# Long-term Outcomes of Non-LM Bifurcation Studies

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**TCTAP, Seoul, April 25-27, 2012**

# Long term outcome: ≥ 3 years ?

# Five-year outcome of patients with bifurcation lesions treated with provisional SB T-stenting using DES

477 bifurcation, 2003 - 2005, PES or SES, PTS strategy: 92%, SB stent: 28,8%, FKB: 95%.
Long-term FU: median 61 months, available: 93,5% of patients.

| Procedural data | n (%) |
|---|---|
| Radial approach | 350 (73,1) |
| Stenting strategy | |
| PTS | 442 (92,3) |
| T stenting, side branch first | 32 (6,7) |
| Culotte | 3 (0,63) |
| Kissing stents | 2 (0,42) |
| Stents deployed | |
| Main branch | 474 (99,0) |
| Side branch | 138 (28,8) |
| Both branches | 133 (27,8) |
| Final kissing balloon | 457 (95,4) |
| Angiographic success | |
| Both branches | 472 (98,6) |
| Main branch | 477 (100) |
| Side branch | 474 (98,8) |



Lefevre JESFC 2012

# Five-year outcome of patients with bifurcation lesions treated with provisional SB T-stenting using DES

**In-hospital, 1-year and 5-year outcome**

| | **In-Hospital** | **1-year** (cumulative) | **5-year** (cumulative) |
|---|---|---|---|
| Urgent re-PCI, % | 1,3 | - | - |
| MI, % | 0,8 | 1 | 3,9 |
| Target lesion revascularisation, % | - | 3,9 | 7,3 |
| Target vessel revascularisation, % | - | 6,9 | 13,0 |
| CABG, % | 0 | 0,9 | 1,3 |
| Cardiac death | 1,1 | 3 | 6,7 |
| Total death | 1,1 | 3,4 | 10,6 |
| Total MACE (defined as early reintervention, Q / non-Q wave MI or TVR) | 2,5 | 10,7 | 13,6 |



