6th European Bifurcation Club

22-23 October 2010 - BUDAPEST

Extension distance mismatch - a factor for suboptimal SB ostial coverage

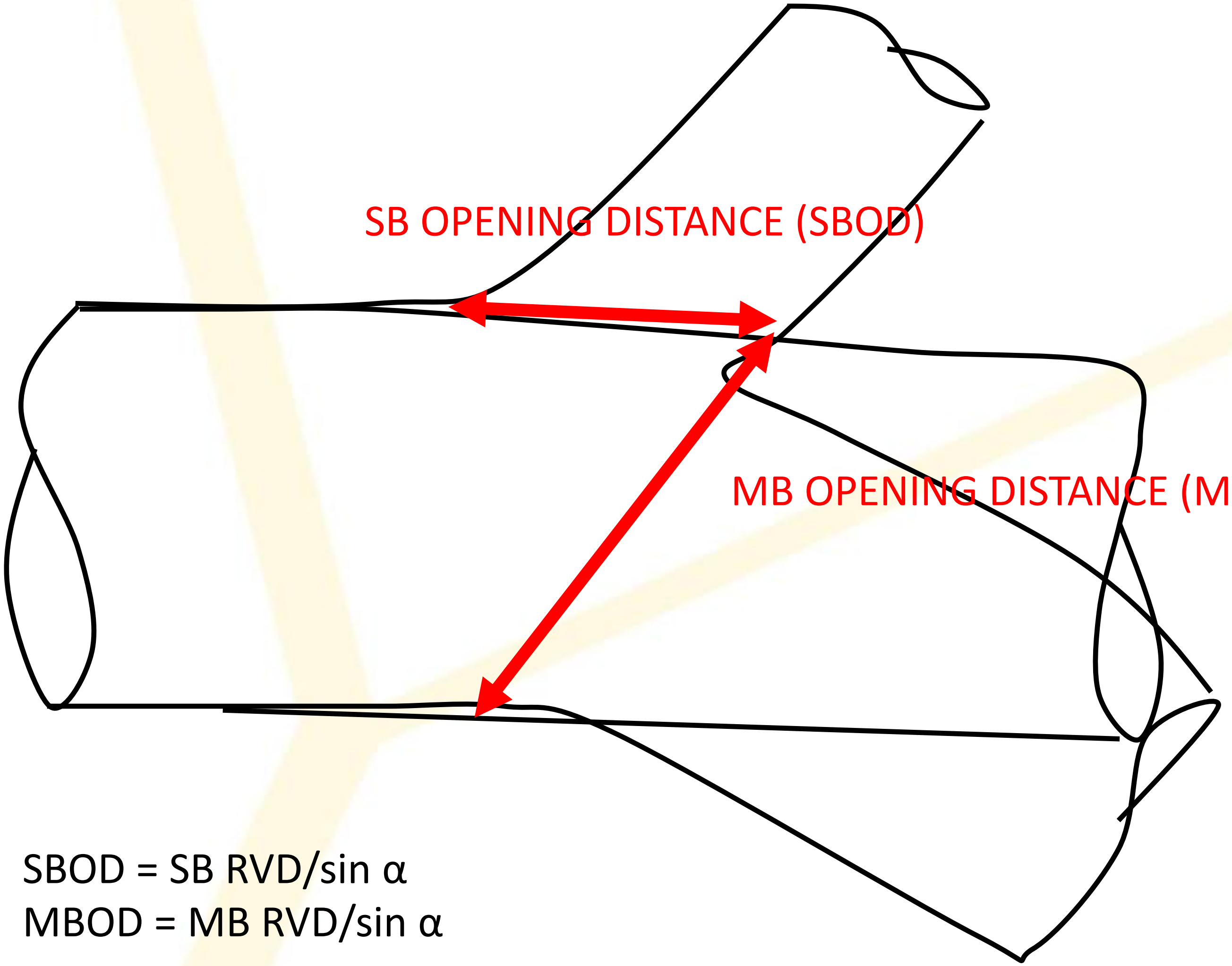
Robert J. Gil, MD, PhD, FESC
Dobrin Vassiliev, MD, PhD

Klinika Kardiologii Inwazyjnej
Centralnego Szpitala Klinicznego MSWiA

IMDiK
POLSKA AKADEMIA NAUK

Stent cell size requirements

(with ideal positioning against SB/MB opening)



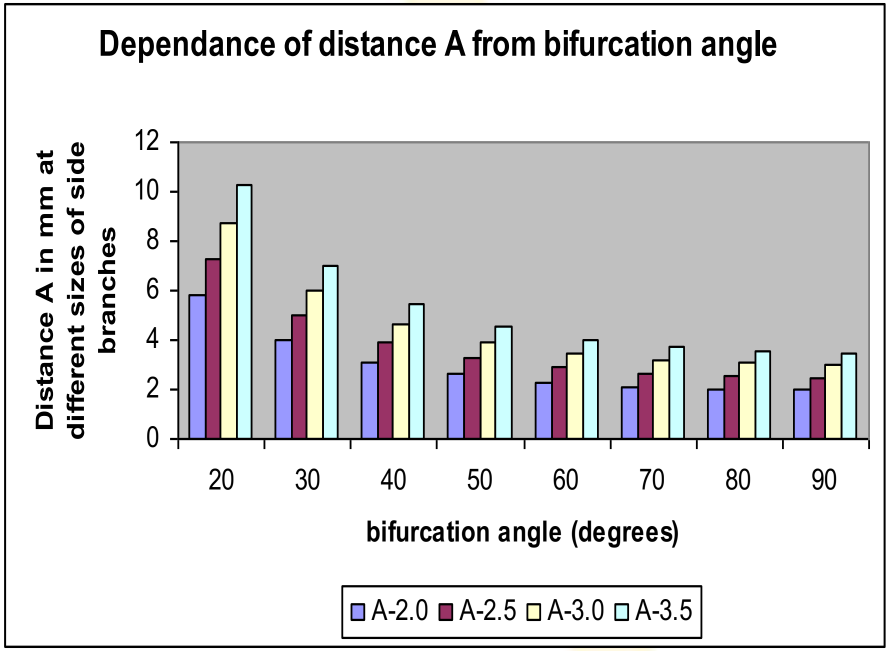
SBOD = SB RVD/sin α
MBOD = MB RVD/sin α

Maximum cell diameter in different stents

3.5 mm stents	Maximum cell diameter (mm)
BioDyvisio (Abbott)	2.9
Bx Velocity (Cordis)	3.0
Carbostent (Sorin)	3.0
Express (Boston)	3.7
Liberte	4.5
Flexstent (Jomed)	2.9–3.6
Penta (Abbott)	4.0
Driver	6.5
R stent (Orbus)	4.5
Chopin2 (Balton)	3.97

