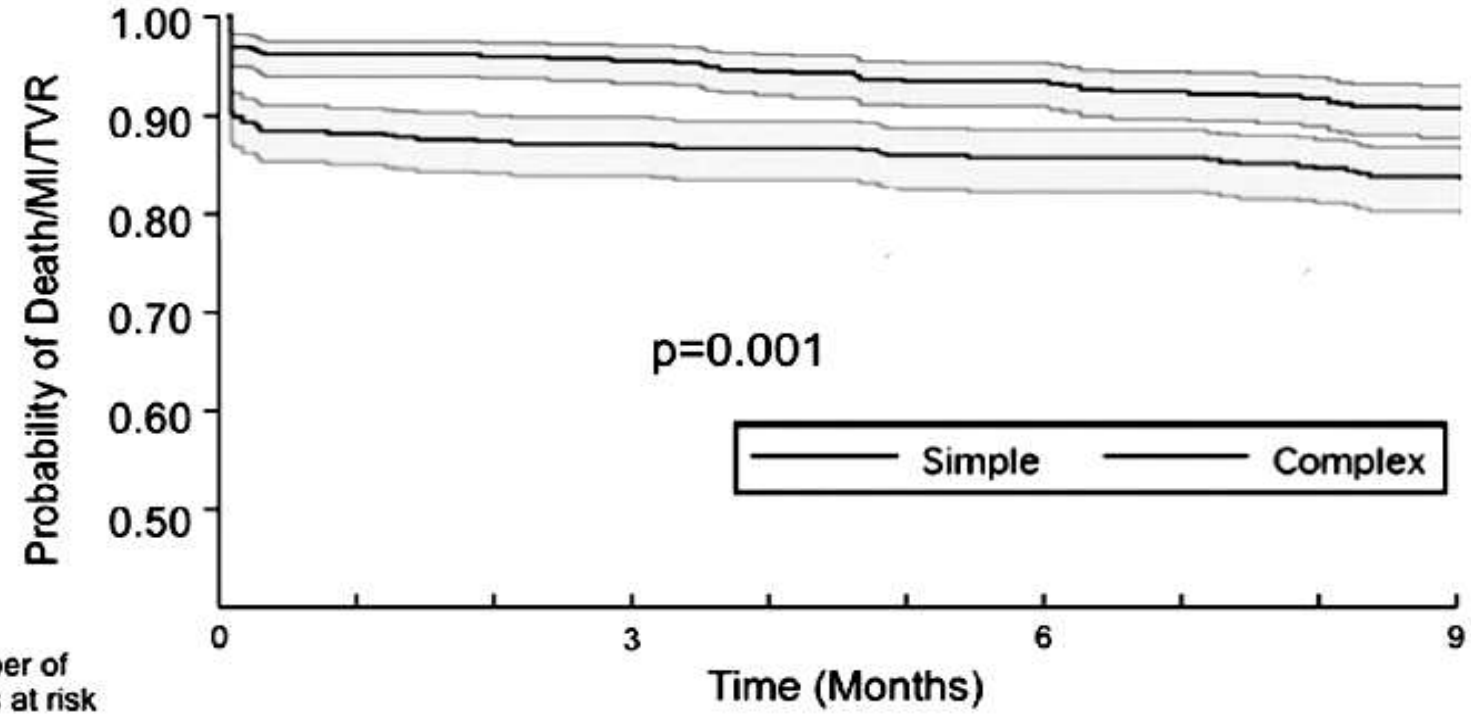
Study	Year	DDS	SDS	DDS better	SDS better	Weight*	RR (random) 95% CI
RANDOMIZED, CONTROLLED TRIALS							
NORDIC	2008	12/196	15/199			7.84%	0.81 (0.39–1-69)
Ferenc et al.	2008	9/101	11/101			6.47%	0.81 (0.35–1.88)
CACTUS	2009	14/177	13/173			7.95%	1.05 (0.50–2.17)
BBC-ONE	2010	13/249	10/248			6.84%	1.29 (0.57–2-17)
DK-CRUSH-II	2011	12/185	27/185			9.23%	0.44 (0.23–0-85)
META-ANALYSIS		**60/908**	**76/906**				**0.80 (0.55–1.17)**
Cochrane Q: 5.08 (p: 0.279) I^2: 21.27%							
NONRANDOMIZED, OBSERVATIONAL STUDIES							
Ge et al.	2007	10/90	2/37			2.53%	2.05 (0.47–8.93)
Di Mario et al.	2007	20/109	8/38			7.85%	0.87 (0.41–1.81)
ARTS2	2007	3/61	26/263			3.82%	0.49 (0.15–1.59)
COBIS	2010	17/292	83/1376			12.32%	0.96 (0.58–1.60)
J-CYPHER	2011	20/263	111/1870			13.60%	1.28 (0.81–2.02)
J-PMS	2011	12/37	43/263			11.51%	1.98 (1.15–3.40)
Assali et al.	2011	15/141	25/260			10.04%	1.11 (0.60–2.03)
META-ANALYSIS		**97/852**	**298/ 3847**				**1.27 (0.85–1-90)**
Cochrane Q: 7.80 (p: 0.252) I^2: 23.09%							
META-ANALYSIS		**157/1901**	**374/5013**			**100 %**	**1.02 (0.80–1.30)**
Cochrane Q: 16.86 (p: 0.119) I^2: 34.77%							



Zimarino J Am Coll Cardiol Intv 2013

Simple or Complex Stenting for Bifurcation Coronary Lesions: A Patient-Level Pooled-Analysis of Nordic 1 and BBC

Kaplan-Meier freedom from the composite event



Number of patients at risk				
Complex	456	396	389	377
Simple	457	433	422	411

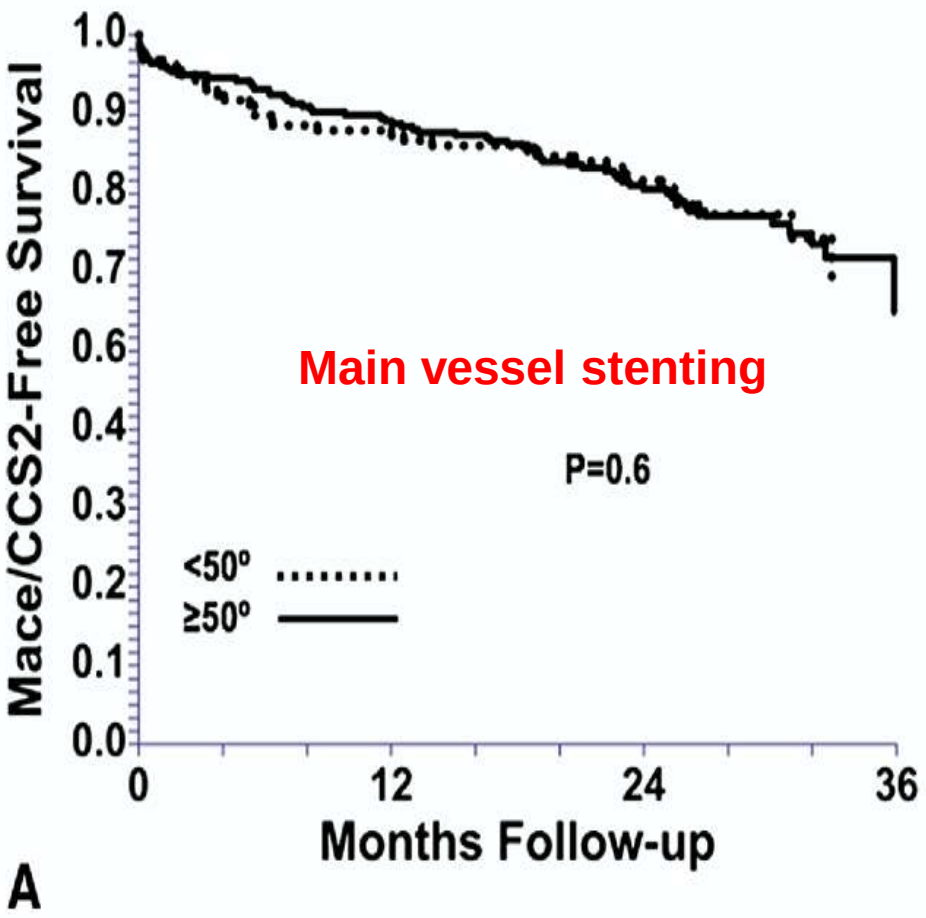
Behan Circ Cardiovasc Interv. 2011;4:57-64