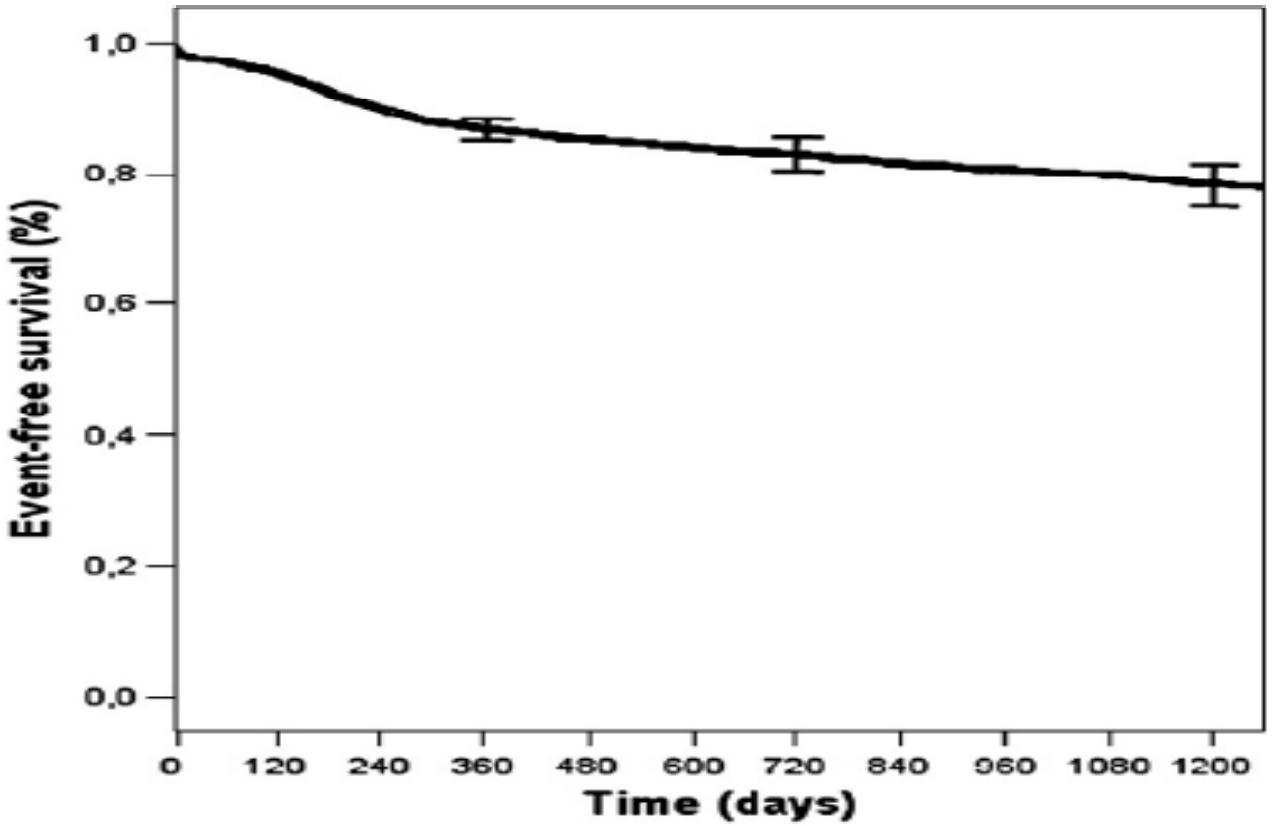
Lefevre JESFC 2012

# Five-year outcome of patients with bifurcation lesions treated with provisional SB T-stenting using DES

- Definite or probable stent thrombosis at 5 years is 3,1%, most cases occurring within the first year (2.5%) .

- TLR in the long-term not predicted by the stenting strategy, and not significantly related to the use of 1 or 2 stents or the type of DES deployed.

# Real-world outcome of coronary bifurcation lesions in the DES era: Results from the 4,314-patient SICI-GISE, I-BIGIS




**Freedom from MACE**

Romagnoli Am Heart J 2010;160:535-542.