Modified from Louvard et al. Heart 2004

SB diameter and angle α relationships

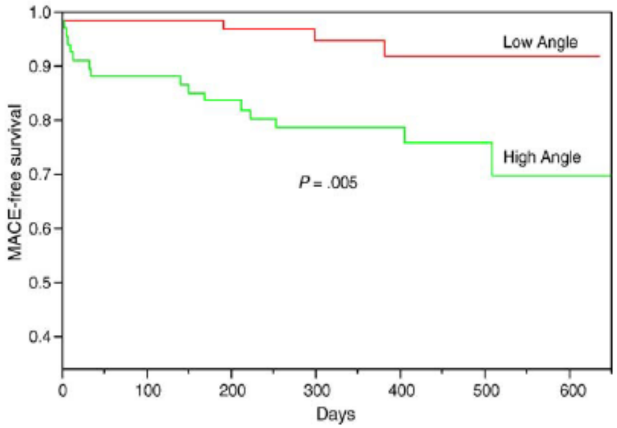


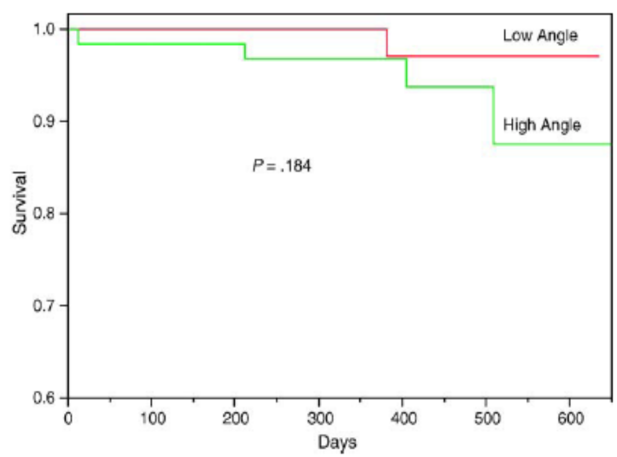
angle α	SB-2.0	SB-2.5	SB-3.0	SB-3.5	MB-2.5	MB-3.0	MB-3.5	MB-4.0
20	5,84	7,30	8,77	10,23	7,30	8,77	10,23	11,69
30	4	5	6	7	5	6	7	8
40	3,11	3,88	4,66	5,44	3,88	4,66	5,44	6,22
50	2,61	3,26	3,91	4,56	3,26	3,91	4,56	5,22
60	2,30	2,88	3,46	4,04	2,88	3,46	4,04	4,61
70	2,12	2,66	3,19	3,72	2,66	3,19	3,72	4,25
80	2,03	2,53	3,04	3,55	2,53	3,04	3,55	4,06
90	2	2,5	3	3,5	2,5	3	3,5	4

SBOD	MBOD

SBOD is important for Crush stenting
MBOD is important for Culotte stenting

Higher branching angle predicts higher restenosis rates and worse survival





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

Predictors of binary restenosis. CI, confidence interval.

Dzavik et al.
Am Heart J 2006;152:76229

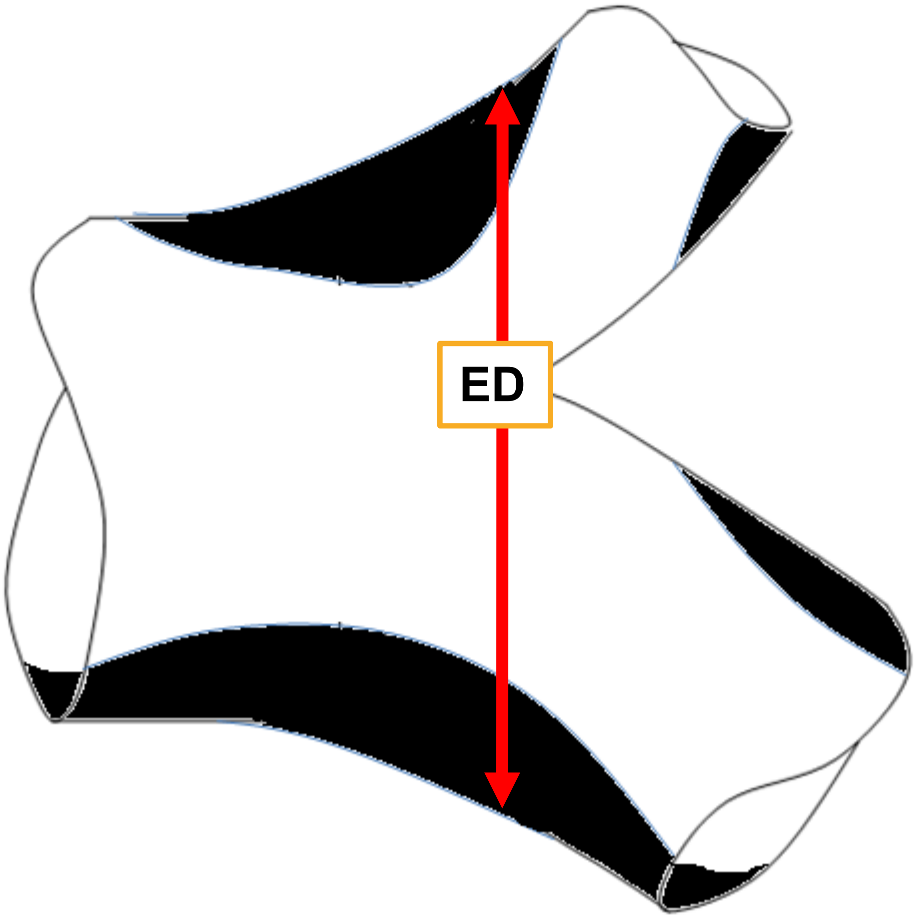
T. Adriaenssens et al.
Eur. Heart Jour. 2008; 29: 2868–2876

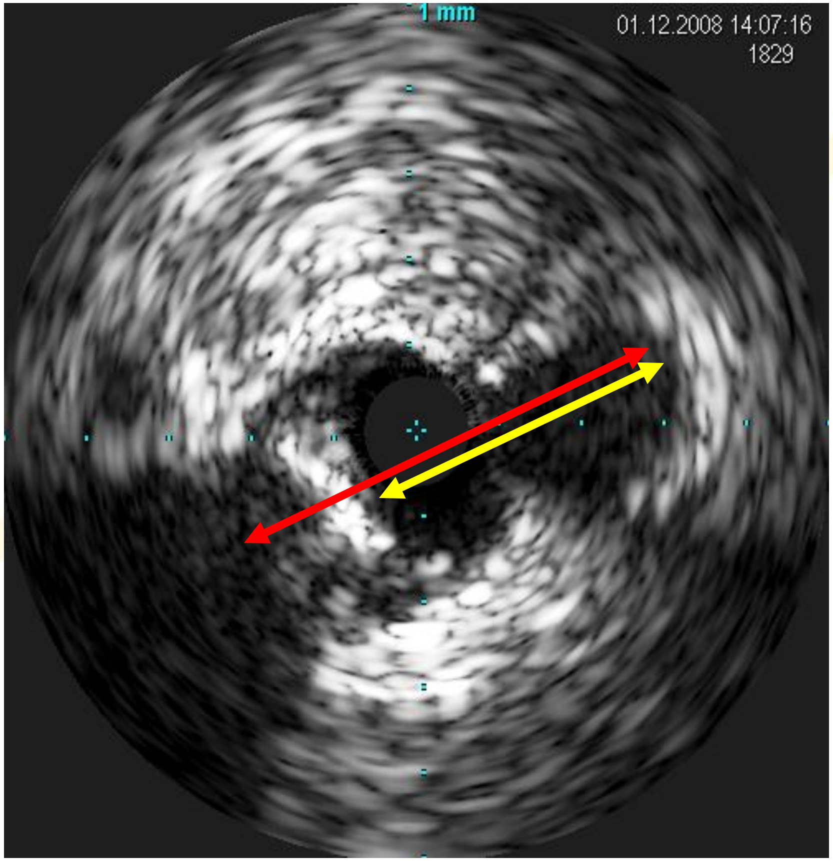
Stent`s factors for good acute results

1. Stent strut position relative to carina tip (MB ostium proper)
2. Stent cell geometry
3. Stent`s material
4. Implantation pressure

