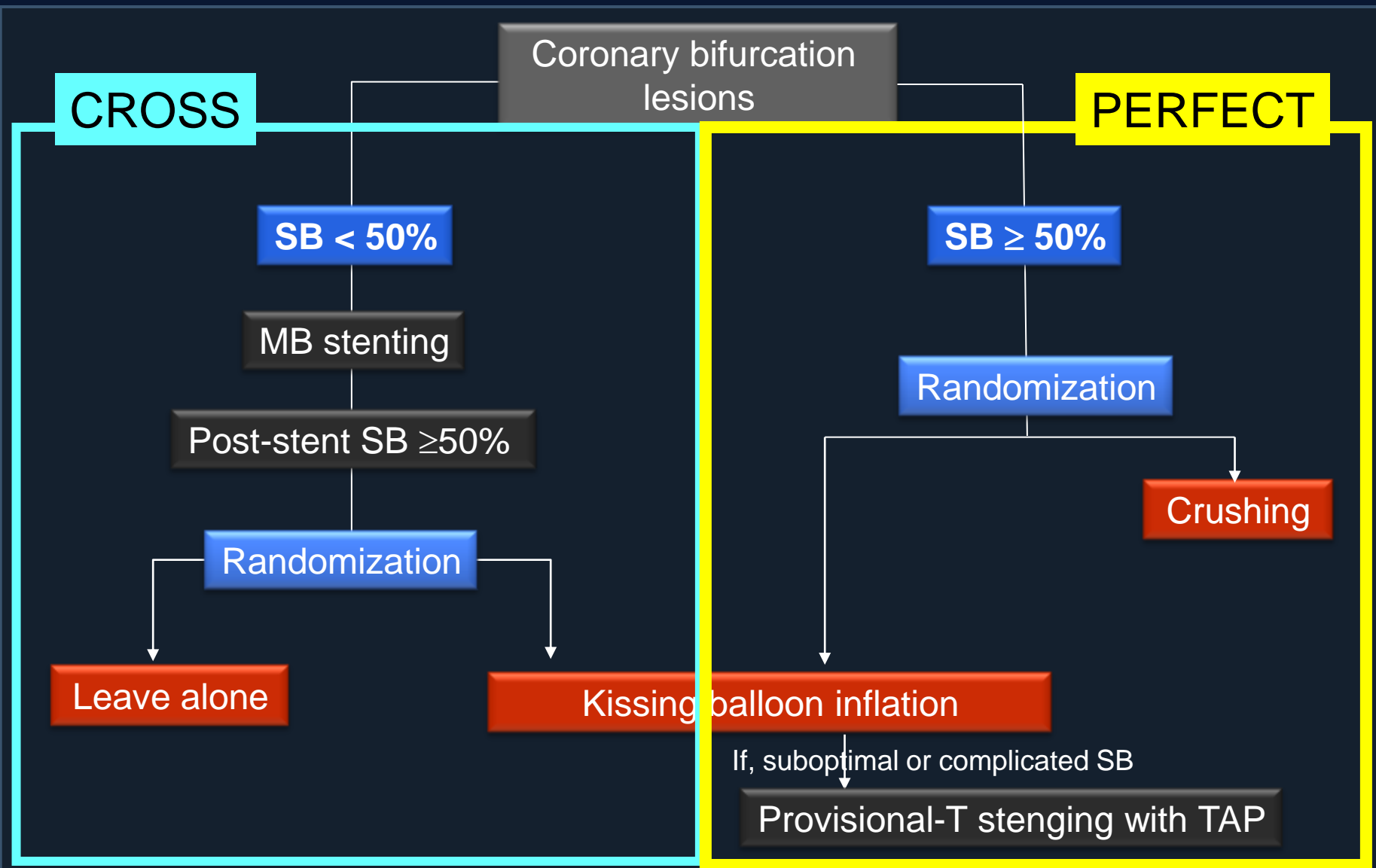


Key Lessons from CROSS and PERFECT Trials

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CROSS & PERFECT Trials



Inclusion Criteria

1. Clinical

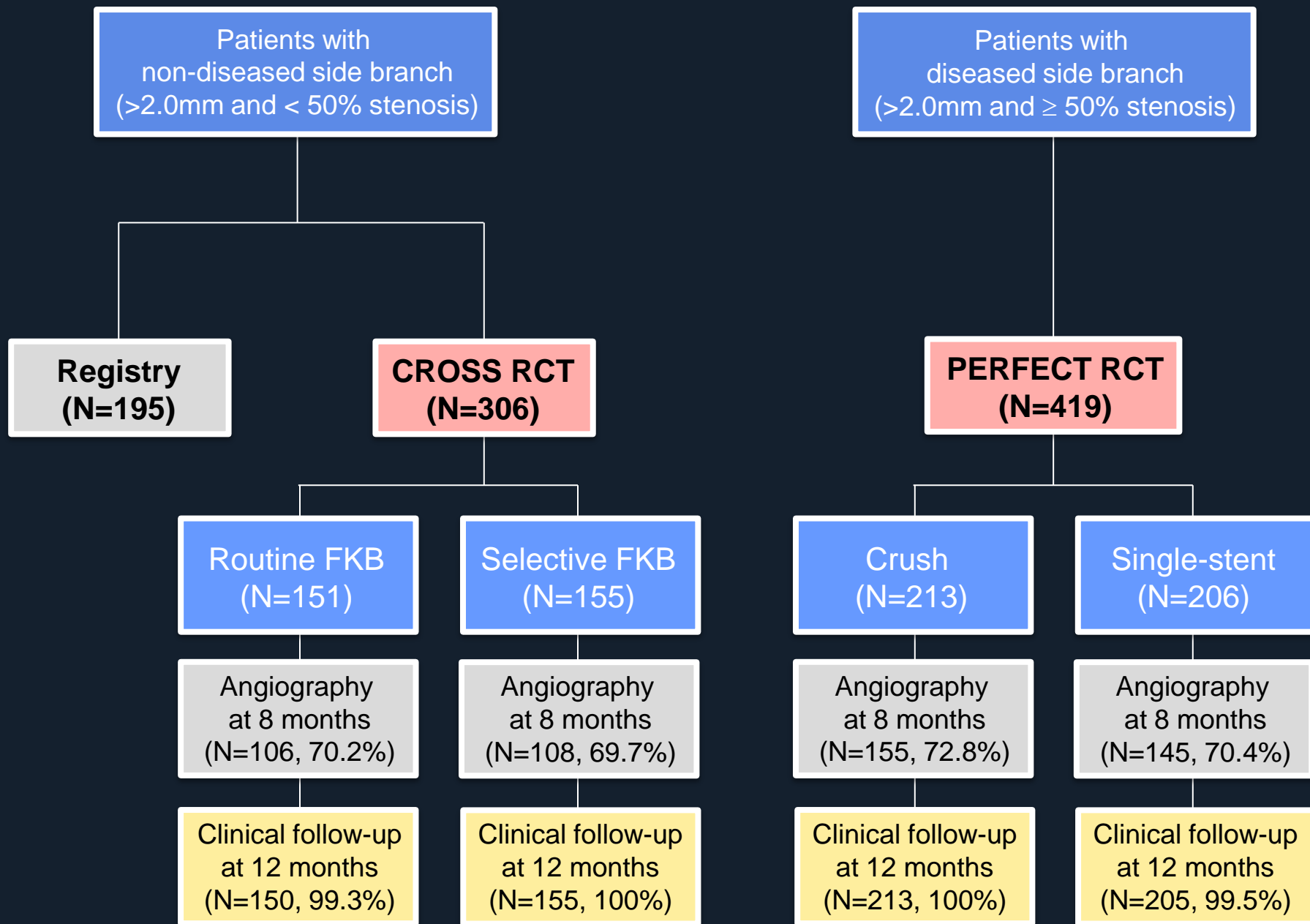
- Ischemic symptom or sign
- Eligible lesion for intracoronary stenting
- Age >18 years, <75 ages