# Real-world outcome of coronary bifurcation lesions in the DES era: Results from the 4,314-patient SICI-GISE, I-BIGIS

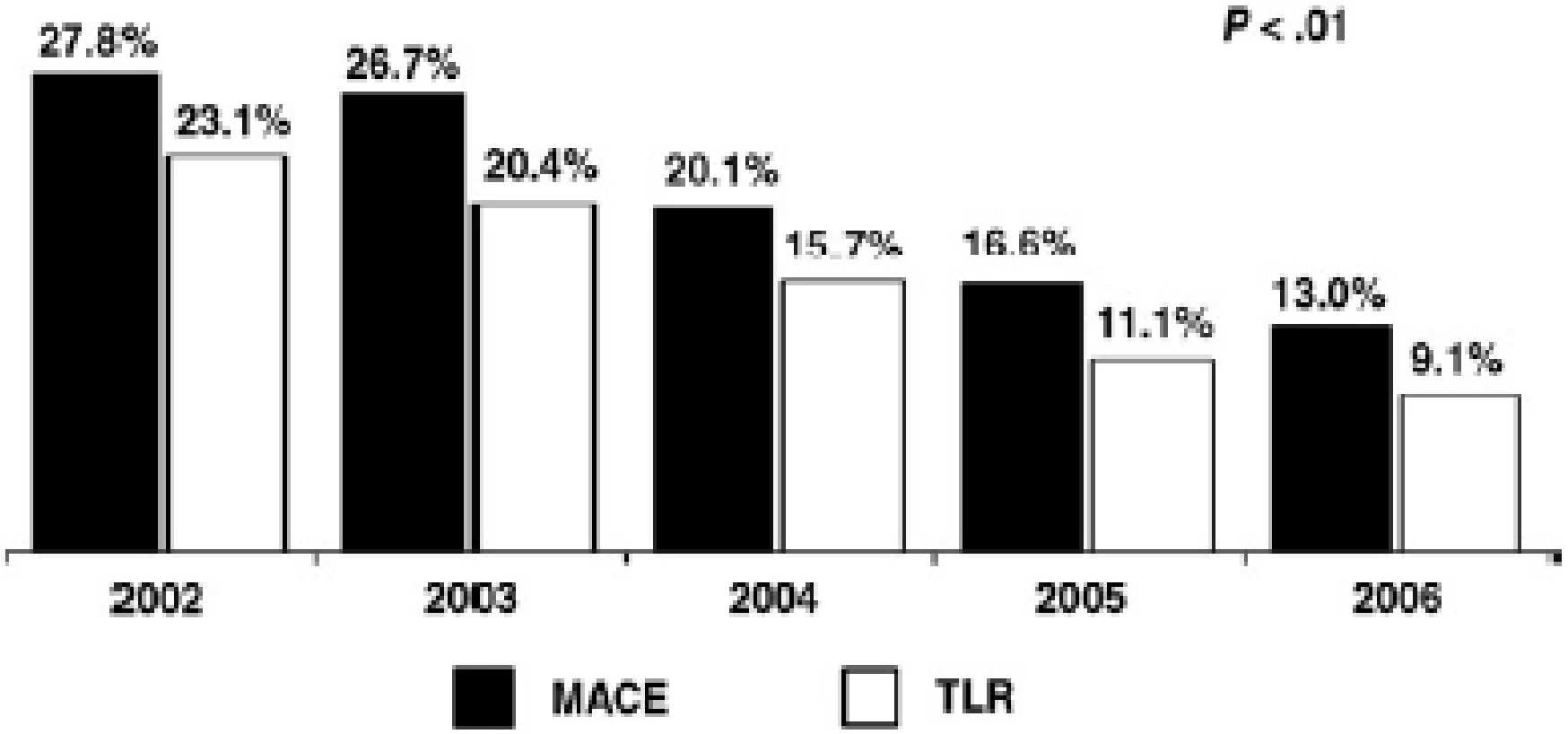
| Variables | MACE | Cardiac death | MI | TLR | Stent thrombosis | Definite thrombosis |
|---|---|---|---|---|---|---|
| Age | HR = 1.02 (1.01-1.03) P < .01 | HR = 1.06 (1.03-1.08) P < .01 | HR = 1.02 (1.01-1.04) P = .03 | HR = 1.01 (1.01-1.02) P = .03 | HR = 1.03 (1.01-1.06) P < .01 | – |
| Diabetes | HR = 1.45 (1.20-1.76) P < .01 | HR = 1.69 (1.10-2.58) P = .02 | HR = 1.50 (1.02-2.21) P = .04 | HR = 1.53 (1.23-1.90) P < .01 | HR = 1.76 (1.14-2.71) P = .01 | – |
| Chronic kidney disease | HR = 1.37 (1.05-1.78) P = .02 | HR = 2.23 (1.36-3.64) P < .01 | HR = 1.83 (1.13-2.98) P = .01 | – | – | – |
| Prior revascularization | HR = 1.41 (1.15-1.72) P < .01 | – | – | HR = 1.71 (1.35-2.17) P < .01 | – | – |
| Impaired LVEF | HR = 1.37 (1.13-1.66) P < .01 | HR = 2.50 (1.64-3.82) P < .01 | HR = 1.82 (1.26-2.64) P < .01 | – | HR = 2.07 (1.34-3.19) P < .01 | - |
| Multivessel CAD | HR = 1.31 (1.04-1.65) P = .02 | HR = 2.49 (1.40-4.43) P < .01 | – | – | – | – |
| LMT disease | – | – | – | – | – | – |
| Site of in-stent restenosis | HR = 2.38 (1.76-3.21) P < .01 | HR = 2.03 (1.01-4.10) P = .04 | HR = 2.45 (1.39-4.32) P < .01 | HR = 2.31 (1.67-3.20) P < .01 | HR = 2.68 (1.43-5.01) P < .01 | – |
| Acute MI | HR = 1.68 (1.21-2.31) P < .01 | HR = 3.55 (2.12-5.94) P < .01 | – | – | – | – |
| Complex stenting strategy | HR = 1.39 (1.13-1.71) P < .01 | – | – | HR = 1.73 (1.38-2.17) P < .01 | – | – |
| DES implantation | HR = 0.59 (0.44-0.80) P < .01 | – | – | HR = 0.59 (0.44-0.80) P < .01 | – | – |
| Final kissing balloon performed | – | – | – | – | – | – |



Romagnoli Am Heart J 2010;160:535-542.