Extension distance

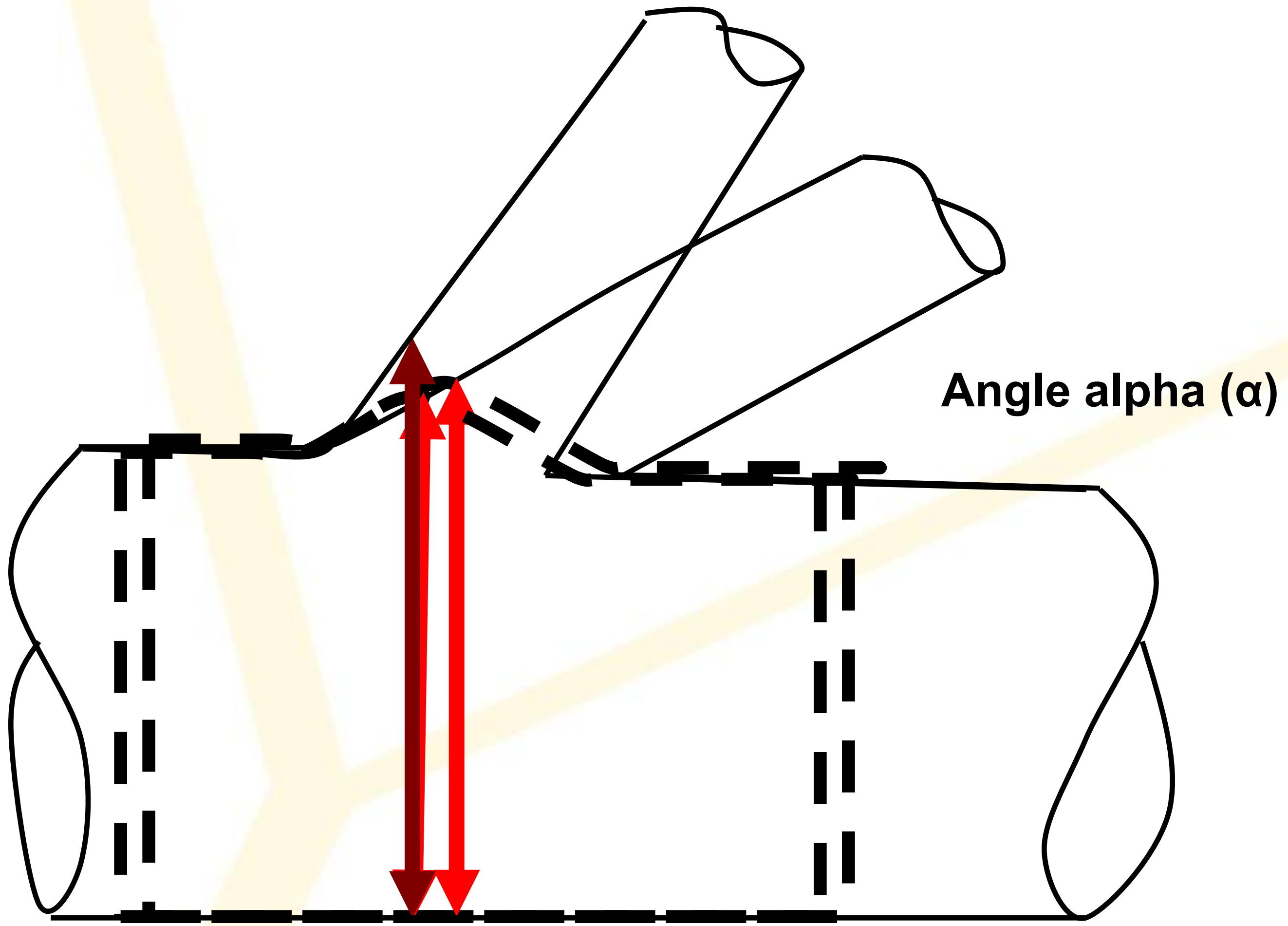
factor determinig side branch ostial coverage in bifurcation lesion stenting