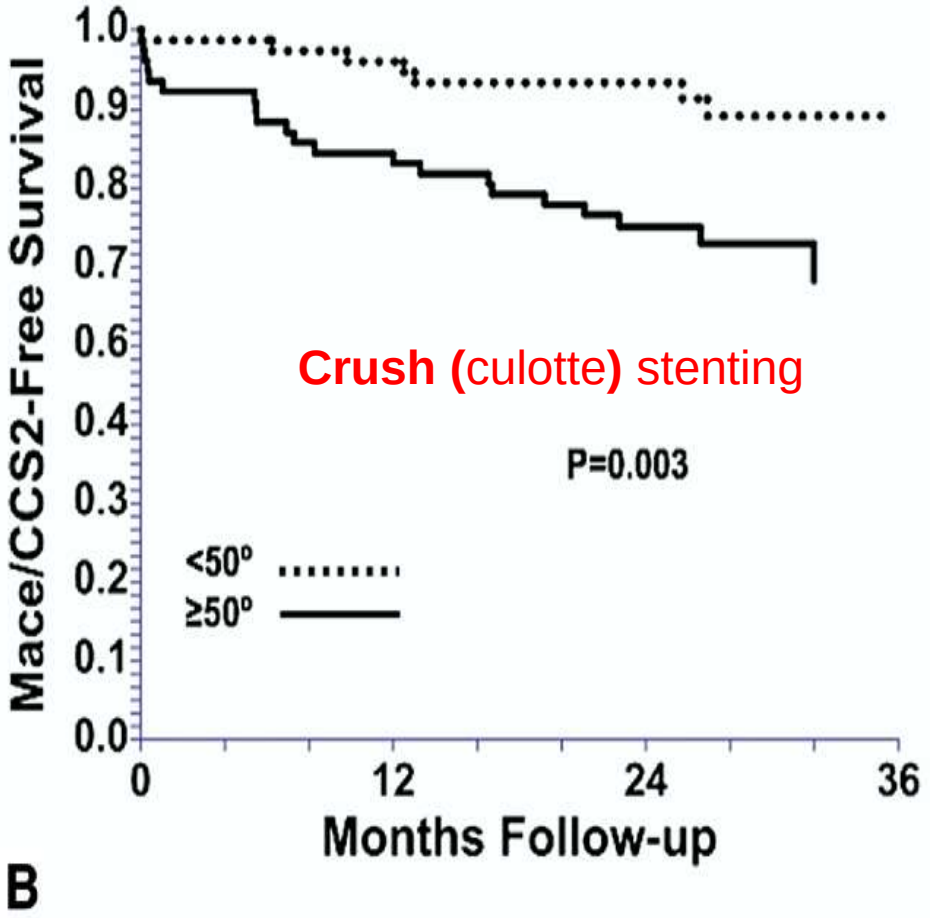
Pathological Findings at Bifurcation Lesions: Impact of Flow Distribution on Atherosclerosis and Arterial Healing After Stent Implantation

	DES (12 Lesions, 17 Stents)			BMS (14 Lesions, 18 Stents)			p Value for DES vs. BMS	
	Flow Divider	Lateral	p Value	Flow Divider	Lateral	p Value	Flow Divider	Lateral
Neointimal thickness (mm)	0.07 (0.03-0.15)	0.17 (0.09-0.23)	0.001	0.26 (0.16-0.73)	0.44 (0.17-0.67)	0.25	0.0002	0.004
Fibrin deposition (% struts)	60 (21-67)	17 (0-55)	0.01	8 (0-33)	3 (0-21)	0.21	0.008	0.19
Uncovered struts (% struts)	40 (16-76)	0 (0-15)	0.001	0 (0-21)	0 (0-0)	0.10	0.004	0.38

Nakazawa, Virmani, J Am Coll Cardiol 2010;55:1679–87

Outcome After Bifurcation PCI: role of angle





Kaplan-Meier curves for MACE or CCS class 2 angina-free survival / bifurcation angle

Collins Am J Cardiol 2008;102:404–410

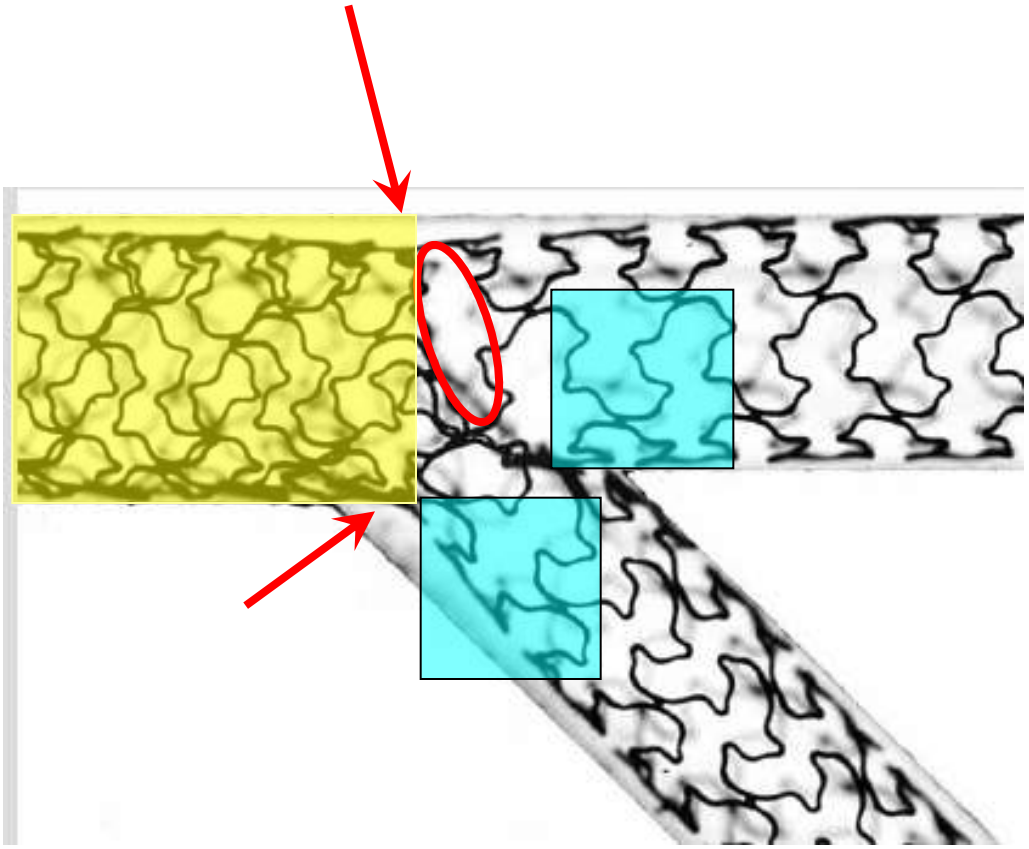
Culotte stenting : 12m dedicated QCA and clinical outcomes

Predictors of binary restenosis

Variable	Odds ratio (95% CI)	*P*-value
Age increase by 10 years	2.38 (1.21–4.96)	0.01
Diabetes	3.43 (0.71–16.60)	0.13
Male sex	0.62 (0.15–2.53)	0.51
Medina classification	0.42 (0.13–1.32)	0.14
Restenotic lesion	0.52 (0.12–2.24)	0.38
Bifurcation angle increase by 10°	1.53 (1.04–2.23)	0.03
Calcified lesion	0.53 (0.12–2.24)	0.39
Proximal main vessel		
Reference vessel diameter decrease by 1 mm	4.55 (0.17–123.36)	0.37
Baseline stenosis increase by 10%	0.91 (0.67–1.23)	0.54
Distal main vessel		
Reference vessel diameter decrease by 1 mm	0.10 (0.00–3.17)	0.19
Baseline stenosis increase by 10%	1.47 (1.03–2.09)	0.03
Side branch vessel		
Reference vessel diameter decrease by 1 mm	31.83 (1.71–592.77)	0.02
Baseline stenosis increase by 10%	0.97 (0.82–1.15)	0.75
Kissing balloon post-dilatation	0.37 (0.13–1.10)	0.07

Adriaenssens EHJ 2008; 29: 2868–2876

Culotte Technique



Stent not apposed

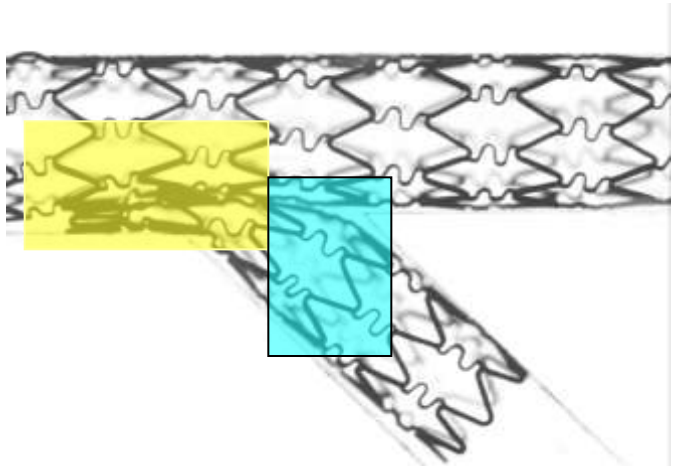
Stagnation area between the struts

Delayed endothel.