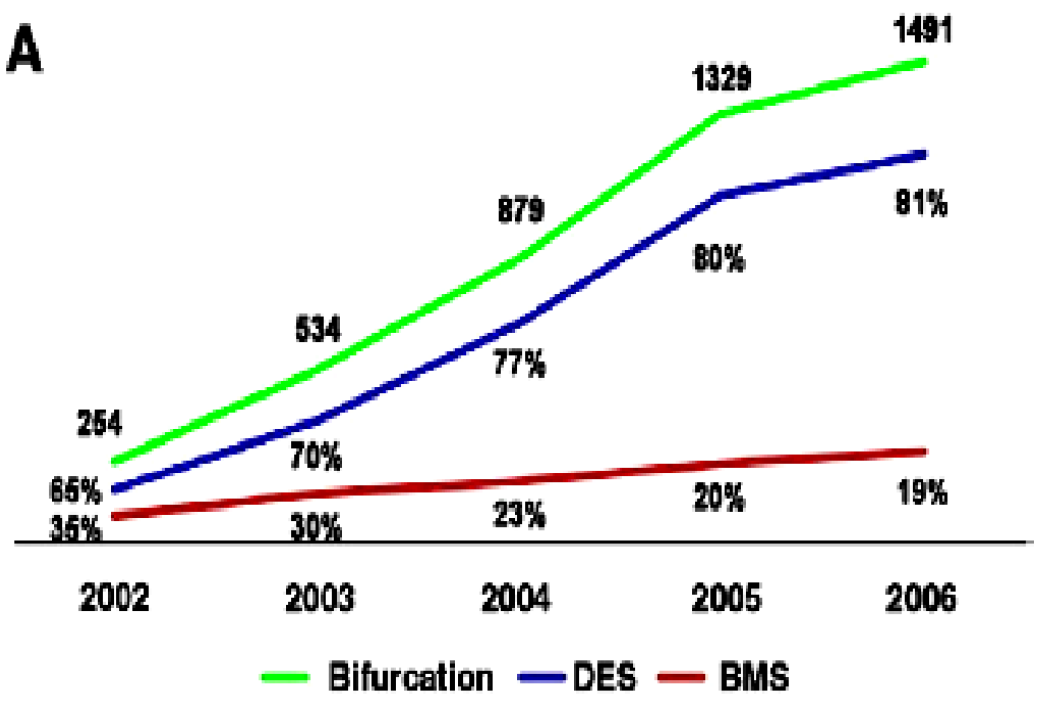
# Real-world outcome of coronary bifurcation lesions in the DES era: Results from the 4,314-patient SICI-GISE, I-BIGIS

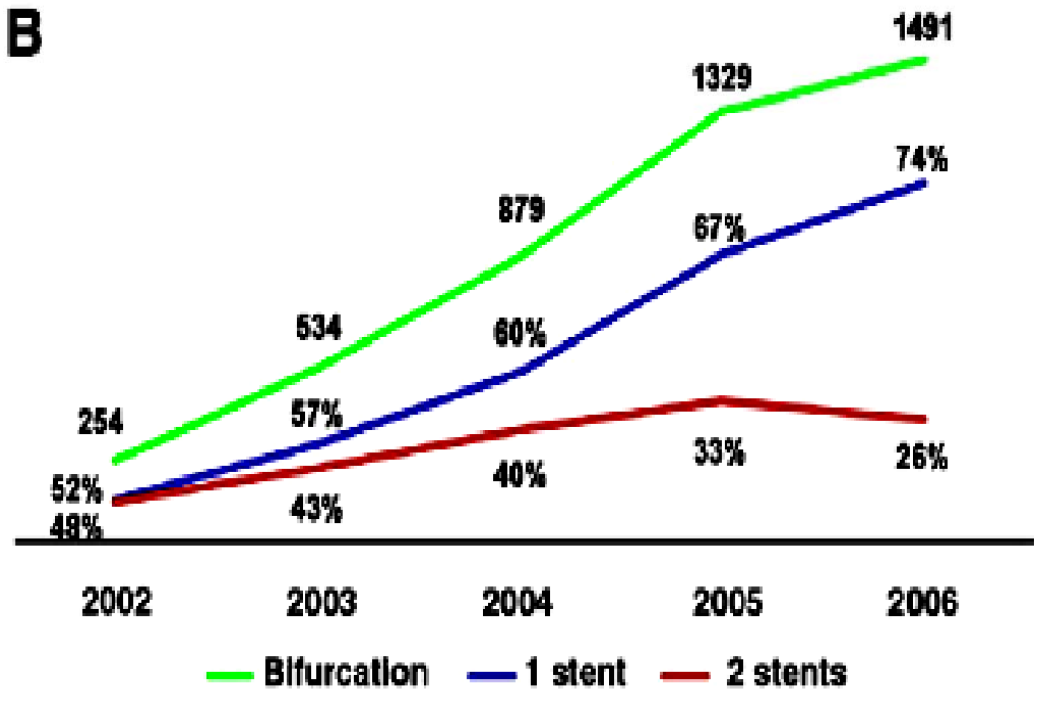
**Temporal trend of MACE and TLR rates during the study period**