2. Angiographic

- De novo bifurcation
- **MB:** ≥ 2.5 mm, $\geq 50\%$ stenosis, ≤ 50 mm length covered with ≤ 2 stents
- **SB:** ≥ 2.0 mm, $< 50\%$ stenosis (CROSS)
- **SB:** ≥ 2.0 mm, $\geq 50\%$ & < 20 mm length (PERFECT)

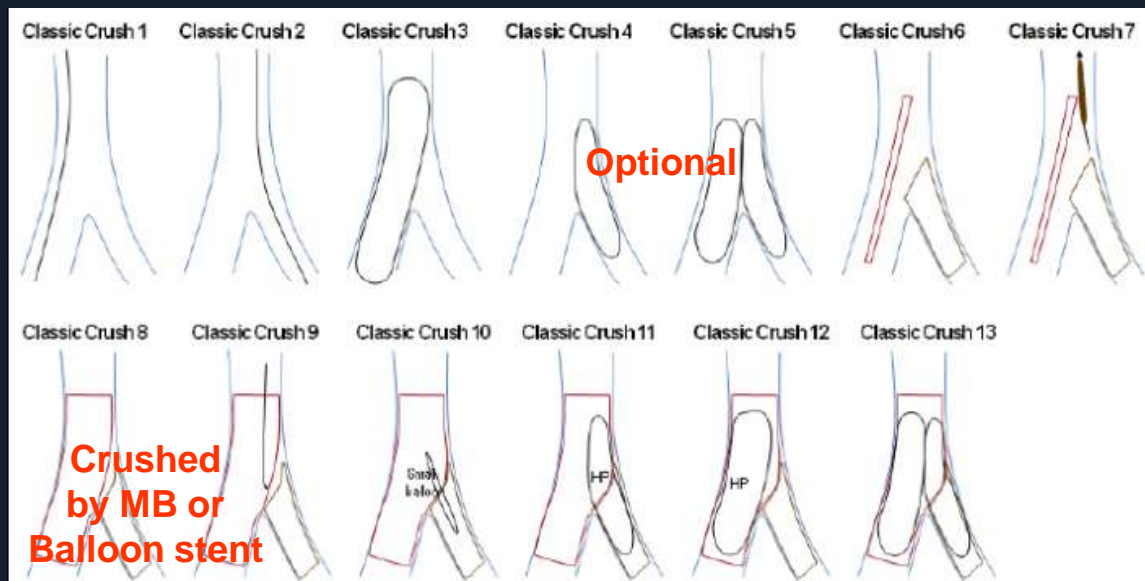
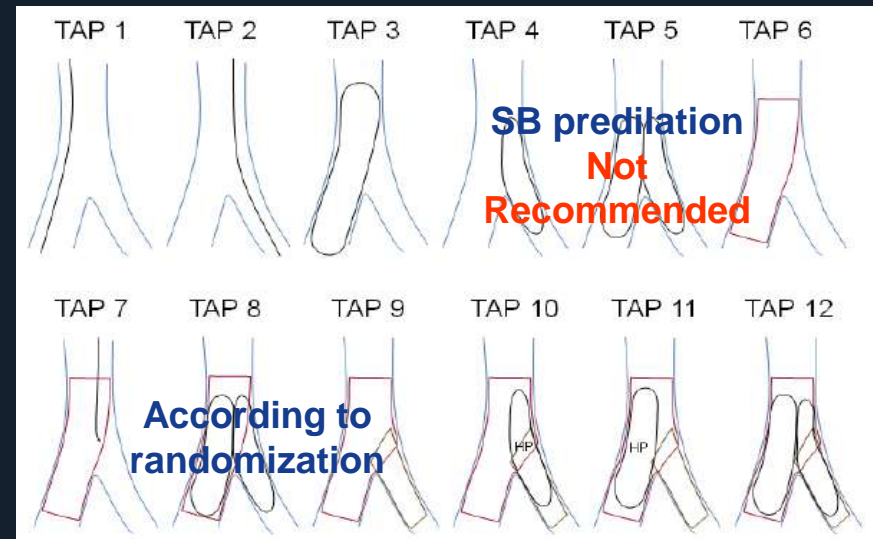
Exclusion Criteria