Recirculation

Courtesy of John Ormiston

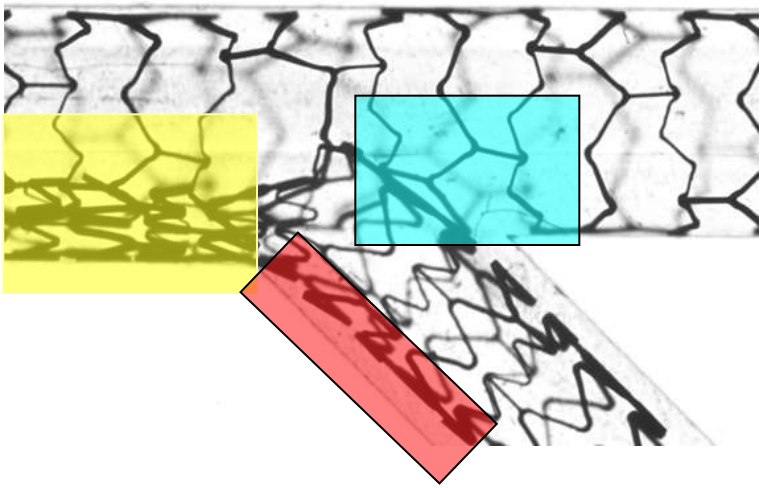
Crush Technique

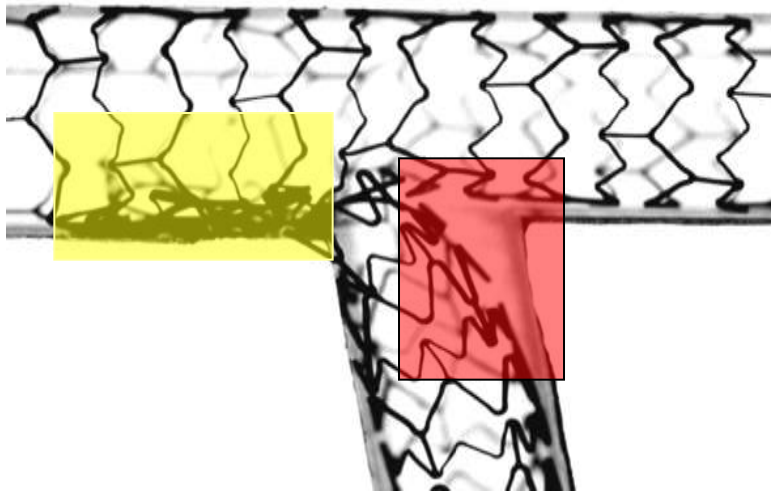


Stagnation area between the struts

Delayed endothel. Recirculation

Stent not apposed





Courtesy of John Ormiston

Nordic II

Procedure data II

	Crush n = 210	Culotte n = 215	P Value
MV stented, %	99.5	99.1	ns
SB stented, %	98.6	97.7	ns
Final kissing balloon	84.3	91.6	0.02
Tx acc. to ran., %	96.7	96.7	ns
Tx successful, % (residual sten.<30% of MV+TIMI III flow in SB)	97.6	97.7	ns

Niemela, Circulation. 2011;123:79-86

Nordic II

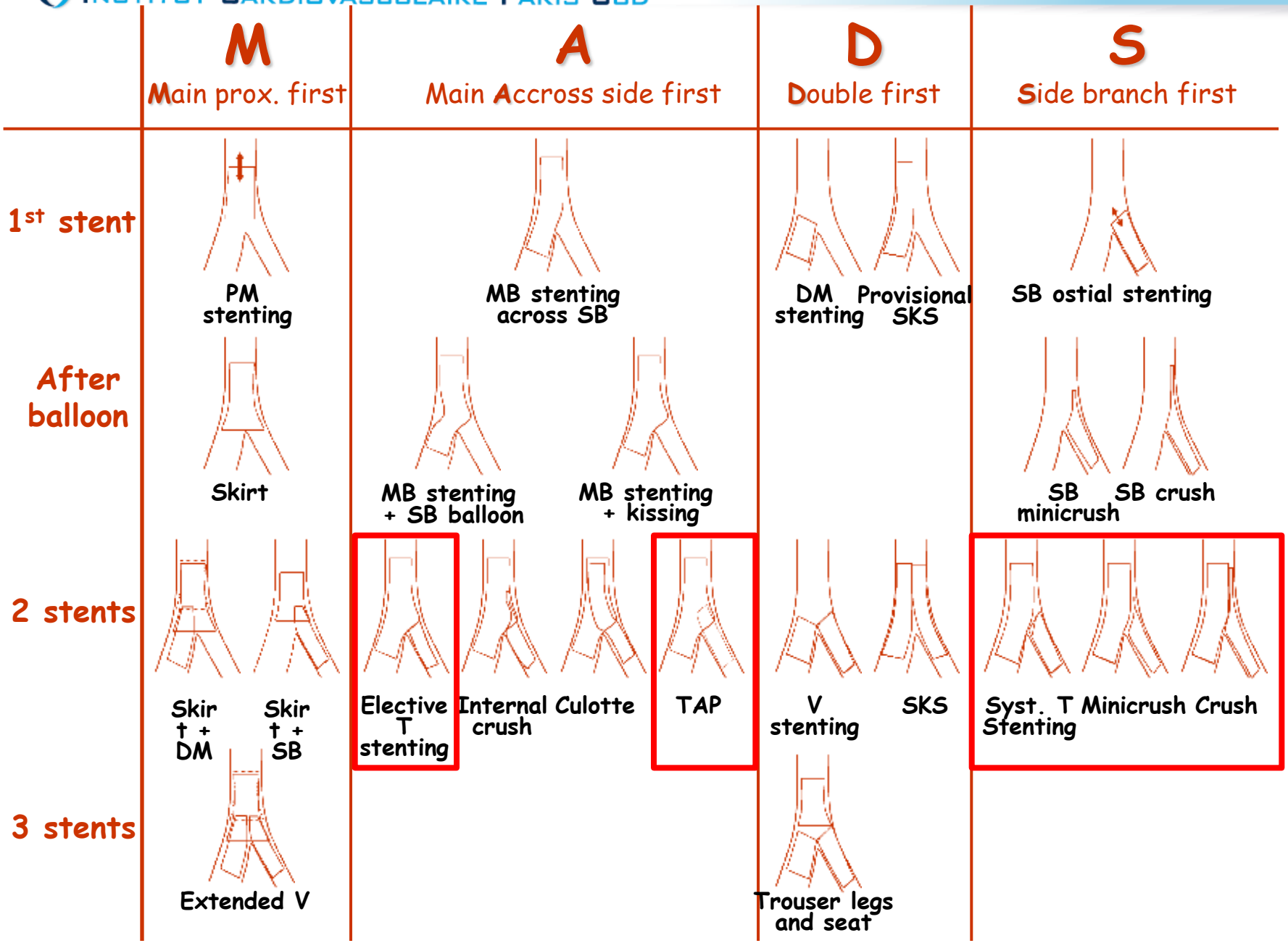
Individual endpoints after 6 months

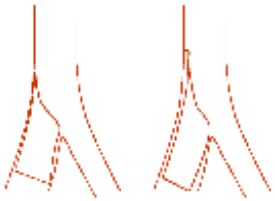
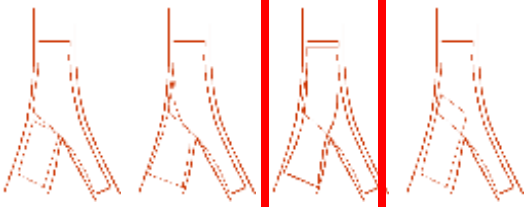
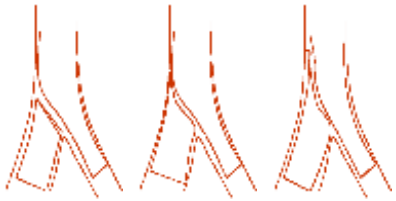
	Crush n = 210	Culotte n = 215	P Value
Non-cardiac death, %	0.0	0.5	ns
Cardiac death, %	1.0	0.0	ns
Myocard. infarc., %	0.5	0.9	ns
TVR, %	3.3	3.3	ns
Stent thrombosis, %	1.9	1.4	ns

Niemela, Circulation. 2011;123:79-86

Is it the same for distal LM stenting ?