Romagnoli Am Heart J 2010;160:535-542.

# Real-world outcome of coronary bifurcation lesions in the DES era: Results from the 4,314-patient SICI-GISE, I-BIGIS



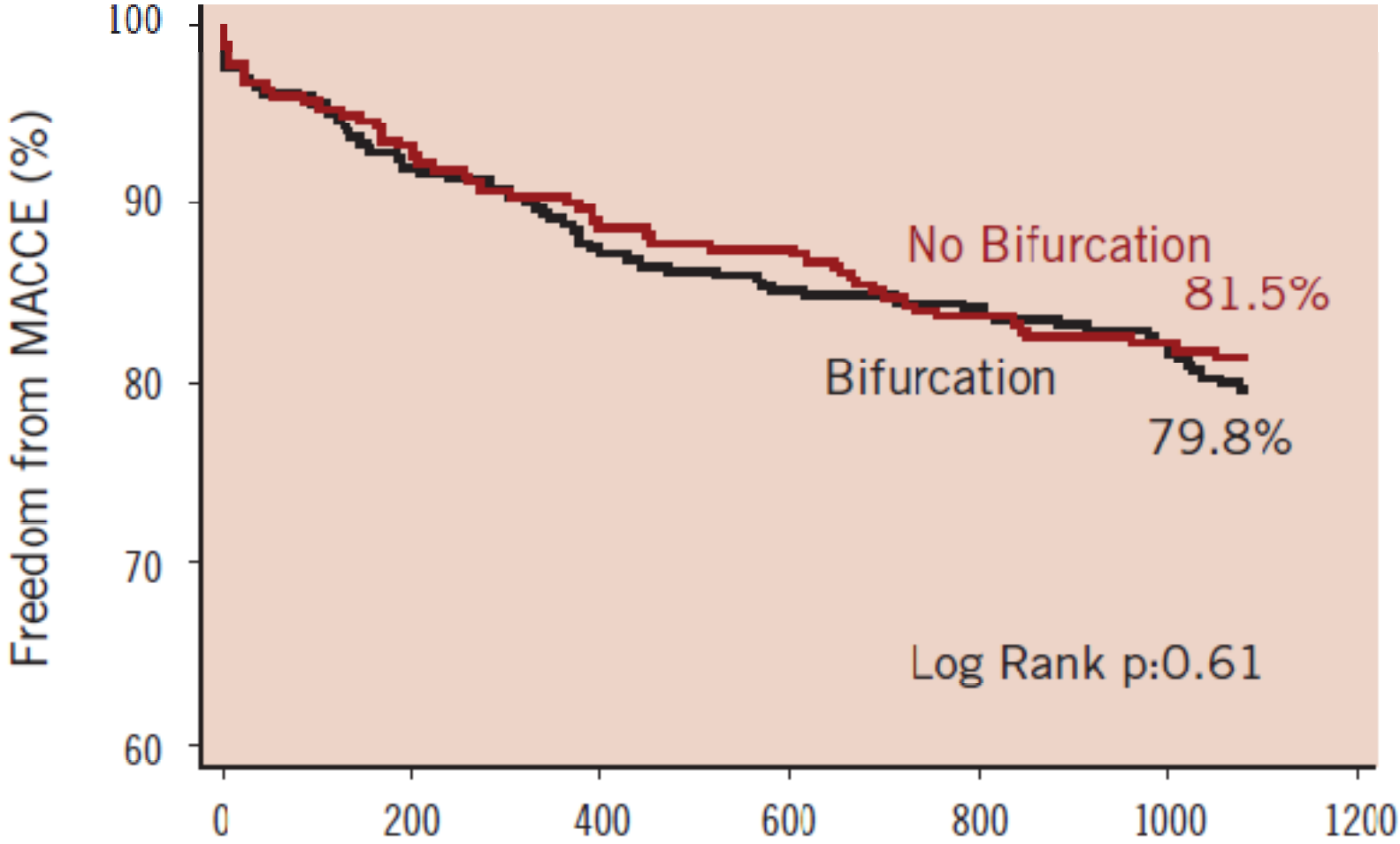




Drug-eluting stent penetration (A) Frequency of the 2 different stenting approaches (B) during the study period

Romagnoli Am Heart J 2010;160:535-542.

# 3Y clinical outcome of PCI of bifurcation lesions in multivessel CAD with the SES: insights from ARTS II

Freedom from MACCE in 324 patients including bifurcation treatment and 283 with no bifurcation