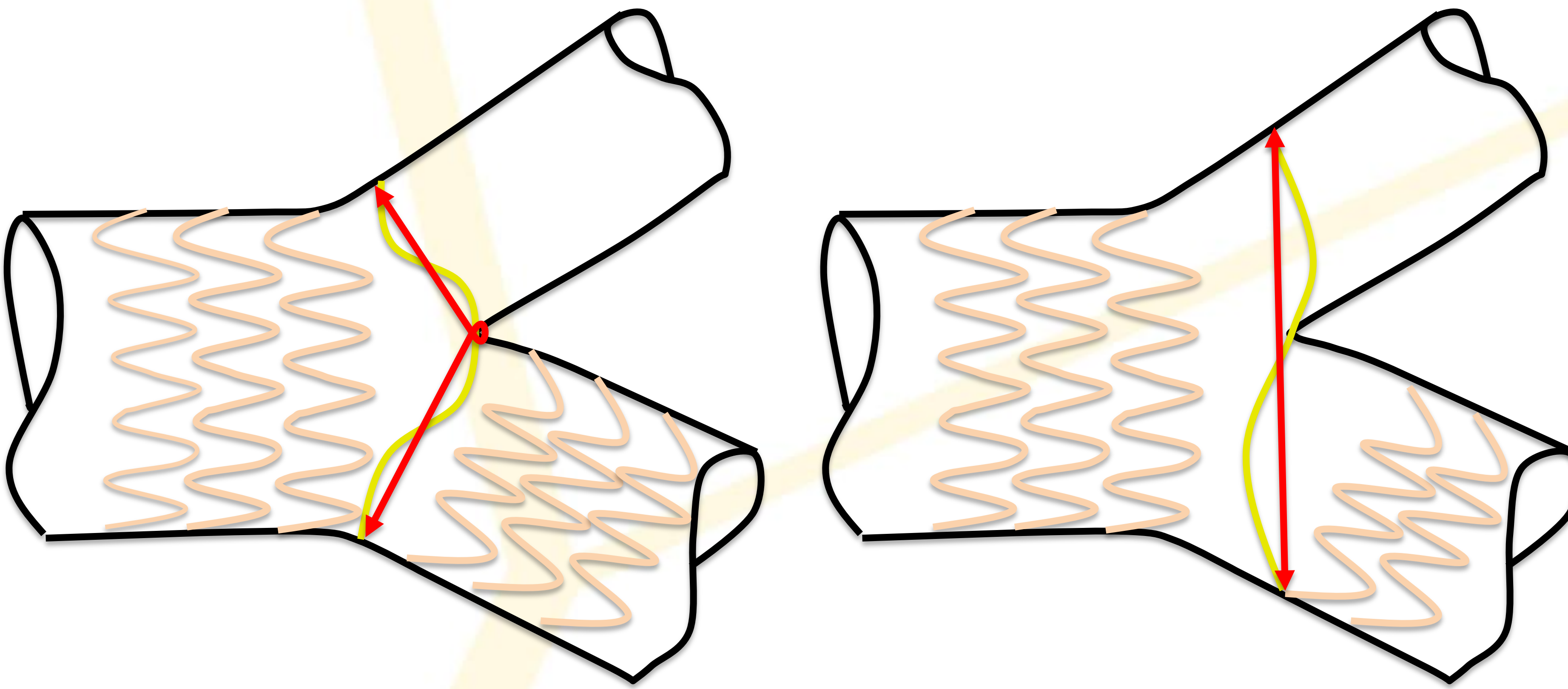
Real ED Desired ED

Geometric factors important for extension distance

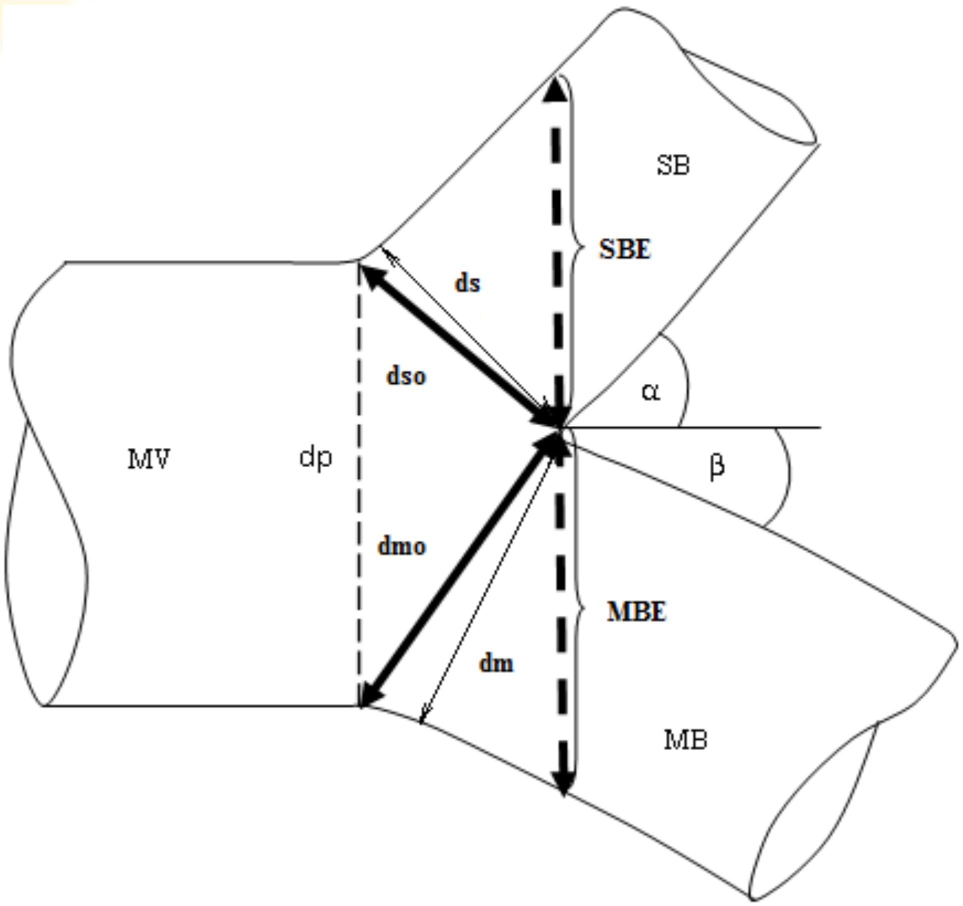


Case 1

Stent totally conforms to bifurcation geometry



ED calculation for „ideal situation”