- Distal LM is a bifurcation like others
- But with larger diameter segments
- Easier to treat
- Frequently unadequate stents
- **Much more clinical consequences:**
  - **acutely (complications)**
  - **mid to longterm: residual ischemia (symptoms), restenosis**


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

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

Comparison of DK crush versus culotte stenting for unprotected distal left main bifurcation lesions: A multicenter, randomized, prospective DKCRUSH-III study

(ChiCTR-TRC-00000151)

Shao-Liang Chen, M.D., FACC

Jun-Jie Zhang, M.D., FSCAI

Nanjing First Hospital

Nanjing Medical University, Nanjing, China

On behalf of the DKCRUSH-III Investigators

Disclosures: DKCRUSH-III study was funded by the Jiangsu Provincial Outstanding Medical Program (JPOMP-20071230).

DKCRUSH-III

Exclusion criteria

- Pregnant
- Life expectancy <12 months
- Intolerance to the study drugs
- LVEF<30%
- eGFR<40ml/min
- LM RVD>5.0mm
- Difference in RVD between LAD and LCX >1.0mm
- Severe calcification needing rotational atherectomy
- LMb restenosis lesion

DKCRUSH-III

Study endpoints

- Primary endpoint

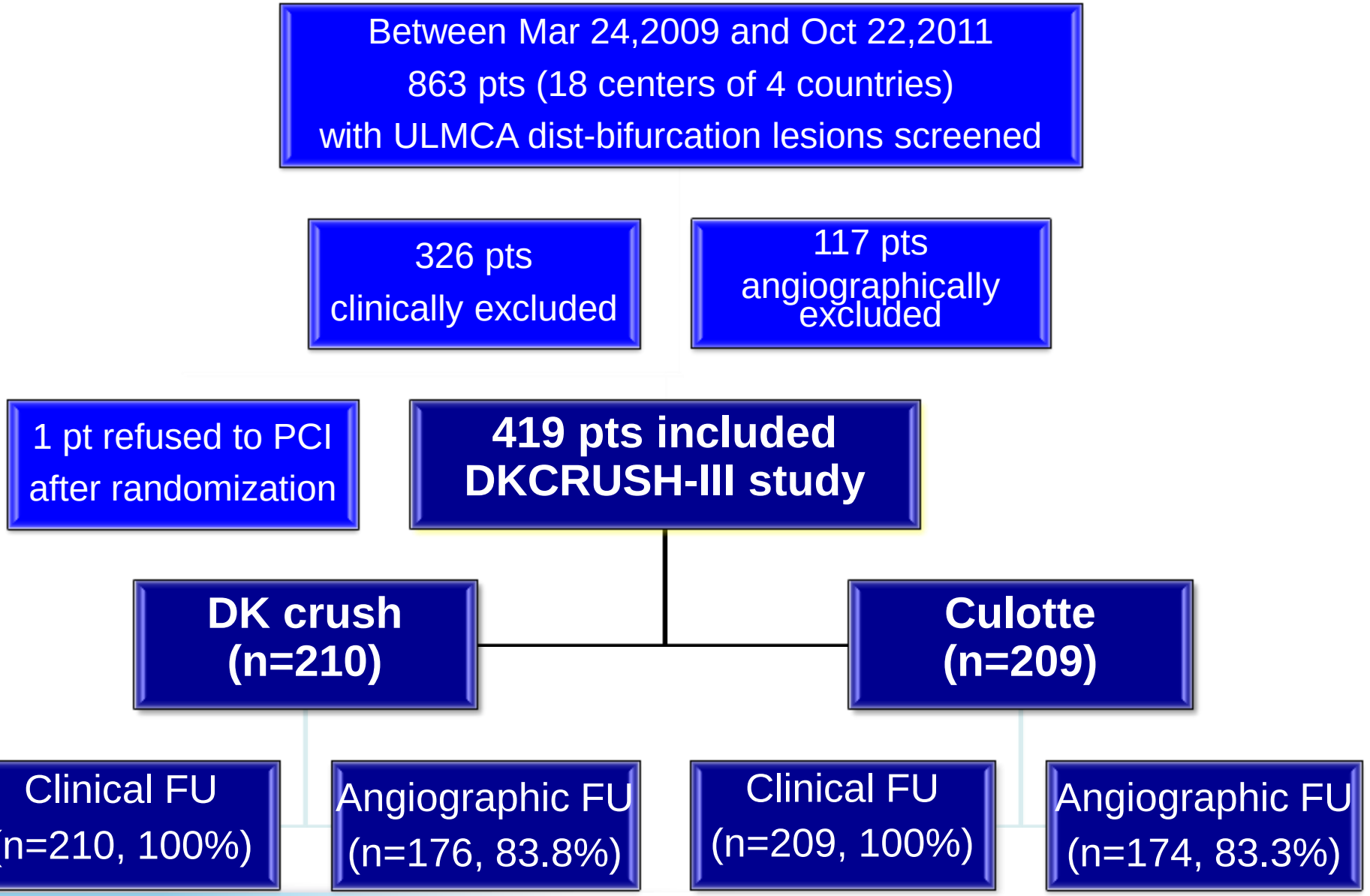
  MACE (cardiac death, MI and TVR) at 1-year
- Secondary endpoint

  In-stent restenosis (ISR) at 8-month
- Safety endpoint

  Stent thrombosis (ST) at 1-year

DKCRUSH-III

DKCRUSH-III study Flow Chart



DKCRUSH-III

Lesion characteristics (1)

	DK crush (n=210)	Culotte (n=209)	p
3-vessel disease, n (%)	149(71.3)	145(69.5)	0.130
Left main trunk, n (%)			
Chronic total occlusion	1(0.4)	0	0.653
Ostial	31(15.2)	42(20.4)	0.197
Mid shaft	71(34.8)	60(28.7)	0.102
Whole trunk	45(21.8)	39(18.9)	0.159
Distal bifurcation			0.896
Medina 1,1,1	207(98.7)	198(94.8)	
Medina 0,1,1	3(1.3)	11(5.2)	

Lesion characteristics (3)

	DK crush (n=210)	Culotte (n=209)	p
Syntax score (points)	30.67±12.89	31.51±15.60	0.254
0~22, n (%)	69(32.9)	54(25.8)	0.462
NERS score (points)	26.03±10.70	26.12±10.55	0.677
<20, n (%)	55(26.2)	47(22.5)	0.241

DKCRUSH-III

Procedural characteristics (2)

	DK crush (n=210)	Culotte (n=209)	p
Main vessel stent			
Number, n	1.38±0.45	1.39±0.49	0.556
Diameter, mm	3.40±0.34	3.34±0.40	0.106
Length, mm	33.48±14.01	35.74±15.99	0.124
Side branch Stent			
Number, n	1.20±0.39	1.14±0.35	0.159
Diameter, mm	3.04±0.41	3.03±0.41	0.587
Length, mm	25.90±13.83	26.72±11.86	0.519
Post-dilation, n (%)			
Main vessel	205(97.6)	200(95.7)	0.693
Side branch	202(96.2)	200(95.7)	0.810
FKBI, n (%)	209(99.5)	208(99.5)	1.000

DKCRUSH-III

Procedural characteristics (3)

	DK crush (n=210)	Culotte (n=209)	p
Angiographic success, n (%)	204(97.1)	208(99.5)	0.122
Procedural success, n (%)	203(96.7)	201(96.2)	0.800
Complete revascularization, n (%)	180(85.7)	171(82.0)	0.351
Procedural time, min.	56.88±33.11	54.87±32.09	0.529
Fluoroscopy time, min.	26.57±14.39	27.66±17.53	0.487
Contrast volume, ml	184.40±22.01	170.10±7.22	0.048
Non-left main lesions			
Stent number, n	1.41±0.73	1.26±0.53	0.410
Stent diameter, mm	2.89±0.42	2.99±0.46	0.468
Stent length, mm	36.86±27.33	32.33±15.34	0.468
Staged procedures, n (%)	82(39.0)	72(34.4)	0.711

DKCRUSH-III

QCA of LM

	DK crush (n=176)	Culotte (n=174)	p
Days from indexed procedure (d)	223.0.±15.3	211.9±14.1	0.109
Left main trunk			
Lesion length, mm	6.36±3.69	6.97±3.86	0.100
Minimal lumen diameter, mm			
Prior-stenting	1.47±0.43	1.49±0.42	0.719
Acute gain, mm	2.34±0.47	2.34±0.49	0.980
Late loss, mm	0.18±0.29	0.23±0.34	0.378
Diameter stenosis, %			
Prior-stenting	59.84±9.35	59.18±8.47	0.772
Follow-up	11.08±7.24	11.81±6.83	0.401
Restenosis, n (%)	0	0	NS

DKCRUSH-III

QCA of distal main vessel (LAD)