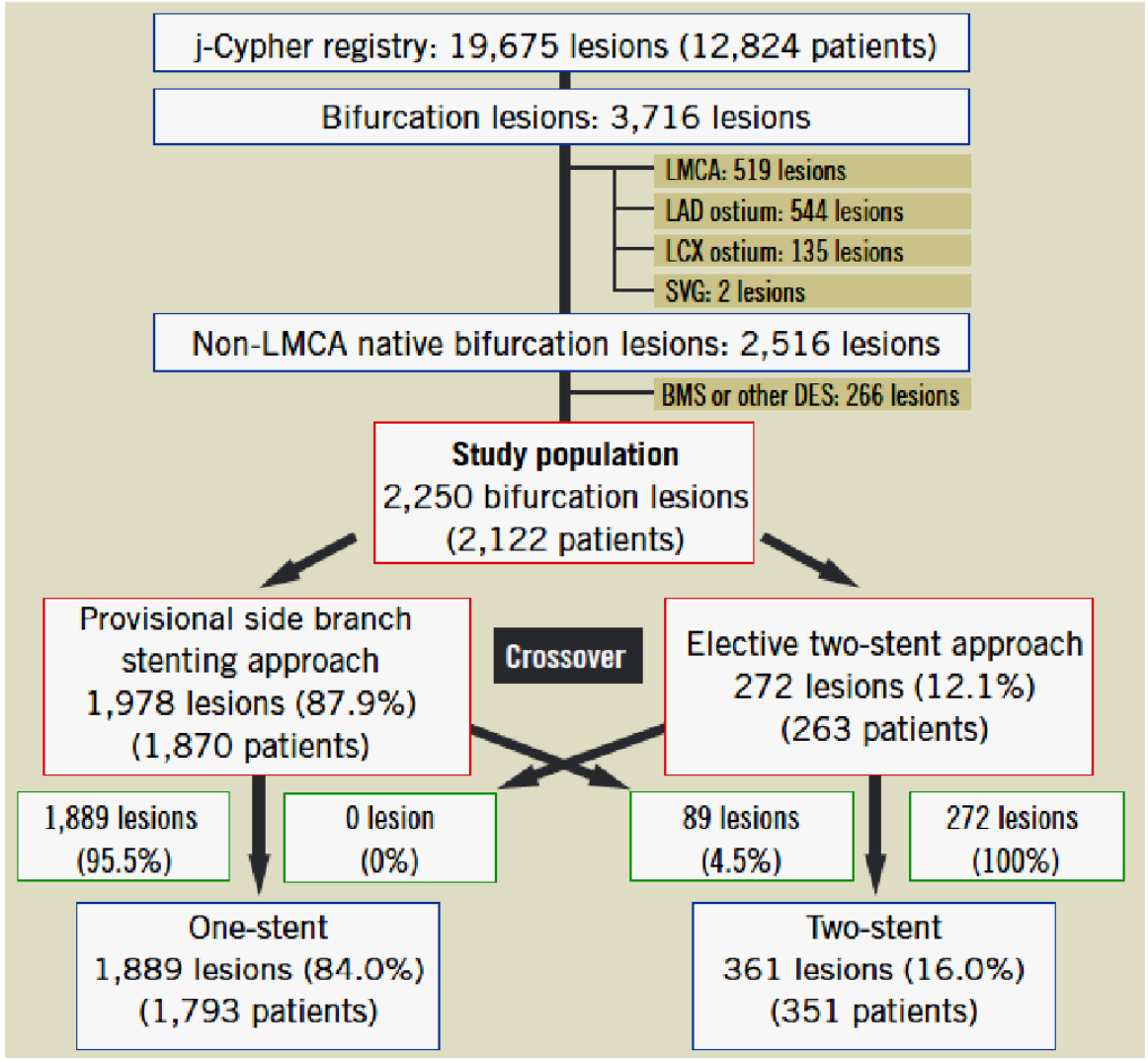





Routledge, EuroIntervention 2009;5:190-196

# Long term outcome: influence of stenting technique