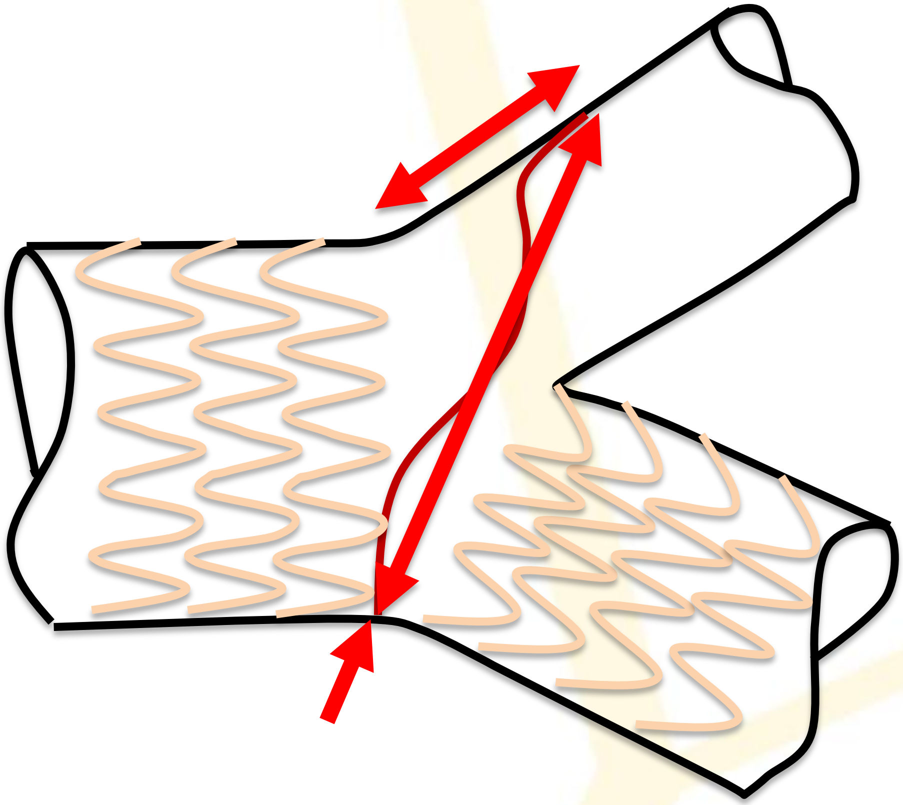


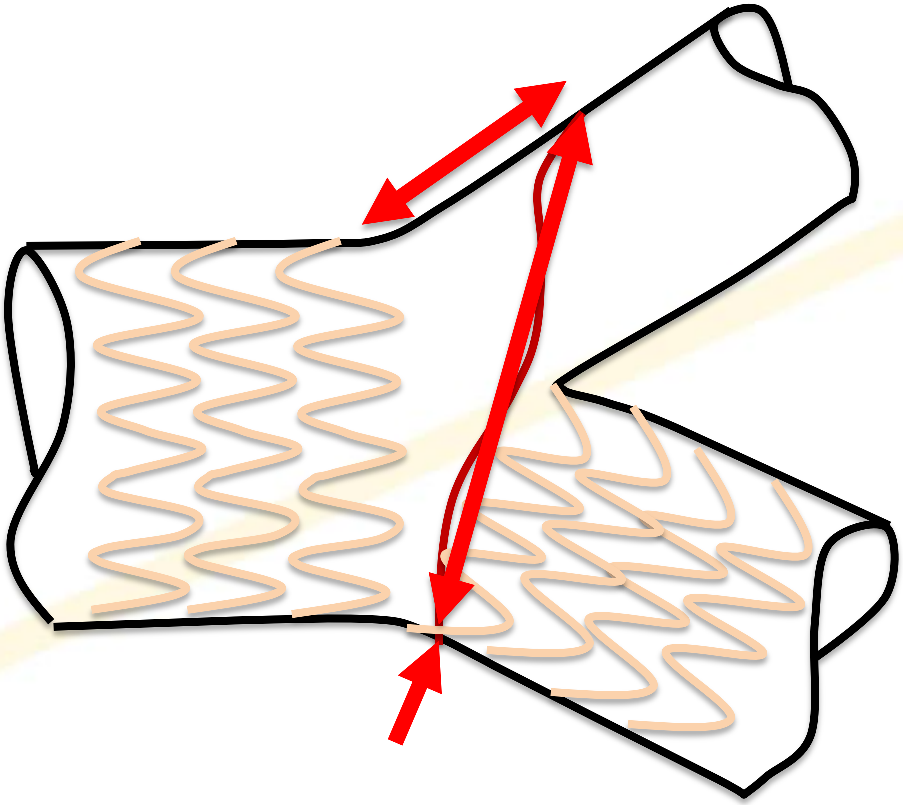
ED = dm + ds

ED = SBE + MBE = ds/cos α + dm/cos β

Case 2

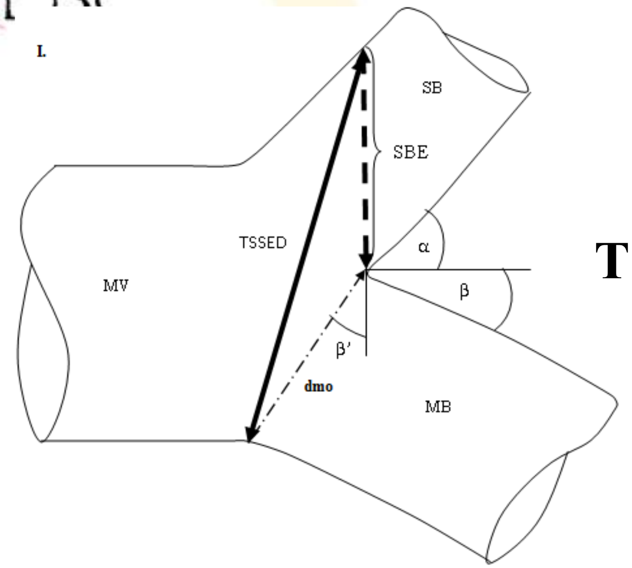
More realistic conformation





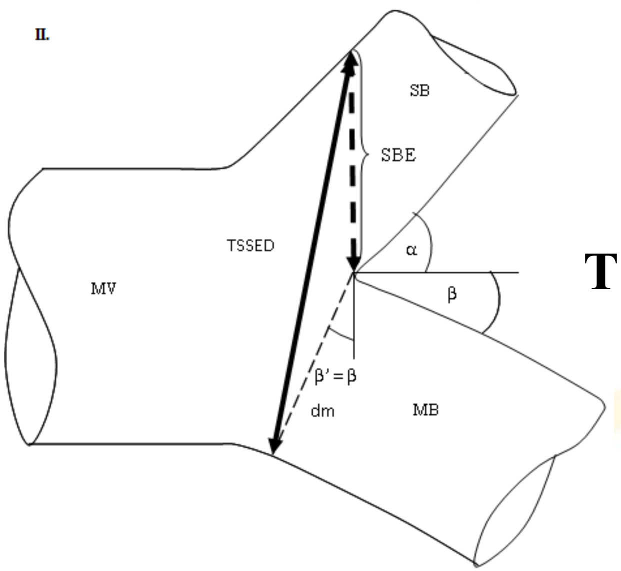
How to calculate for case 2 scenario?

I.



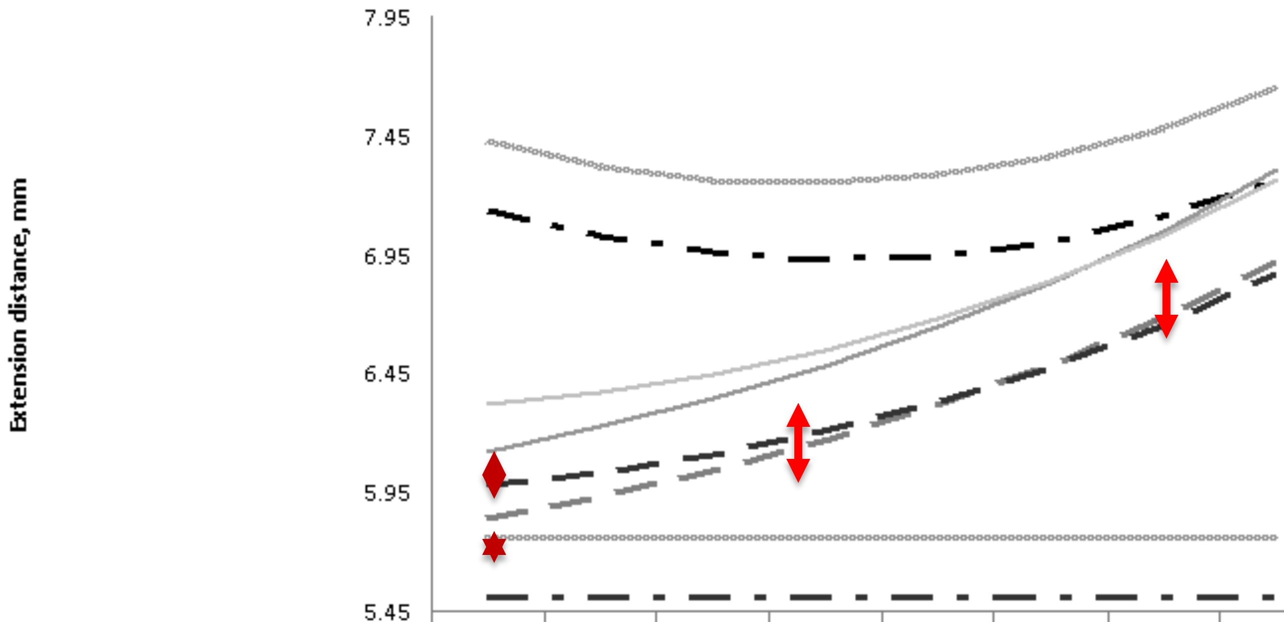
$$TSSED–opening=\sqrt{(dme^2+SBE^2+2\cdot dme\cdot SBE\cdot \cos \beta')}$$

II.



$$TSSED\text{-}ostial = \sqrt{(dm^2 + SBE^2 + 2\cdot dm\cdot SBE\cdot \cos \beta)}$$

