

Lessons from CROSS and PERFECT Study

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Cross and Perfect Trials

- A single bifurcation stenting cohort containing two parallel randomized trials of CROSS and PERFECT trials
- Performed in the same sites organized by the CVRF
- All comer-based randomization stratified by the presence of side branch (SB) stenosis
- Use of new-generation DES
- CROSS study for bifurcation without SB stenosis
- PERFECT study for bifurcation with SB stenosis

Patients with non-LM bifurcation lesions

No

Side branch stenosis *

Yes

No

SB TIMI grade 3 & stenosis \geq 50% after MB stenting

Yes

Registry
(N=195)

CROSS
(N=306)

PERFECT
(N=419)

Randomization

Randomization

Routine FKB
(N=151)

Leave-alone
(N=155)

Crush
(N=213)

Single-stent
(N=206)

Angiography
at 8 months
(N=106, 70.2%)

Angiography
at 8 months
(N=108, 69.7%)

Angiography
at 8 months
(N=155, 72.8%)

Angiography
at 8 months
(N=145, 70.4%)

Clinical follow-up
at 12 months
(N=150, 99.3%)

Clinical follow-up
at 12 months
(N=155, 100%)

Clinical follow-up
at 12 months
(N=213, 100%)

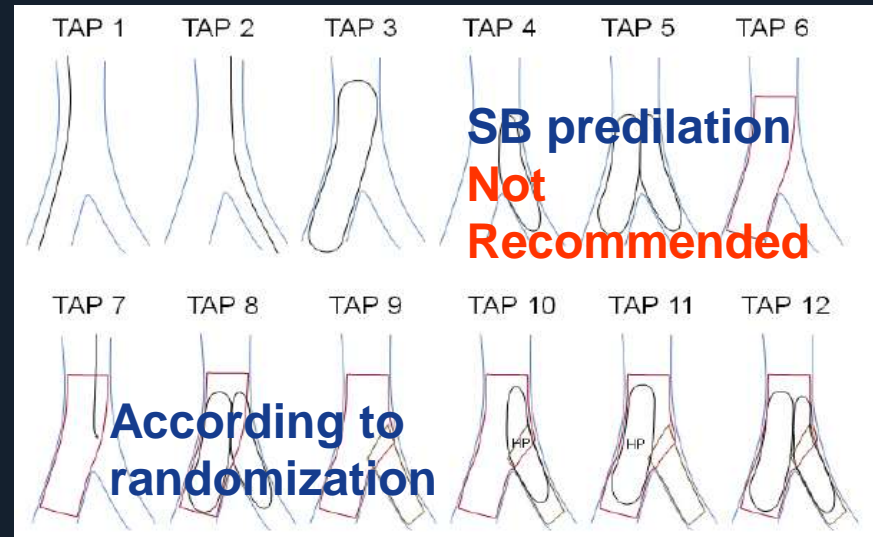
Clinical follow-up
at 12 months
(N=205, 99.5%)

* \geq 2mm diameter and \geq 50% stenosis

Standardization on Procedures

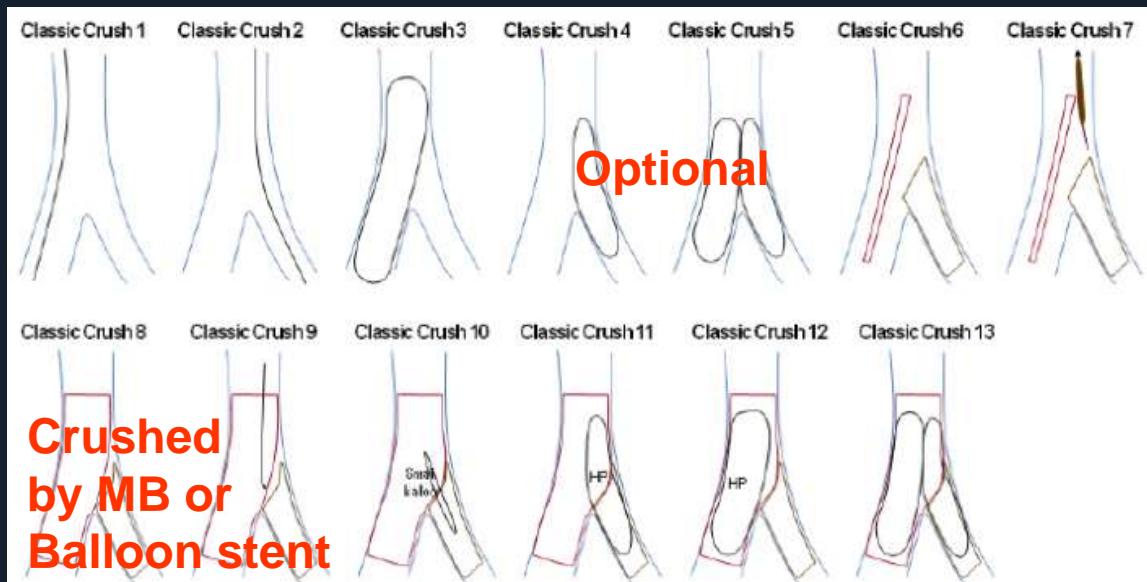
Single-stent

- IVUS guidance
- No SB predilation in CROSS study
- Optional T stenting for suboptimal result or dissection in SB
- FFR at the operator's discretion



Planned 2-stent

- IVUS guidance
- Mini-crush or Balloon crush
- Mandatory FKB



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

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

MB Treatment

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
Predilatation	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)	

SB Treatment

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 Treatment

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	

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

MB 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)	

SB 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						
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)	