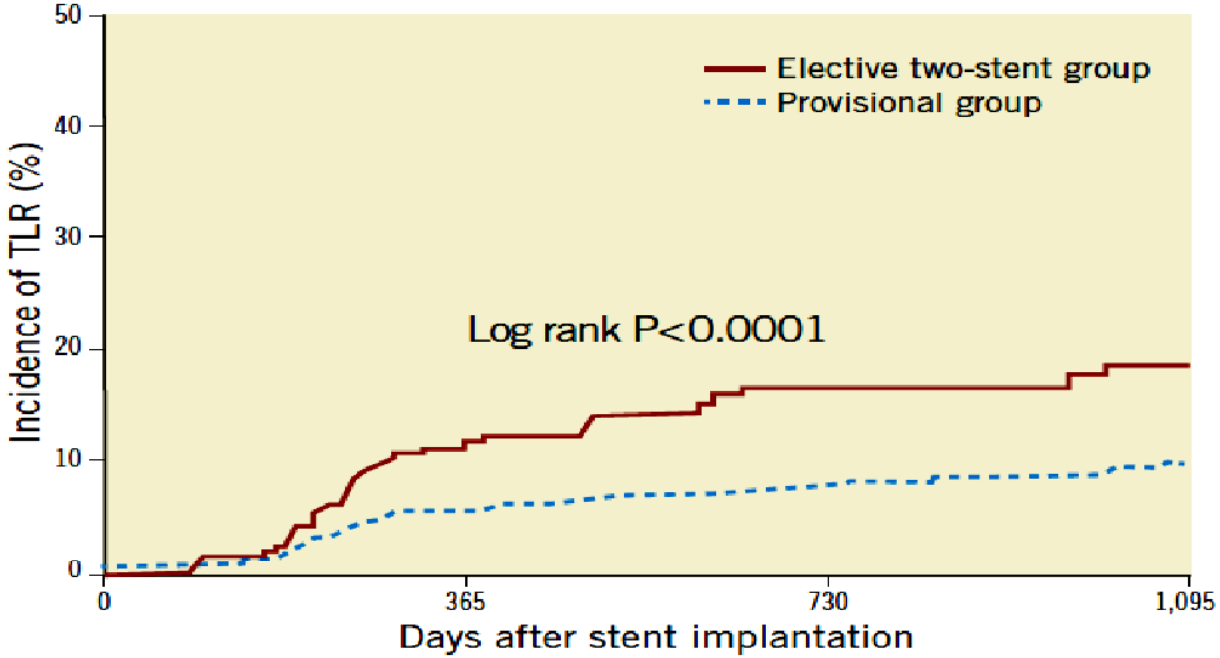
# 3-year outcome of SES in coronary bifurcation lesions: provisional SB stenting approach vs elective 2-stent