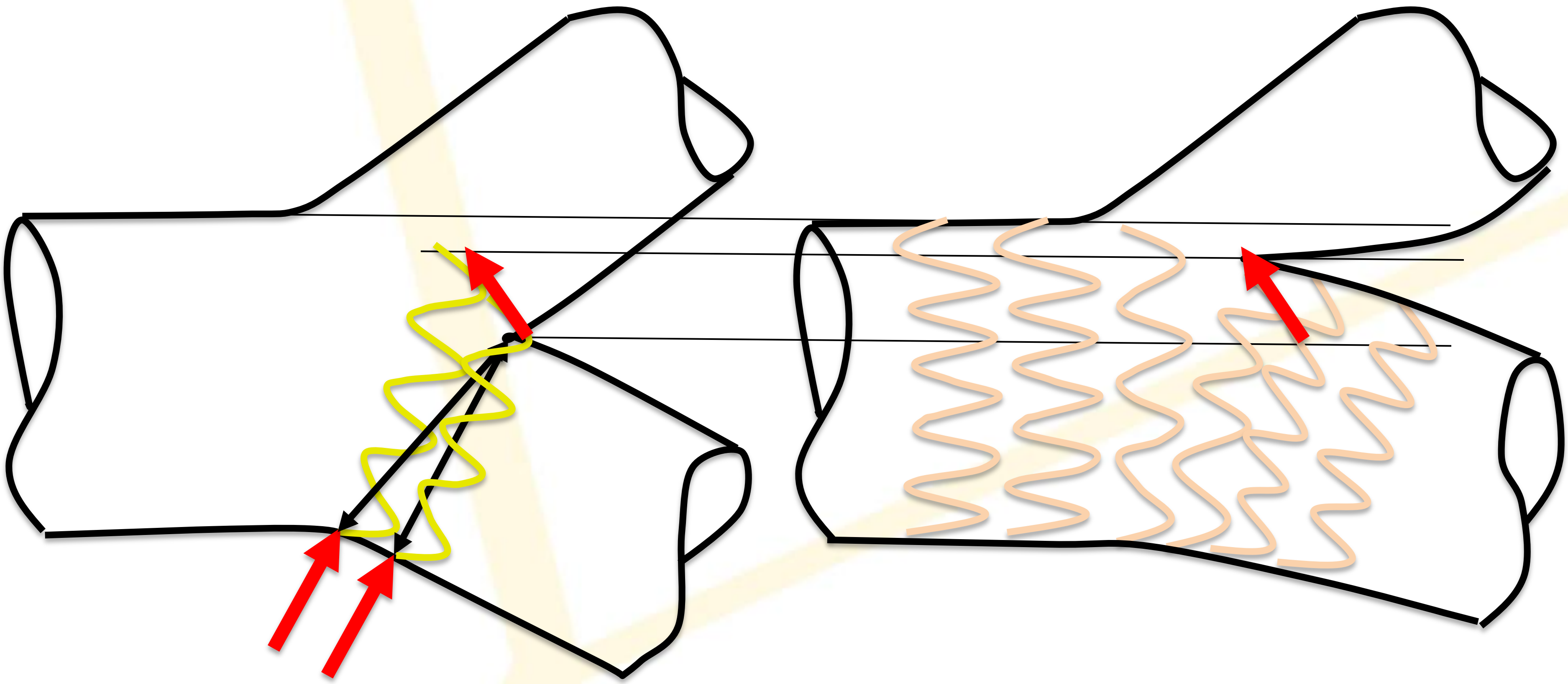
Role of stent strut position relative to MB ostium proper SB RVD increase



	30.00	33.00	36.00	39.00	42.00	45.00	48.00	51.00
ED min SB 2.5mm	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50
ED max SB 2.5mm	7.13	7.02	6.95	6.93	6.94	7.00	7.10	7.26
TSSED ostial SB 2.5mm	5.84	5.93	6.04	6.16	6.31	6.48	6.68	6.91
TSSED opening SB 2.5mm	5.98	6.03	6.10	6.20	6.32	6.47	6.65	6.86
ED min SB 2.75mm	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75
ED max SB 2.75mm	7.42	7.32	7.26	7.25	7.28	7.35	7.48	7.65
TSSED ostial SB 2.75mm	6.12	6.22	6.34	6.48	6.64	6.83	7.05	7.31
TSSED opening SB 2.75mm	6.32	6.37	6.45	6.55	6.68	6.84	7.03	7.26

Case 3

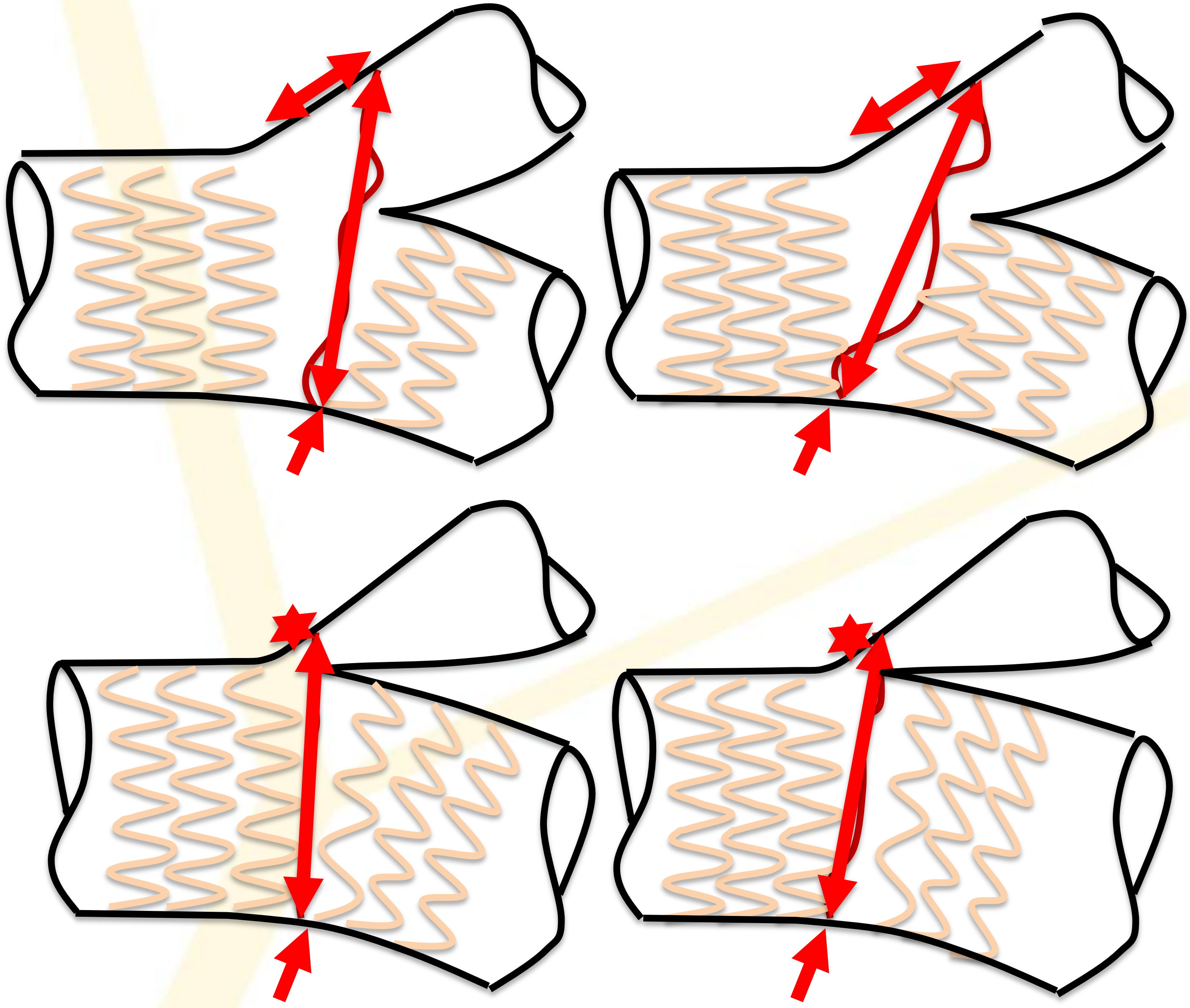
Real situation – stent causes carina region deformation