	DK crush (n=176)	Culotte (n=174)	p
Days from indexed procedure (d)	223.0.±15.3	211.9±14.1	0.109
Distal main vessel (LAD)*			
Lesion length, mm	16.67±9.23	18.65±12.26	0.067
Minimal lumen diameter, mm			
Prior-stenting	1.09±0.42	1.07±0.44	0.984
Acute gain, mm	1.79±0.41	1.79±0.42	0.988
Late loss, mm	0.19±0.32	0.20±0.33	0.938
Diameter stenosis, %			
Prior-stenting	64.62±5.66	65.69±6.46	0.414
Follow-up	16.15±8.33	15.41±7.10	0.622
Restenosis, n (%)	2(1.14)	1(0.57)	1.000

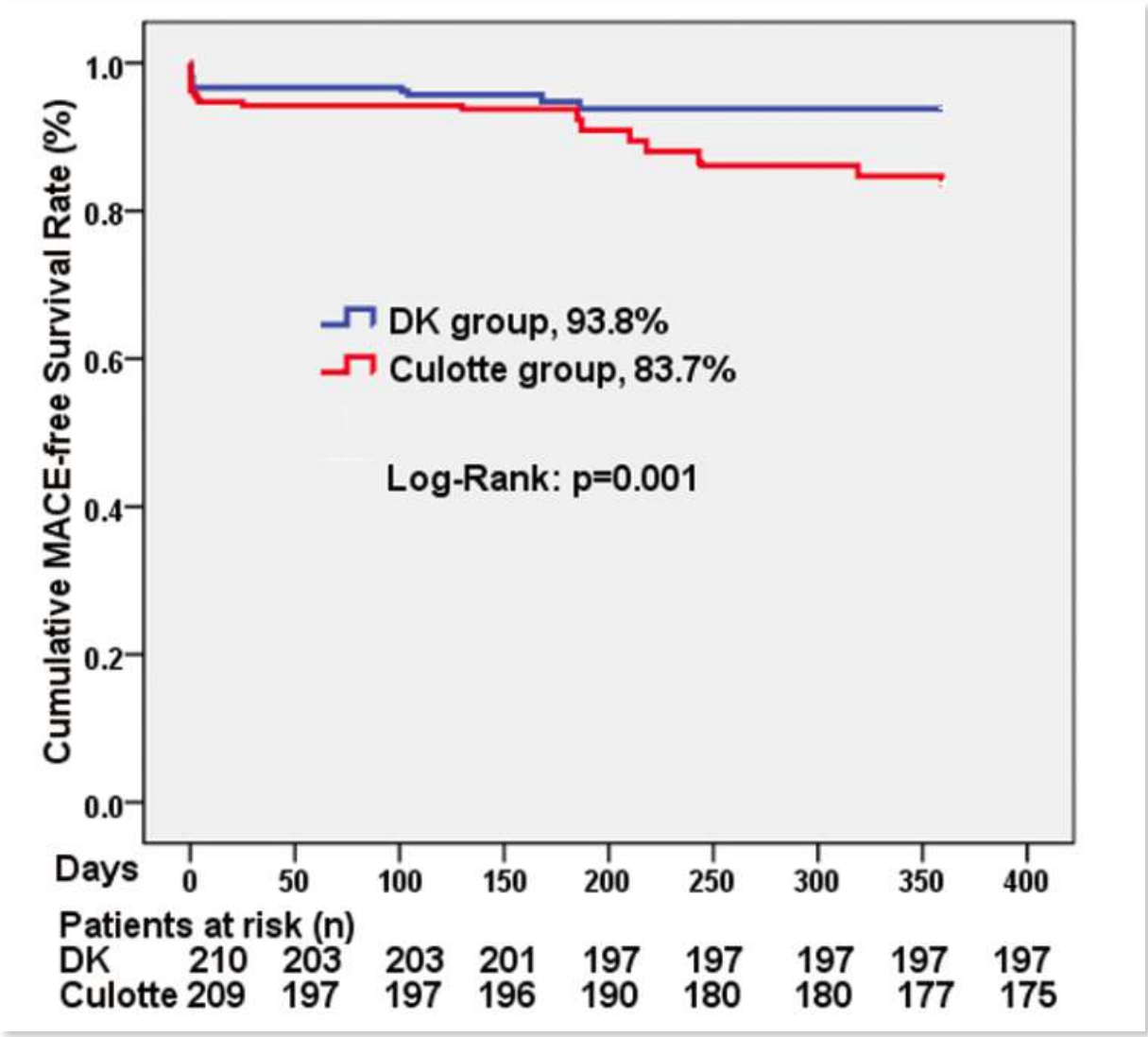
DKCRUSH-III

QCA of side branch (LCX)

	DK crush (n=176)	Culotte (n=174)	p
Side branch (LCX)*			
Lesion length, mm	16.48±11.09	16.97±13.01	0.804
Minimal lumen diameter, mm			
Prior-stenting	1.01±0.43	1.07±0.49	0.597
Acute gain, mm	1.58±0.43	1.58±0.49	0.990
Late loss, mm			
In-stent	**0.20±0.30**	**0.39±0.36**	0.001
In-segment	0.09±0.21	0.21±0.30	0.048
Diameter stenosis, %			
Prior-stenting	65.29±7.34	63.36±7.75	0.640
Follow-up	16.39±7.45	25.50±7.36	0.001
Restenosis, n (%)	12(6.82)	22(12.64)	0.037
In-segment	4(2.27)	6(3.45)	0.540
In-stent	9(5.11)	19(10.92)	0.034
Ostial	9(5.11)	16(9.19)	0.045

DKCRUSH-III

MACE-free Survival Rate at 12-month



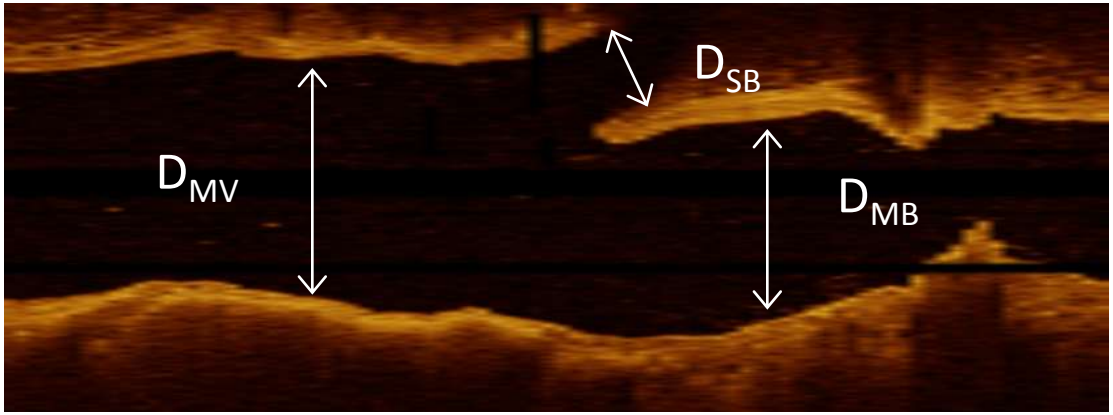
2 stent technique differences

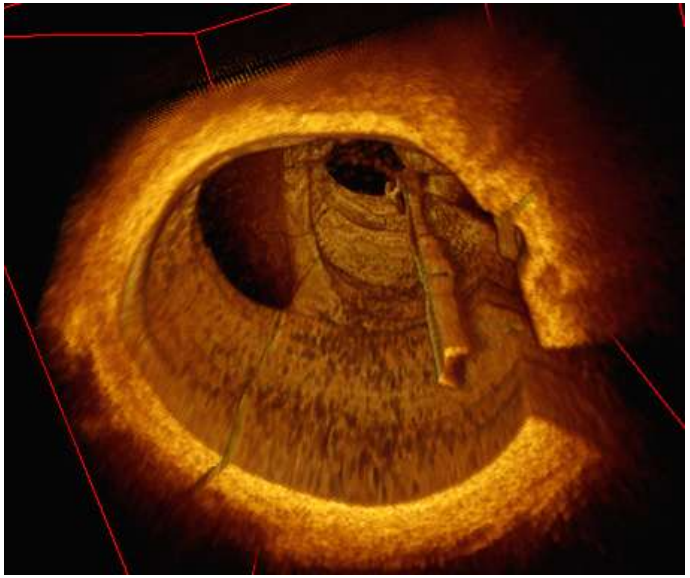
2 stent techniques	**DK-Crush**	**Inverted-Culotte**	**Provisional T** (Culotte ?)	**TAP** (Culotte ?)
Approach	Radial	Radial	Radial	Femoral ?
Catheter size	6F	6F	6F	7F
% SB stenting	100%	100%	variable	variable
2 stent decision	Predictors	Predictors	Result	Result
SB stenting failure	None	None	Very low	Very low
MB stenting failure	Very low	Very low	None	None