- Serious comorbidity with left expectancy < 1 year
- STEMI \leq 2 weeks
- LM disease
- In-stent restenosis
- Graft vessels
- TIMI flow \leq grade 2 in the side branch
- CTO
- Renal dysfunction, Creatinine \geq 2.0 mg/dL



Prespecification and Consensus on Procedural Steps

**Single-stent with
Routine FKB or selective FKB
Or optional Provisional-T**



**Crush
with balloon or
stent crush**

Baseline Characteristics

Variables	CROSS Study			PERFECT Study		
	Routine-FKB	Leave-alone	P	Crush	1-stent	P
	(N=151)	(N=155)		(N=213)	(N=206)	
Age, years	61.0±9.2	61.0±7.9	0.98	60.9±8.9	61.1±8.8	0.86
Male	107 (70.9)	104 (67.1)	0.48	160 (75.1)	155 (75.2)	1.0
BMI, kg/m ²	24.7±3.0	24.9±2.6	0.75	24.9±2.8	24.9±3.0	0.86
Current smoking	50 (33.1)	39 (25.2)	0.13	54 (25.4)	67 (32.5)	0.11
Diabetes mellitus	46 (30.5)	45 (29.0)	0.78	55 (25.8)	60 (29.1)	0.45
Hypertension	84 (55.6)	91 (58.7)	0.59	118 (55.4)	114 (55.3)	0.99
Hyperlipidemia	71 (47.0)	77 (49.7)	0.64	132 (62.0)	118 (57.3)	0.33
Family history	10 (6.6)	19 (12.3)	0.092	30 (14.1)	26 (12.6)	0.66
Prior CABG	8 (5.3)	15 (9.7)	0.15	20 (9.4)	11 (5.3)	0.11

Baseline Characteristics

Variables	CROSS Study			PERFECT Study		
	Routine-FKB	Leave-alone	P	Crush	1-stent	P
	(N=151)	(N=155)		(N=213)	(N=206)	
CRF	4 (2.6)	0	0.058	1 (0.5)	1 (0.5)	1.0
CHF	0	0		0	2 (1.0)	0.24
Prior MI	3 (2.0)	6 (3.9)	0.5	9 (4.2)	9 (4.4)	0.94
Clinical symptom			0.64			0.43
Stable	74 (49.0)	84 (54.2)		130 (61.3)	127 (62.0)	
Unstable angina	66 (43.7)	62 (40.0)		74 (34.9)	65 (31.7)	
Recent MI	11 (7.3)	9 (5.8)		8 (3.8)	13 (6.3)	
LVEF, %	60.9 ± 7.0	62.2 ± 5.7	0.098	60.4 ± 6.8	59.5 ± 7.2	0.2

Procedures

Variables	CROSS Study			PERFECT Study		
	Routine-FKB	Leave-alone	P	Crush	1-stent	P
	(N=151)	(N=155)		(N=213)	(N=206)	
Treated vessels			0.54			0.62
1 vessel	111 (73.5)	109 (70.3)		159 (74.6)	145 (70.4)	
2 vessels	35 (23.2)	43 (27.7)		46 (21.6)	52 (25.2)	
3 vessels	5 (3.3)	3 (1.9)		8 (3.8)	9 (4.4)	
Target lesions			0.69			0.33
LAD	137 (90.7)	137 (88.4)		200 (93.9)	190 (92.2)	
LCX	11 (7.3)	12 (7.7)		10 (4.7)	15 (7.3)	
RCA	3 (2.0)	6 (3.9)		3 (1.4)	1 (0.5)	
Trans-radial	56 (37.1)	55 (35.5)	0.77	25 (11.7)	25 (12.1)	0.90
Procedure T, min	40.8±18.5	32.8 ± 16.2	< 0.001	52.5±21.0	48.7±21.2	0.065
Fluoroscopic T, min	21.4±10.3	17.9 ± 8.1	0.001	29.3±14.1	25.9±12.7	0.013
Contrast, cc	287±128	273± 110	0.31	350±145	347±125	0.85

Procedures for Main Branch

Variables	CROSS Study			PERFECT Study		
	Routine-FKB	Leave-alone	P	Crush	1-stent	P
NC balloon	95 (62.9)	87 (56.1)	0.23	141 (66.2)	97 (47.1)	< 0.001
Cutting balloon	0	1 (0.6)	1.00	6 (2.8)	2 (1.0)	0.29
IVUS	139 (92.1)	149 (96.1)	0.13	204 (95.8)	197 (95.6)	0.94
Predilation	148 (98.0)	149 (96.1)	0.50	208 (97.7)	202 (98.1)	1.0
Stents	151 (100)	155 (100)		213 (100)	206 (100)	
Number	1.3±0.5	1.2±0.4	0.61	1.4±0.5	1.4±0.5	0.76
Diameter, mm	3.5±2.2	3.3±0.3	0.23	3.3±0.3	3.3±0.3	0.49
Length, mm	33.2±13.1	33.0±14.8	0.94	37.3±14.7	36.9±15.3	0.76
Maximal Pr, atm	19.2±4.4	18.5±4.6	0.18	18.7±4.1	15.9±4.7	< 0.001
Used stents			0.58			0.98
SES	47 (31.1)	36 (23.2)		127 (59.6)	118 (57.3)	
PES	17 (11.3)	21 (13.5)		2 (0.9)	3 (1.5)	
EES	33 (21.9)	36 (23.2)		59 (27.7)	59 (28.6)	
ZES	44 (29.1)	53 (34.2)		19 (8.9)	19 (9.2)	
Others	10 (6.6)	9 (5.8)		6 (2.8)	7 (3.4)	