Case 3 scenarios

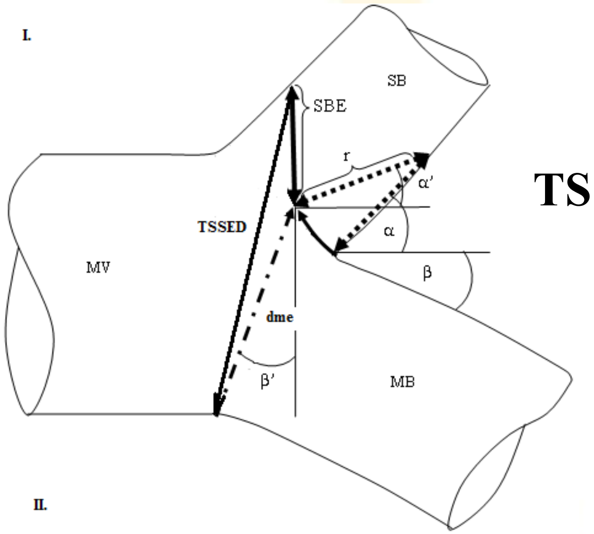
50%

100%



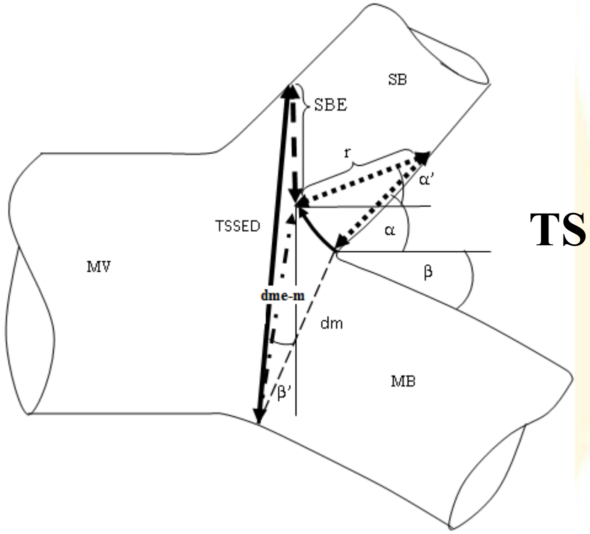
How to calculate for case 3 scenario?

I.



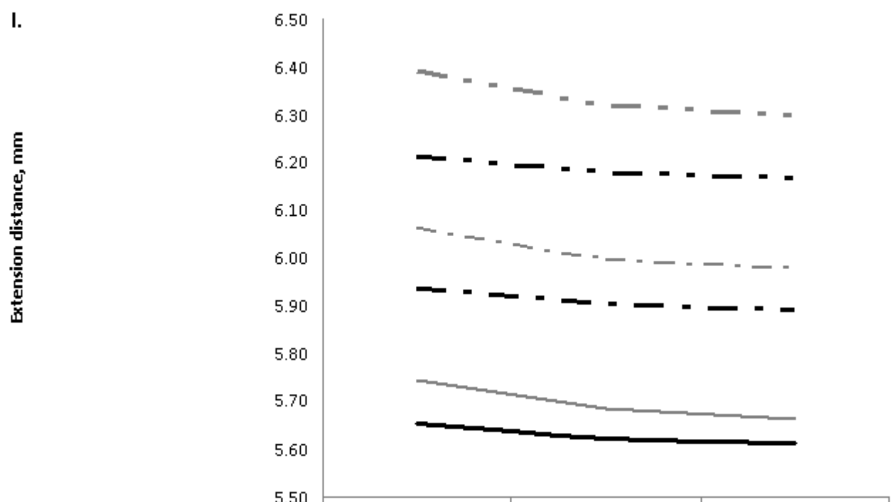
$$\text{TSSED-opening} = \sqrt{[dme^2 + SBE^2 + 2 \cdot dme \cdot SBE \cdot \cos \beta']}$$

II.



$$\text{TSSED-ostial} = \sqrt{[dme\text{-}m^2 + SBE^2 + 2\ dme\text{-}m \cdot SBE \cdot \cos \beta']}$$

The effect of SB RVD increase at different extents of carina displacement



	0.50	0.75	1.00
TSSED opening SB 2.5 mm, alpha 30 degrees	5.74	5.68	5.66
TSSED opening SB 2.75 mm, alpha 30 degrees	6.06	6.00	5.98
TSSED opening SB 3.0 mm, alpha 30 degrees	6.39	6.32	6.29
TSSED ostial SB 2.5 mm, alpha 30 degrees	5.65	5.62	5.61
TSSED ostial SB 2.75 mm, alpha 30	5.93	5.90	5.89
TSSED ostial 3.0 mm, alpha 30 dgrees	6.21	6.18	6.16

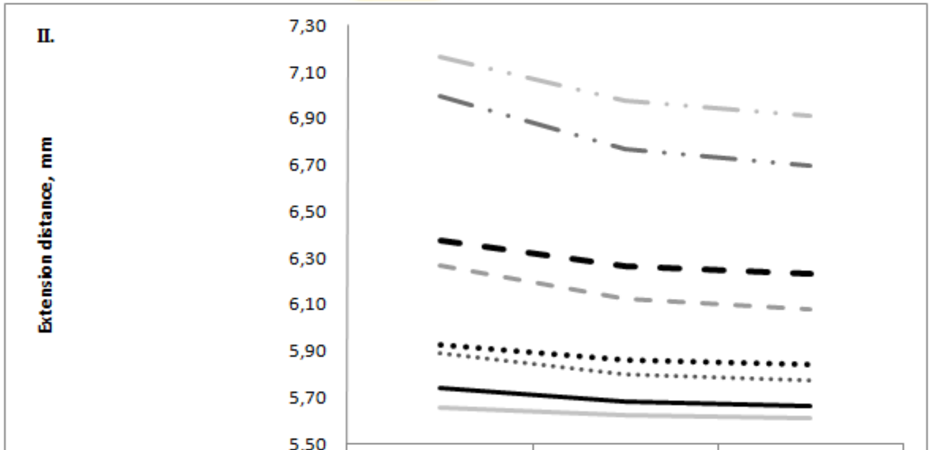
Increasing of carina displacement causes decrease in extension distances

The difference between two extension distances decreases with increase in carina displacement

The difference between extension distances is larger with larger SB diameters

The relative increase in ED is homogenous with increase in SB diameter

The effect of carina angle increase at different extents of carina displacement



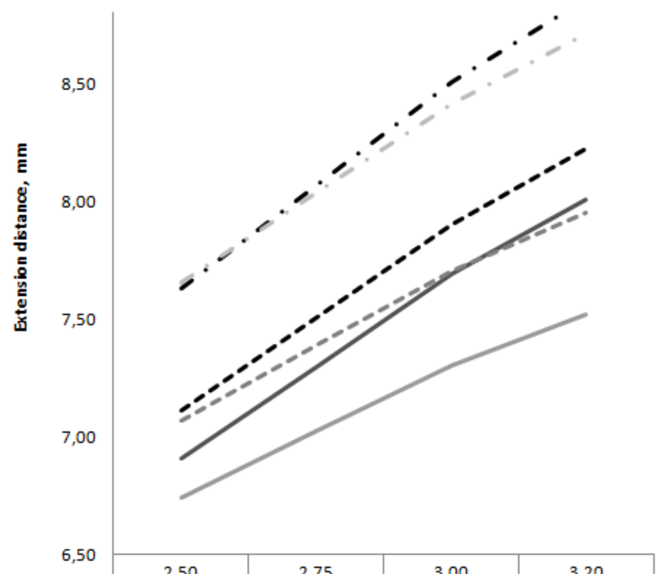
	0,50	0,75	1,00
TSSED opening SB 2.5 alpha 40 degrees	5,89	5,80	5,77
TSSED opening SB 2.5 alpha 50 degrees	6,26	6,13	6,08
TSSED opening SB 2.5 alpha 60 degrees	7,00	6,77	6,69
TSSED ostial SB 2.5 alpha 40 degrees	5,92	5,86	5,84
TSSED ostia SB 2.5 alpha 50 degrees	6,37	6,27	6,23
TSSED ostial SB 2.5 alpha 60 degrees	7,17	6,97	6,91
TSSED opening SB 2.5 alpha 30 degrees	5,74	5,68	5,66
TSSED ostial SB 2.5 alpha 30 degrees	5,65	5,62	5,61