Definition of complex Bif	Sen (%)	Spe (%)
One Major**+any** two **of** Minor **criteria**	>84 **(78)**	**≥79 (71-72)**

Chen et al. JACC interv 2014, online

Anatomy of Bifurcations



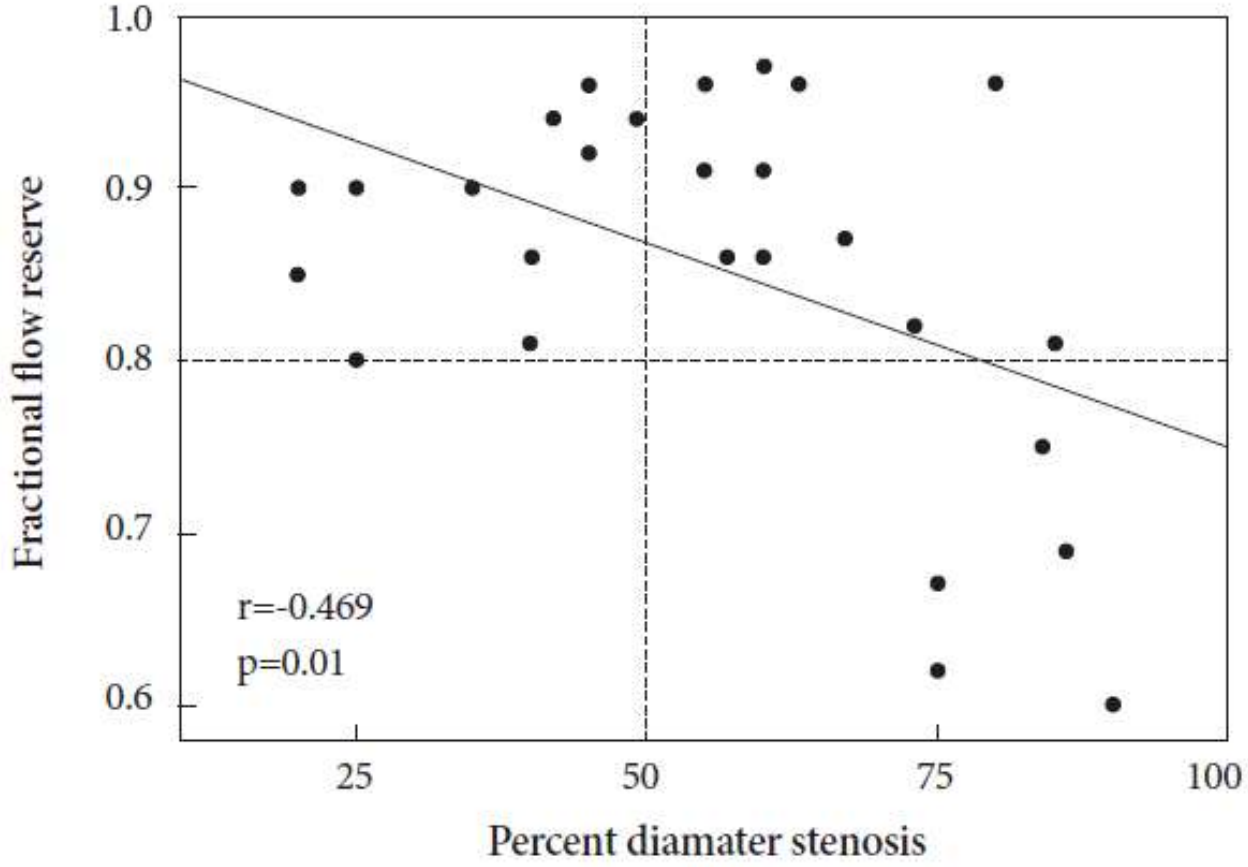


	Principle	Relation	*Ratio Dm/Dd for D_{d1}~ D_{d2}*
Murray's law	Minimum Work	$D_m3 = D_{d1}3 + D_{d2}3$	*1.26*
HK: Huo-Kassab	Minimum Energy	$D_m7/3 = D_{d1}7/3 + D_{d2}7/3$	*1.35*
Flow conservation	$Q_m = Q_{d1} + Q_{d2}$	$D_m2 = D_{d1}2 + D_{d2}2$	*1.4*
Finet	Measurement	$D_m = \underline{0.678}\ (D_{d1} + D_{d2})$	*1.36*

- The larger the SB, the larger the change in MV diameter throughout the bifurcation

Courtesy of N Foin

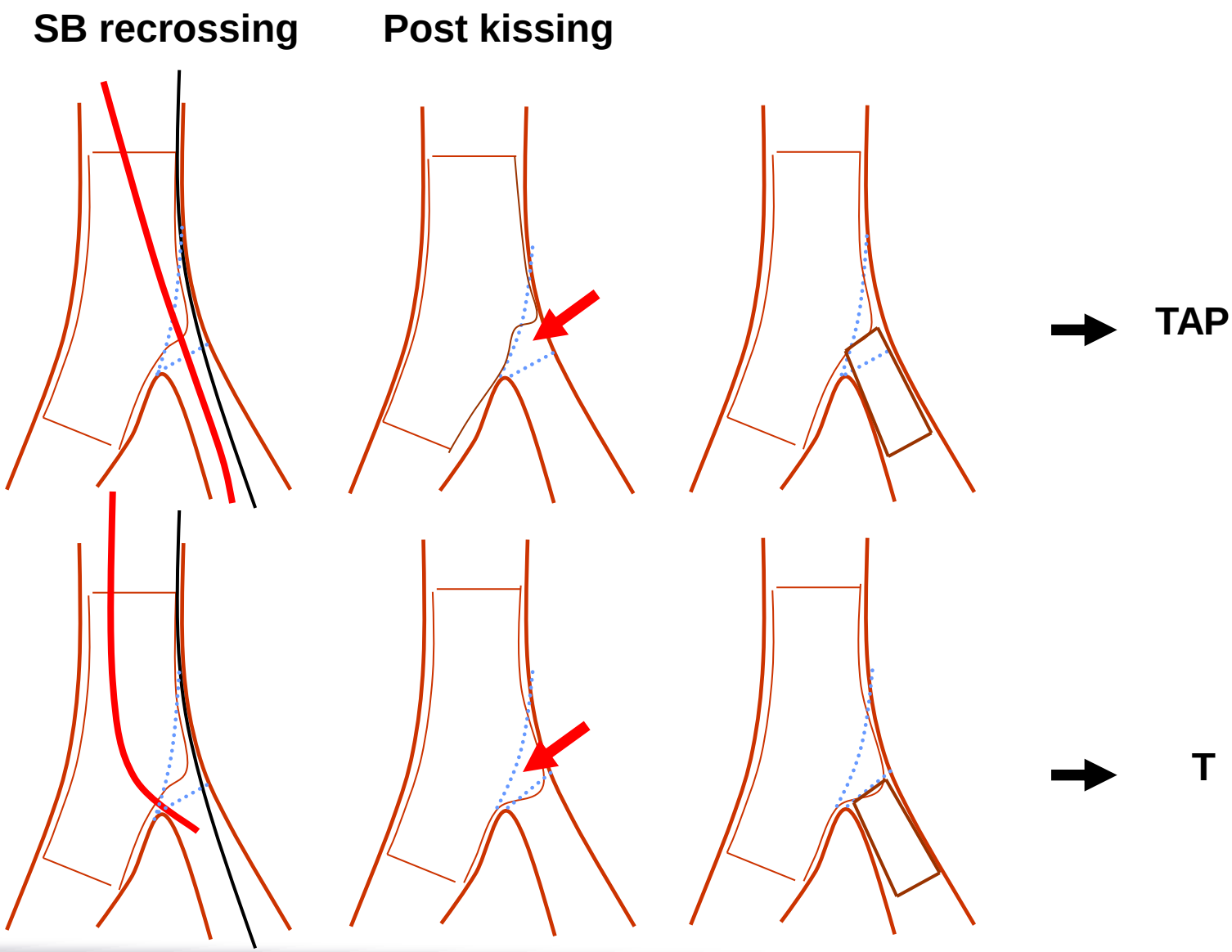
FFR Versus Angiography in Left Circumflex Ostial Intervention After Left Main Crossover Stenting