Procedures for Side Branch

Variables	CROSS Study			PERFECT Study		
	Routine-FKB	Leave-alone	P	Crush	1-stent	P
NC balloon	18 (11.9)	2 (1.3)	< 0.001	116 (54.5)	26 (12.6)	< 0.001
Cutting balloon	0	1 (0.6)	1.00	2 (0.9)	0	0.50
IVUS	73 (48.3)	51 (32.9)	0.006	195 (91.5)	164 (79.6)	< 0.001
Predilation	5 (3.3)	6 (3.9)	0.79	177 (83.1)	76 (36.9)	< 0.001
Stent	3 (2.0)	1 (0.6)	0.37	208 (97.7)	58 (28.2)	< 0.001
Number	1	1	-	1.0 ± 0.2	1.0 ± 0.2	0.66
Diameter, mm	2.6±0.1	2.8	0.42	2.7±0.2	2.7±0.2	1.00
Length, mm	24.7±2.9	30.0	0.25	21.4±6.7	21.5±6.9	0.93
Max. Pr, atm	15.7±5.1	17.0	0.84	18.0±4.2	15.1±4.0	< 0.001
Used stents			0.50			0.85
SES	2 (66.7)	0		126 (60.6)	34 (58.6)	
PES	0	0		2 (1.0)	0	
EES	1 (33.3)	0		54 (26.0)	19 (32.8)	
ZES	0	1 (100)		18 (8.7)	4 (6.9)	
Others	0	0		8 (3.8)	1 (1.7)	

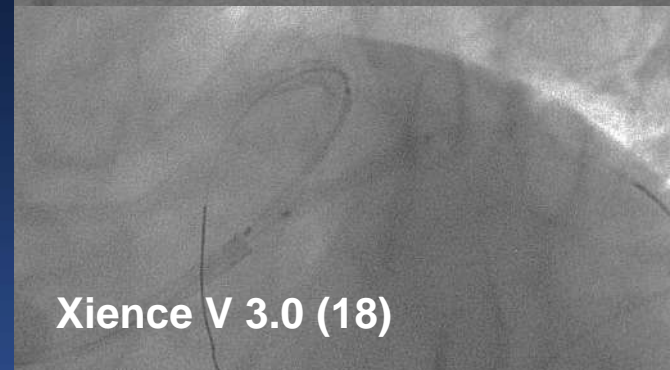
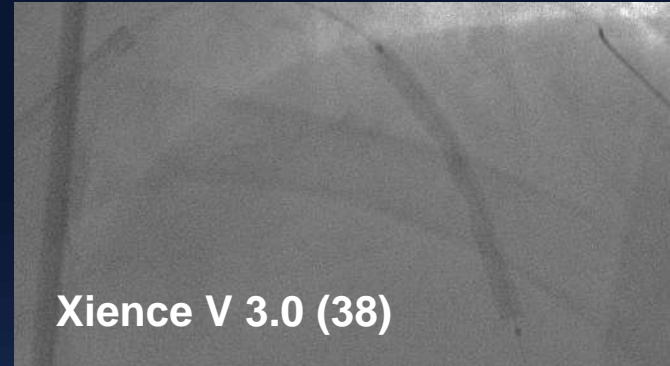
SB Stenting Techniques

Variables	CROSS Study			PERFECT Study		
	Routine-FKB (N=151)	Leave-alone (N=155)	P	Crush (N=213)	1-stent (N=206)	P
FKB	144 (95.4)	7 (4.5)	< 0.001	204 (95.8)	163 (79.1)	< 0.001
Stent	3 (2.0)	1 (0.6)	0.37	208 (97.7)	58 (28.2)	< 0.001
Stenting technique			0.75			< 0.001
Crush	0	0		206 (99.0)	15 (25.9)	
Provisional T	2 (66.7)	1 (100)		1 (0.5)	43 (74.1)	
Others	1 (33.3)	0		1 (0.5)	0	