Increasing of carina displacement causes decrease in extension distances

The difference between the 2 ED's increases with increase of SB angulation

The relative increase of ED with increase in SB angulation is larger than changes observed with increase in SB diameter -> changes of SB angulation influence ED more than changes in SB diameter

Extension distances at full carina displacement and achieved SB minimal lumen diameter after stent implantation that is equal to the baseline diameter



	2,50	2,75	3,00	3,20
TSSED opening SB increase alpha 30 degrees	6,91	7,30	7,69	8,01
TSSED ostial SB increase alpha 30 degrees	6,74	7,02	7,30	7,52
TSSED opening SB increase alpha 40 degrees	7,11	7,50	7,90	8,22
TSSED opening SB increase alpha 50 degrees	7,63	8,07	8,50	8,85
TSSED ostial SB increase alpha 40 degrees	7,07	7,39	7,70	7,95
TSSED ostial SB increase alpha 50 degrees	7,65	8,04	8,41	8,71

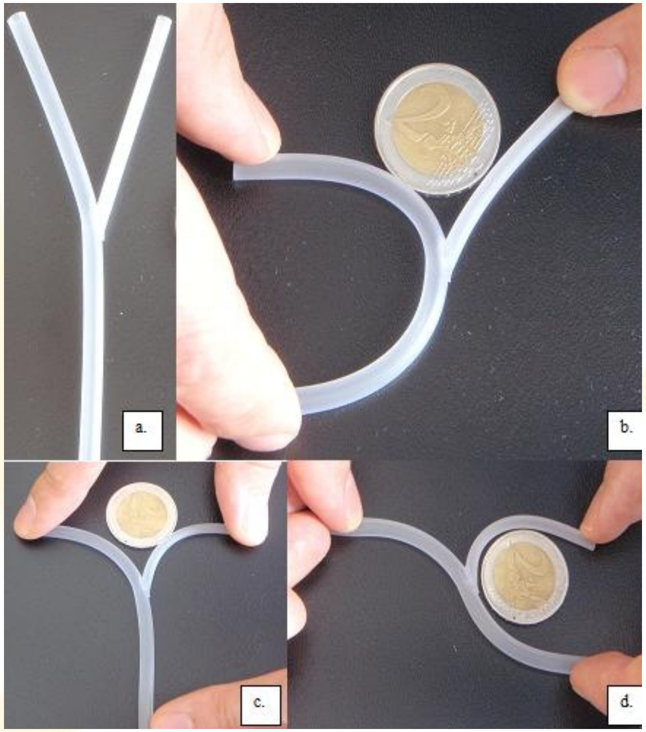
The increase in SB diameter increase ED.

The relative increase of ED with increase in SB angulation is larger than changes observed with increase in SB diameter -> changes of SB angulation influence ED more than changes in SB diameter

The extension distances in that situation are much larger in comparison with cases, where optimal result is not a target

Bench test verification

Materials for test - soft polyethilene, deformable, elastic, with characteristics close to vessel wall, wall thickness – 0.4 mm, MV 3.5 mm, MB 3.0 mm, SB 2.5 mm. all stents implanted – Chopin2, Balton, PL; model used: 45 degrees between branch angle

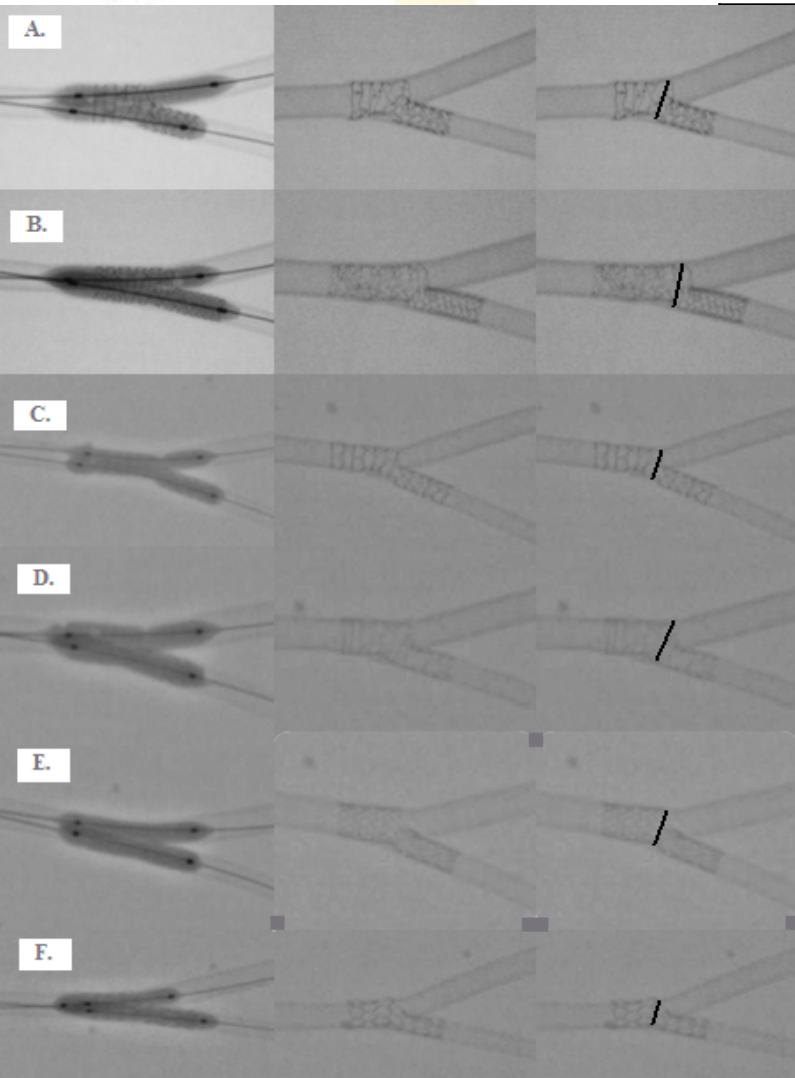


Microscopic observations with up to 300 x magnification

EBC

SSED

Opening Ostium



Vision, Abbott Vascular	5.62 ± .04	5.41 ± .05	*6.91*	*6.74*
Liberte, Scientific Corp.	5.2 ± .03	5.0 ± .04	*6.91*	*6.74*
Chopin2, Balton	4.58 ± .05	4.52 ± .03	*6.91*	*6.74*
Volo, Invatec	4.41 ± .04	4.30 ± .02	*6.91*	*6.74*
Driver, Medtronic	4.39 ± .04	4.30 ± .06	*6.91*	*6.74*
BxSonic, Cordis, J&J	4.48 ± .05	4.26 ± .04	*6.91*	*6.74*

Conclusions

- **Extension distance (ED) is an inherent feature of every bifurcation, which has to be considered during PCI**
- **Side branch diameter and between-vessel angulations determine the magnitude of extension distance**
- **One single stent can produce different extension distances just because of the random positioning of stent struts at the main branch ostium/carina tip**
- **Restoration of SB ostial diameter to reference value is difficult/impossible to obtain with available stents**
- **Minimalistic approach (small balloon inflation at SB ostium) could ensure good strut apposition, because of much smaller ED, which have to be covered**