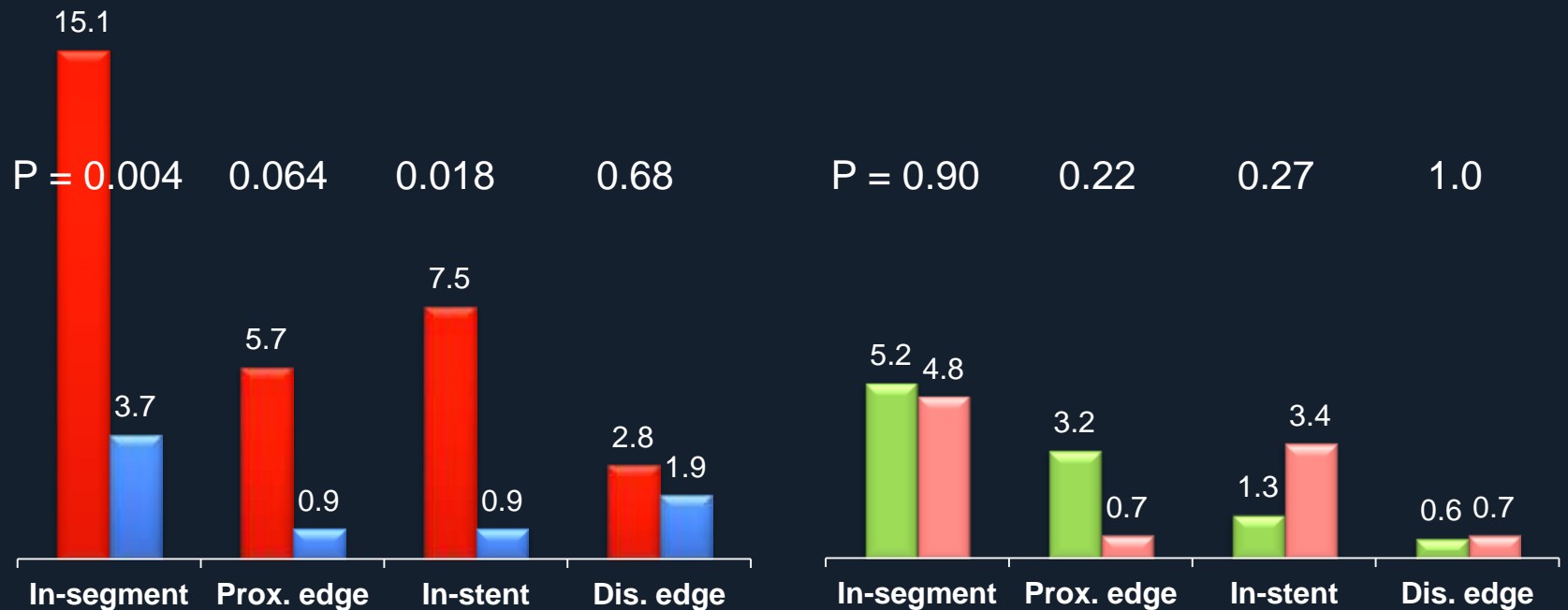
MB Restenosis

CROSS

PERFECT

■ FKB ■ Leave-alone

■ Crush ■ 1-stent

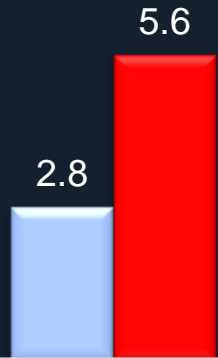


SB Restenosis

CROSS

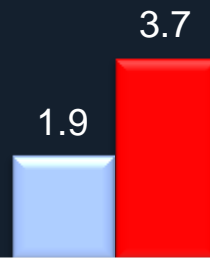
■ FKB ■ Leave-alone

P = 0.50



In-segment

0.68

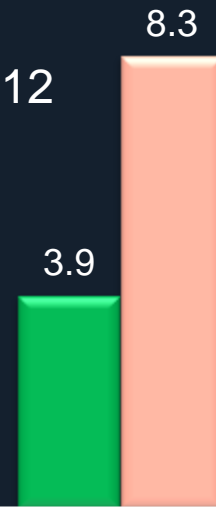


Ostium

PERFECT

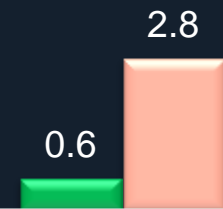
■ Crush ■ 1-stent

P = 0.12



In-segment

0.20



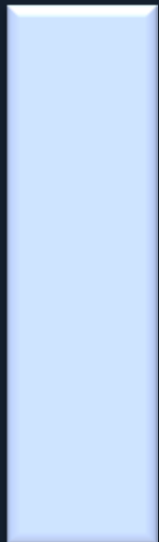
Ostium

Overall Restenosis Rate

CROSS

PERFECT

17.9



P = 0.064

9.3



FKB

Leave-alone

8.4



P = 0.44

11



Crush

1-stent

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 **CROSS** for Normal SB

- Predilation is not routinely necessary.
- For SB, routine FKB can achieve greater lumen gain but may not be translated into better long-term angiographic outcomes.
- For MB, due to mechanical trauma or stent distortion, routine FKB may lead to more frequent restenosis.
- Selective FKB is not inferior to routine FKB in terms of angiographic and clinical outcomes.

Lessons From **PERFECT** for Diseased SB

- Planned 1-stent is safe and effective compared with planned crush.
- Provisional 2-stent is still be required for selective true bifurcations.
- Final FKB is necessary after 2-stent technique.
- IVUS-guided 1- or 2-stent using new-generation DES can lead to excellent long-term angiographic and clinical outcomes.

For true bifurcations	1-stent restenosis	2-stent restenosis
NORDIC	22.5 %	16.0 %
CACTUS	18.7 %	28.0 %
PERFECT	11.0%	8.4 %