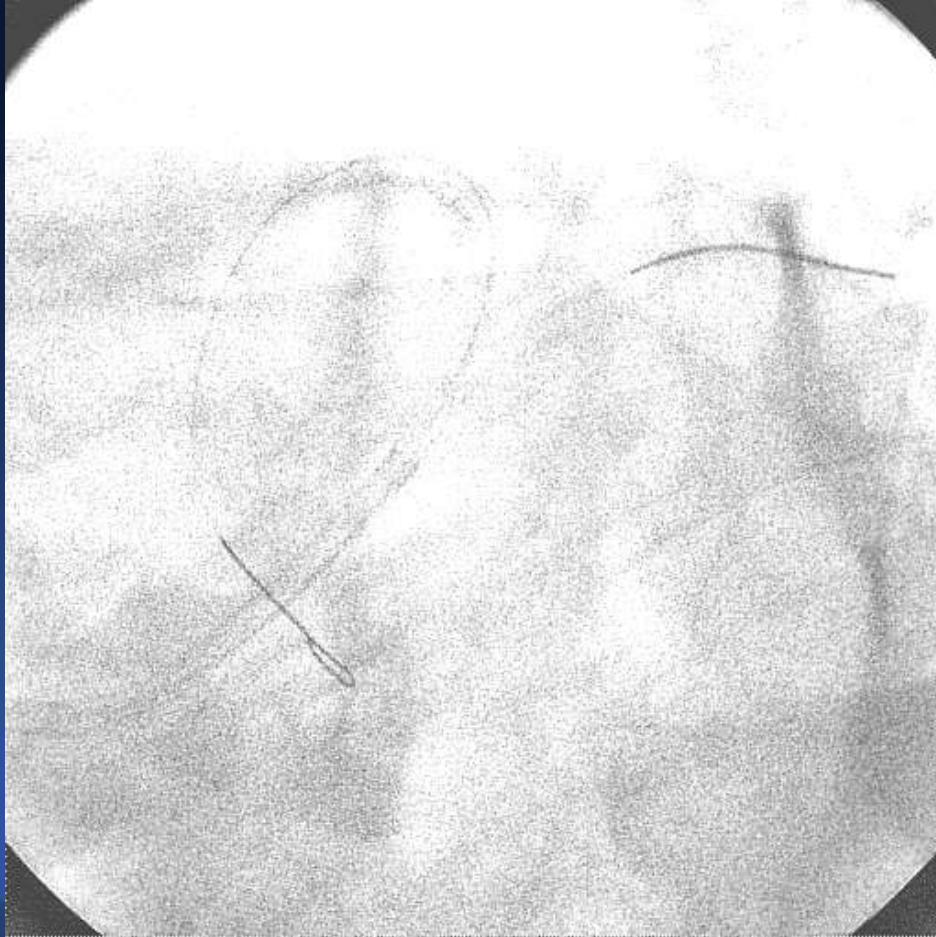
Procedures According to As-treated Groups in PERFECT Trial

	Single-stent (N=153)	Provisional -T (N=44)	Crush (N=221)	P value
Procedural time, min	46.6 ± 20.5	56.0 ± 23.1	52.4 ± 20.9	0.007
Fluoroscopic time, min	24.4 ± 12.0	31.3 ± 13.8	29.4 ± 14.1	0.001
Contrast amount, cc	331 ± 114	409 ± 142	350 ± 144	0.004

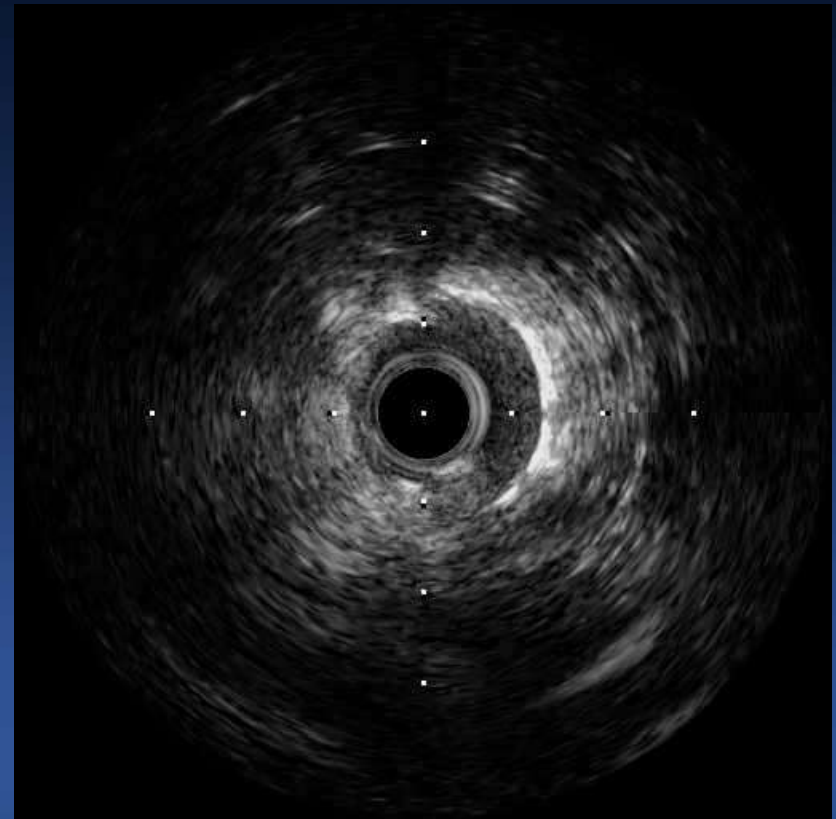
IVUS-Guided Crush for LAD Bifurcation



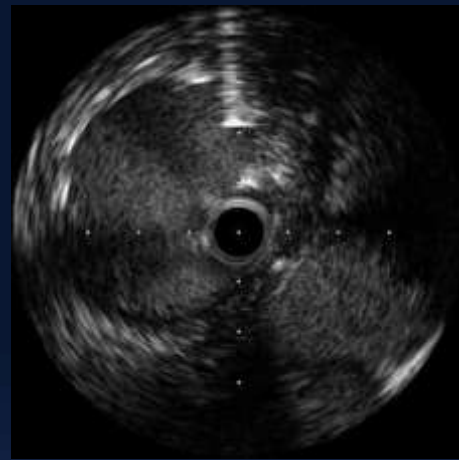
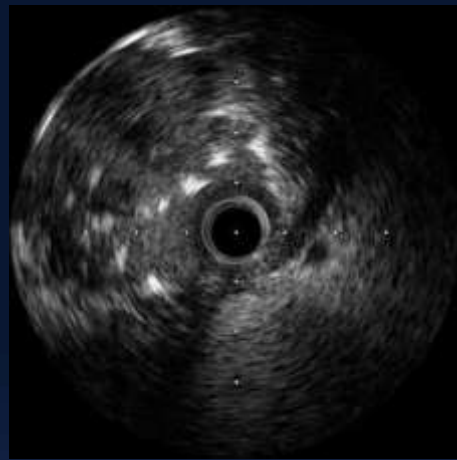
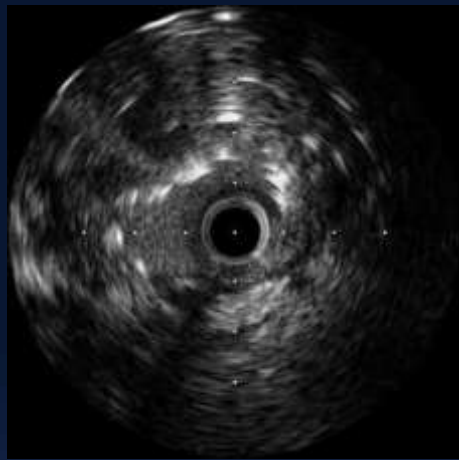
- The recrossed SB wire was placed outside of MB stent.
- Therefore, SB stent was not completely crushed but was tunneled like the morphology of kissing stenting.