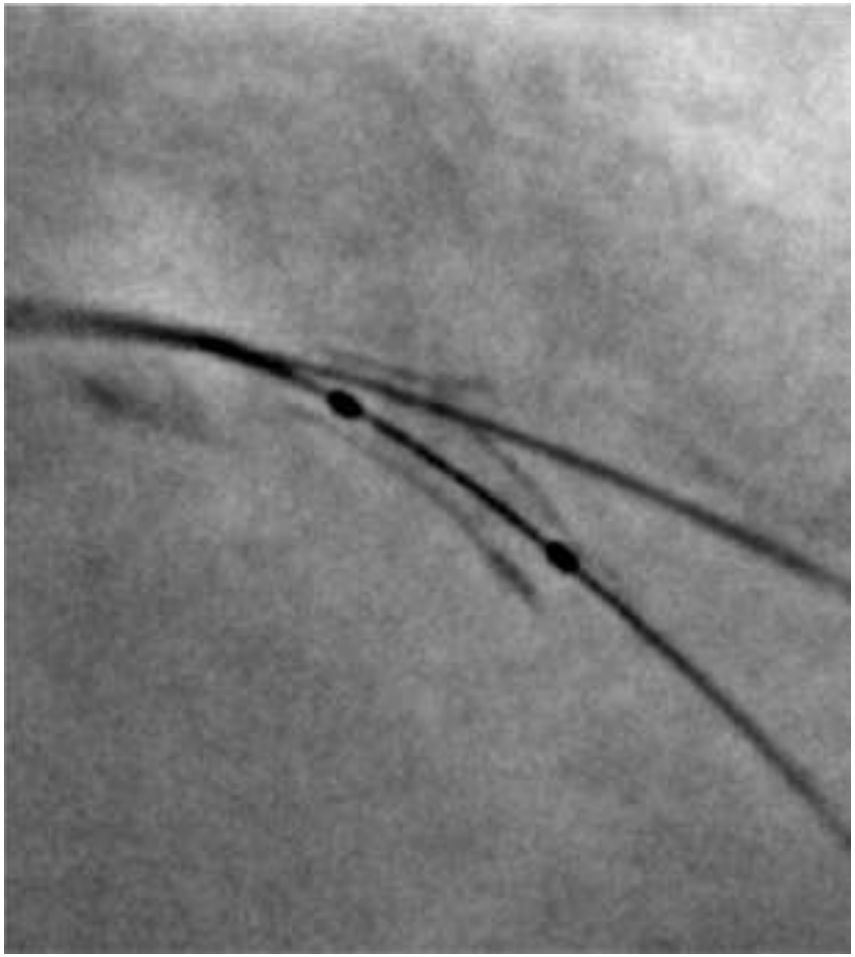
Correlation between fractional flow reserve and percent diameter stenosis of ostial circumflex coronary artery after left main to left anterior descending coronary artery stenting.

Nam, Korean Circ J 2011;41:304-3

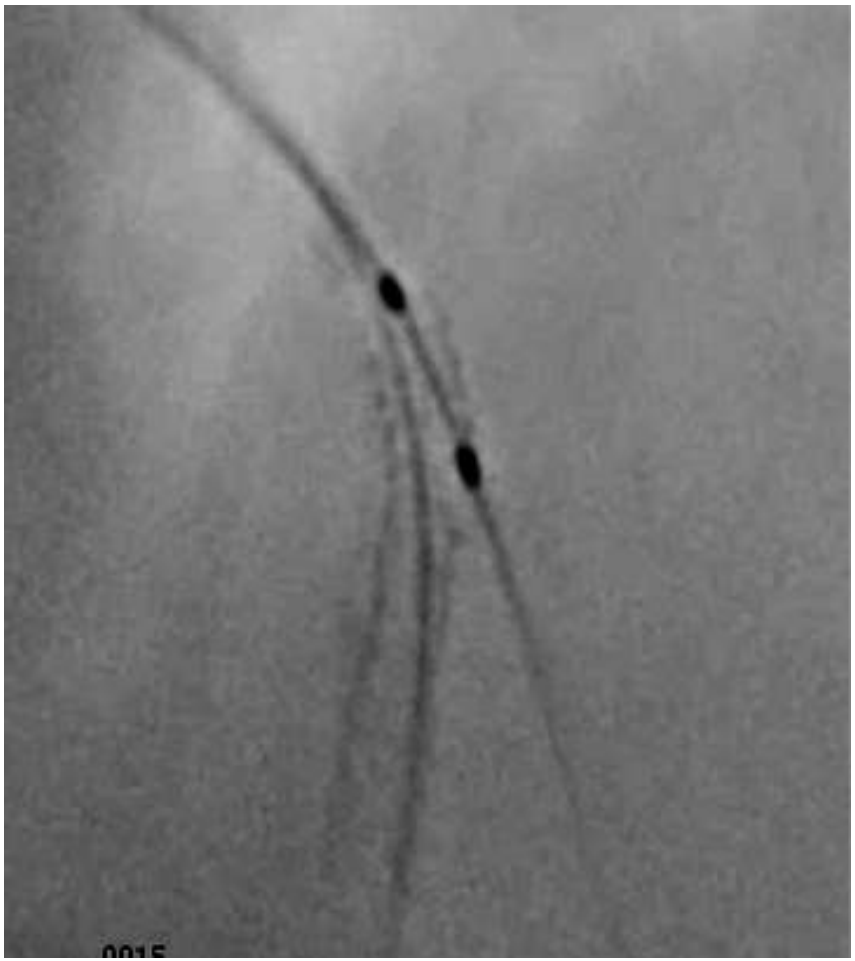
T or TAP ?



T or TAP ? (stent boost)