IVUS from SB



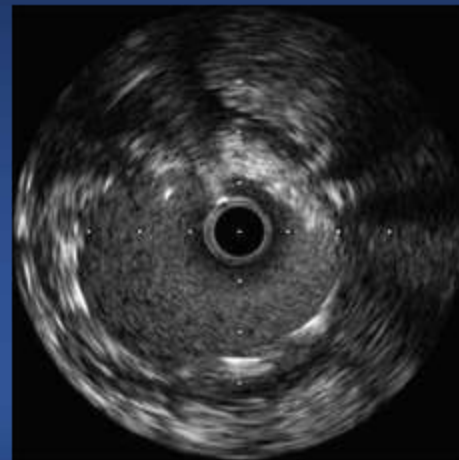
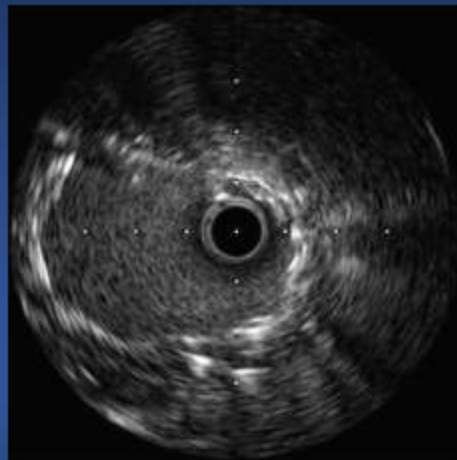
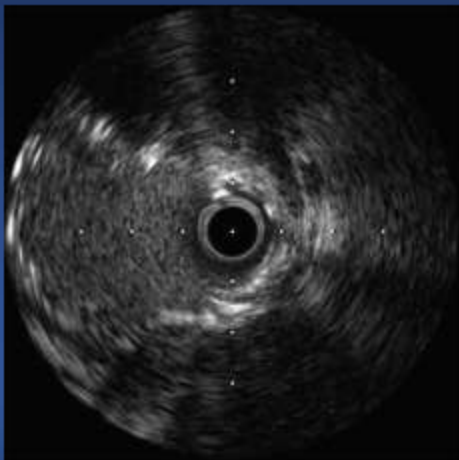
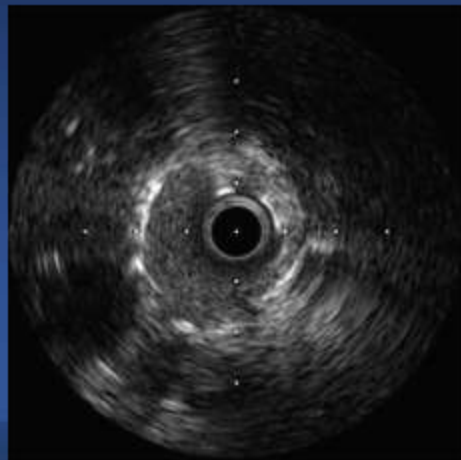
Post stent



distal

proximal

Final after repeated final kissing inflation



Lessons From Procedures

CROSS study

- In normal SB, predilation is not necessary
- Any procedure including balloon angioplasty or FKB is not routinely necessary for good procedural outcome

PERFECT study

- Single- or two-stent techniques are good for a success under the guidance of IVUS
- Two-stent is finally necessary for a third of true bifurcations for good procedural outcome
- Provisional-T stent is sometime more technically challenging than planned two-stent technique

Medina Classification in Core Lab

Variables	CROSS Study			PERFECT Study		
	Routine-FKB	Leave-alone	P	Crush	1-stent	P
Medina class			0.18			0.012
1. 0. 0.	18 (12.2)	15 (9.8)		2 (1.0)	4 (2.0)	
1. 1. 0.	52 (35.1)	74 (48.4)		5 (2.4)	22 (10.9)	
1. 0. 1.	8 (5.4)	4 (2.6)		18 (8.7)	18 (8.9)	
1. 1. 1.	28 (18.9)	24 (15.7)		137 (65.9)	126 (62.4)	
0. 1. 0.	34 (23.0)	25 (16.3)		4 (1.9)	5 (2.5)	
0. 1. 1.	6 (4.1)	4 (2.6)		39 (18.8)	25 (12.4)	
0. 0. 1.	1 (0.7)	3 (2.0)		3 (1.4)	2 (1.0)	
0. 0. 0.	1 (0.7)	4 (2.6)		0	0	
SB stenosis	29.1%	22.9%		94.8%	84.7%	

Angiography after Procedure

Variables	CROSS Study			PERFECT Study		
	Routine-FKB	Leave-alone	P	Crush	1-stent	P
Main branch						
Stent length, mm	31.5±12.0	30.9±11.7	0.66	34.0±13.5	34.7±13.4	0.64
MLD, mm						
In-stent	2.6±0.4	2.6±0.4	0.68	2.6±0.4	2.7±0.4	0.041
In-segment	2.2±0.4	2.2±0.4	0.53	2.2±0.4	2.3±0.5	0.13
DS, %						
In-stent	11.6±6.6	12.8±7.2	0.12	13.5±7.2	13.0±6.9	0.48
In-segment	20.3±8.7	20.7±8.3	0.70	22.1±10.0	20.7±8.7	0.12
Side branch						
Stent length, mm	15.3±8.1	24.6	0.42	15.4±7.1	16.4±6.6	0.32
MLD ostium, mm	1.7±0.4	1.6 ± 0.5	0.053	2.3±0.4	1.9±0.6	< 0.001
DS ostim, %	25.8±15.0	32.2 ± 18.2	0.001	13.7±11.1	25.7±17.8	< 0.001

Main Branch Follow-up Angiography

Variables	CROSS Study			PERFECT Study		
	Routine-FKB (N=106)	Leave-alone (N=108)	P	Crush (N=155)	1-stent (N=145)	P
MLD, mm						
In-stent	2.2±0.6	2.3±0.5	0.32	2.4±0.4	2.4±0.5	1.0
In-segment	1.9±0.6	2.1±0.4	0.071	2.1±0.4	2.2±0.5	0.44
DS, %						
In-stent	22.8±16.2	20.5±13.4	0.24	19.8±10.6	21.3±13.3	0.26
In-segment	29.7±17.3	25.7±13.1	0.064	26.8±13.1	26.1±12.4	0.65
Late loss, mm						
In-stent	0.4±0.5	0.3±0.4	0.13	0.2±0.3	0.3±0.4	0.036
In-segment	0.2±0.5	0.1±0.4	0.094	0.1±0.4	0.2±0.4	0.24
Restenosis	16 (15.1)	4 (3.7)	0.004	8 (5.2)	7 (4.8)	0.90
Restenosis pattern			1.0	1.0		
Focal	10 (62.5)	2 (50.0)		5 (62.5)	4 (57.1)	
Diffuse	6 (37.5)	2 (50.0)		3 (37.5)	3 (42.9)	

Side Branch Angiographic Follow-up

Variables	CROSS Study			PERFECT Study		
	Routine-FKB (N=106)	Leave-alone (N=108)	P	Crush (N=155)	1-stent (N=145)	P
MLD, mm						
Ostium	1.6±0.4	1.5±0.5	0.17	2.0±0.4	1.6±0.5	< 0.001
In-segment	1.5±0.4	1.5±0.4	0.73	1.7±0.4	1.4±0.4	< 0.001
DS, %						
Ostium	27.5±15.9	33.3±16.9	0.010	23.2±15.1	34.3±18.9	< 0.001
In-segment	31.1±14.5	34.9±15.8	0.074	27.7±13.2	37.7±17.1	< 0.001
Late loss, mm						
Ostium	0.1±0.4	0.1±0.4	0.59	0.3±0.4	0.3±0.5	0.15
In-segment	0.1±0.4	0.1±0.4	0.88	0.1±0.3	0.2±0.3	0.36
Restenosis	3 (2.8)	6 (5.6)	0.50	6 (3.9)	12 (8.3)	0.12
Pattern			0.33			0.52
Focal	2 (66.7)	6 (100)		6 (100)	9 (75.0)	
Diffuse	1 (33.3)	0		0	3 (25.0)	