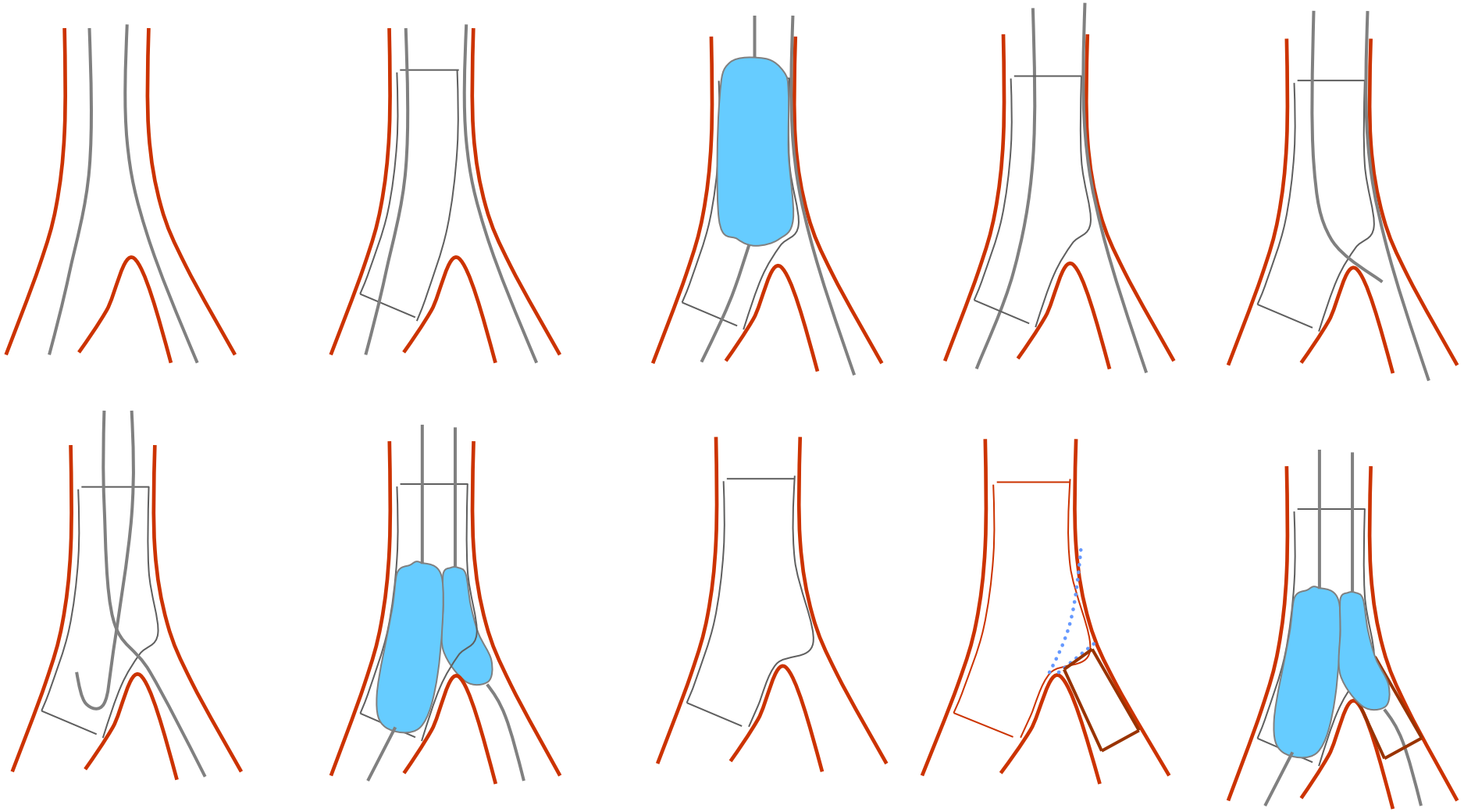


T

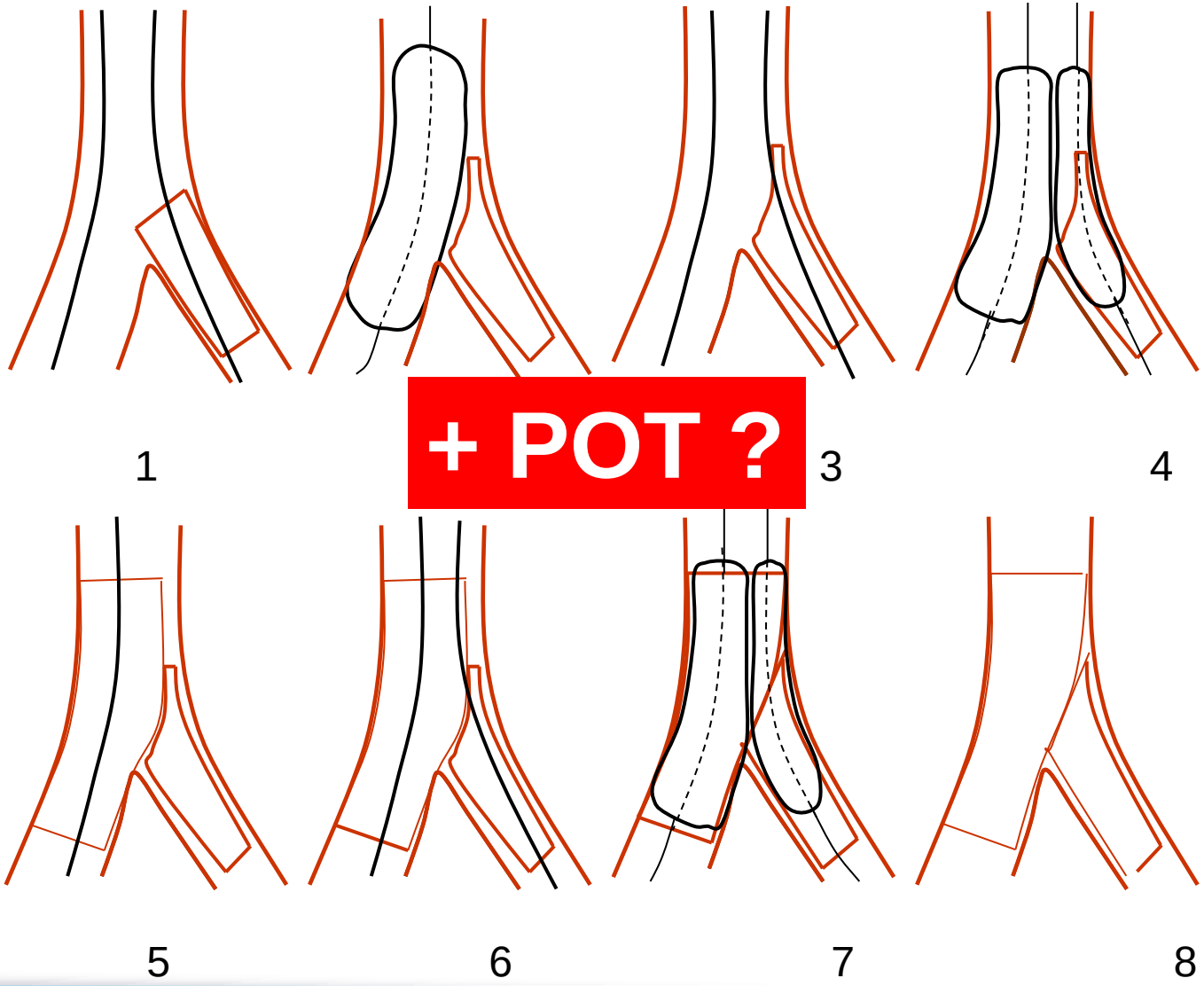


TAP

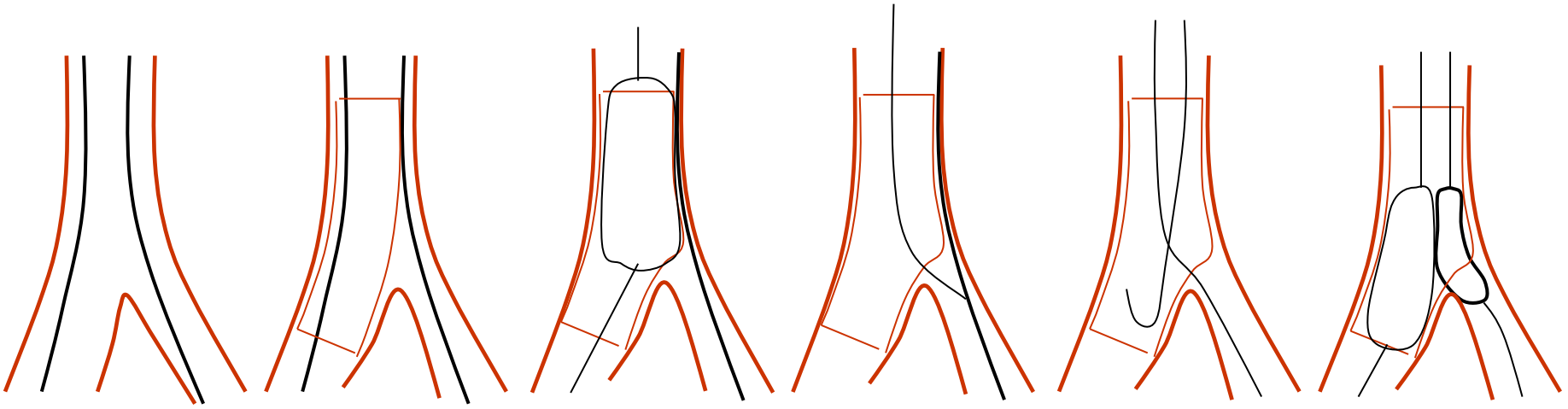
Provisional Side Branch Stenting



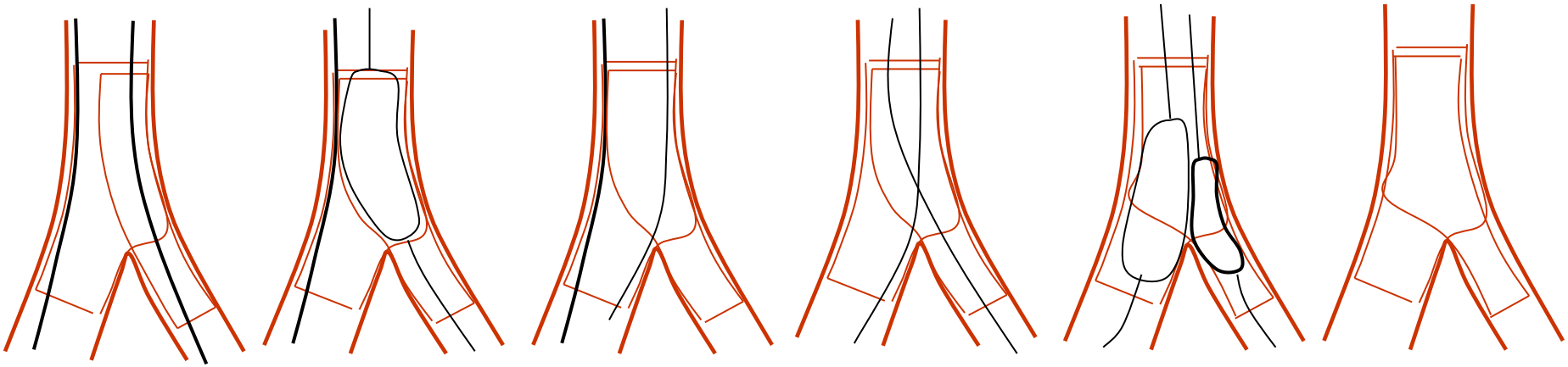
Mini DK Crush technique



Inverted Culotte technique



1 2 3 4 5 6



7 8 9 10 11 12

Conclusions

Looking at distal LM as a population

- With **DK-Crush** (Culotte) stent 100% of LM with complex lesion (without = provisional): 30-40 % ?
- With **Provisonal** with POT stent easily 30-40% of unacceptable results after kissing ?

Will it make a difference ?

- With **DK-Crush** we are mini-crushing, but in front of carena …
- With **Provisional T**
  - we will limit the amount of metal at the carena, respect the anatomy of the bifurcation …
  - other option: stent the SB bad results / prevent restenosis with DEB

EBC Main trial
Provisional vs 2 stents in Distal LM