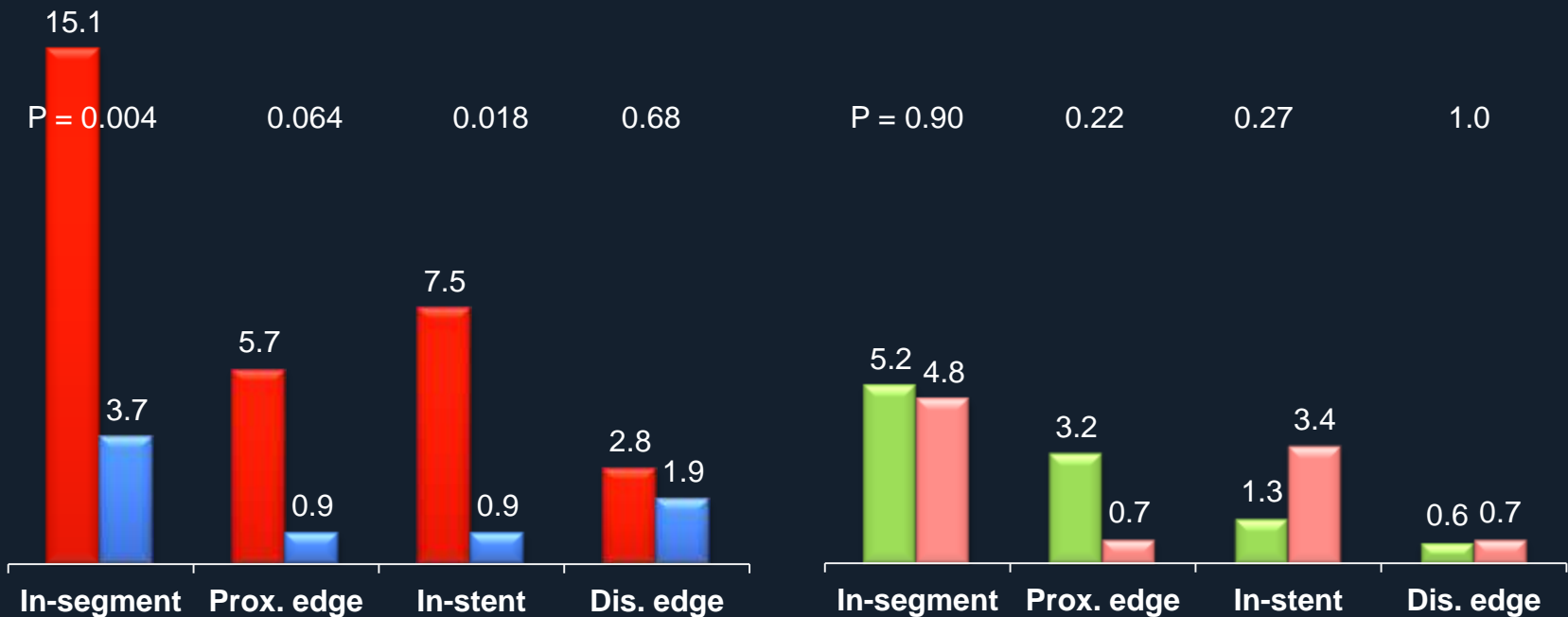
Restenosis of Main Branch

CROSS

PERFECT

■ FKB ■ Leave-alone

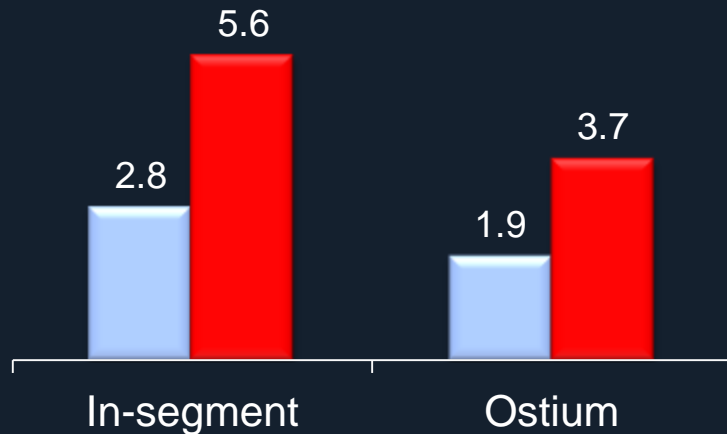
■ Crush ■ 1-stent



Restenosis of Side Branch

CROSS

■ FKB ■ Leave-alone
P = 0.50 0.68



PERFECT

■ Crush ■ 1-stent
P = 0.12 0.20



Overall Restenosis Rate

CROSS

P = 0.064

17.9



FKB

9.3



Leave-alone

PERFECT

P = 0.44

8.4



Crush

11



1-stent

Sites of restenosis

CROSS

● Routine-FKB ● Leave alone

Proximal main branch
(7.5% Routine-FKB vs.
0.9% Leave alone, $p=0.018$)

Side branch
(2.8% Routine-FKB vs.
5.6% Leave alone, $p=0.50$)

Distal main branch
(7.5% Routine-FKB vs.
2.8% Leave alone, $p=0.11$)

PERFECT

● Crush ● Single-stent

Proximal main branch
(3.2% Crush vs.
2.8% Single-stent, $p=1.0$)

Side branch
(3.9% Crush vs.
8.3% Single-stent, $p=0.11$)

Distal main branch
(1.9% Crush vs.
2.1% Single-stent, $p=1.0$)

1-Year Clinical Outcomes

Variables	CROSS Study			PERFECT Study		
	Routine-FKB (N=151)	Leave-alone (N=155)	P	Crush (N=213)	1-stent (N=206)	P
Death	2 (1.3)	0	0.15	3 (1.4)	2 (1.0)	0.68
Cardiac	2 (1.3)	0	0.15	2 (0.9)	1 (0.5)	0.58
Non-cardiac	0	0		1 (0.5)	1 (0.5)	0.98
MI	9 (6.0)	13 (8.4)	0.42	30 (14.1)	29 (14.1)	0.98
Q-wave	0	1 (0.6)	0.32	0	0	
Non-Q wave	9 (6.0)	12 (7.7)	0.55	30 (14.1)	29 (14.1)	0.98
TVR	11 (7.4)	5 (3.2)	0.11	6 (2.9)	7 (3.4)	0.73
Clinically-driven	4 (2.7)	1 (0.6)	0.16	1 (0.5)	3 (1.5)	0.30
TLR	10 (6.7)	4 (2.6)	0.088	4 (1.9)	7 (3.4)	0.33
PCI	10 (6.7)	4 (2.6)	0.088	4 (1.9)	6 (2.9)	0.48
CABG	0	0		0	1 (0.5)	0.31
Stent thrombosis	0	1 (0.6)	0.33	1 (0.5)	0	0.32
MACE	21 (14.0)	18 (11.6)	0.57	38 (17.8)	38 (18.5)	0.85

Lessons From Follow-up

CROSS study

- For SB, FKB had greater lumen gain but was not translated into better angiographic outcomes. Accordingly, net angiographic benefit was not achieved.
- Instead, after kissing, greater mechanical trauma or stent distortion may lead to a greater intimal growth in the MB.
- Selective FKB was not inferior to routine FKB for good angiographic and clinical outcomes if SB was not diseased.

PERFECT study

- Both single- and two-stent techniques had excellent long-term angiographic and clinical outcomes using PCI with current DES under the guidance IVUS.

Key Message

- This study has strengths: (1) inclusion of all consecutive non-LM bifurcations separated into the two cohorts according to the presence of SB stenosis (2) prespecification of procedural steps (3) treatment using new-generation DES and (4) extensive use of IVUS during treatment.
- Any bifurcation stenting using current DES can achieve excellent long-term prognosis once the procedure is performed successfully.