Tamura, EuroIntervention 2011;7:588-596

# 3-year outcome of SES in coronary bifurcation lesions: provisional SB stenting approach vs elective 2-stent

**TLR: two-stent group and the provisional SB stenting group**




| Interval (Days) | 0 | 365 | 730 | 1,095 |
|---|---|---|---|---|
| **Elective** | | | | |
| Cumulative incidence (%) | | 11.2 | 16.4 | 18.5 |
| Number of events | | 29 | 40 | 42 |
| Number of lesions at risk | 272 | 227 | 154 | 61 |
| Number of patients at risk | 263 | 218 | 147 | 57 |
| **Provisional** | | | | |
| Cumulative incidence (%) | | 5.6 | 7.7 | 9.8 |
| Number of events | | 106 | 142 | 160 |
| Number of lesions at risk | 1,978 | 1,754 | 1,325 | 613 |
| Number of patients at risk | 1,870 | 1,657 | 1,259 | 586 |

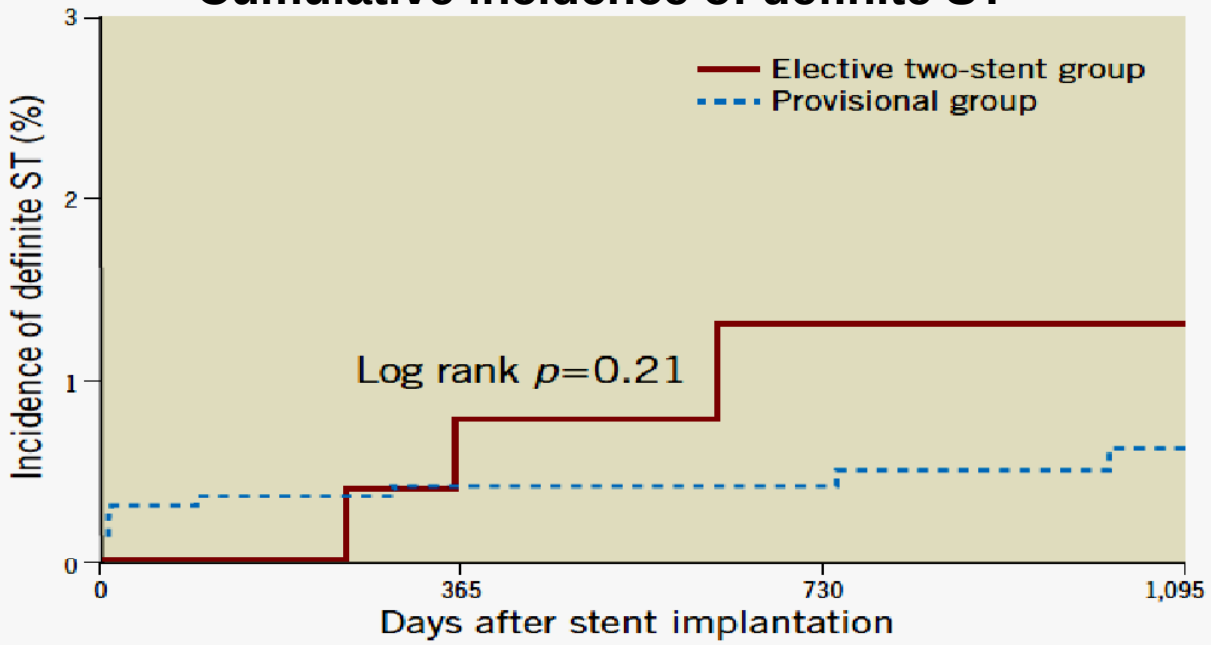
True bifurcation:
Prov. 49%
2 stent 83%
P<0.0001



Tamura, EuroIntervention 2011;7:588-596

# 3-year outcome of SES in coronary bifurcation lesions: provisional SB stenting approach vs elective 2-stent

**Cumulative incidence of definite ST**

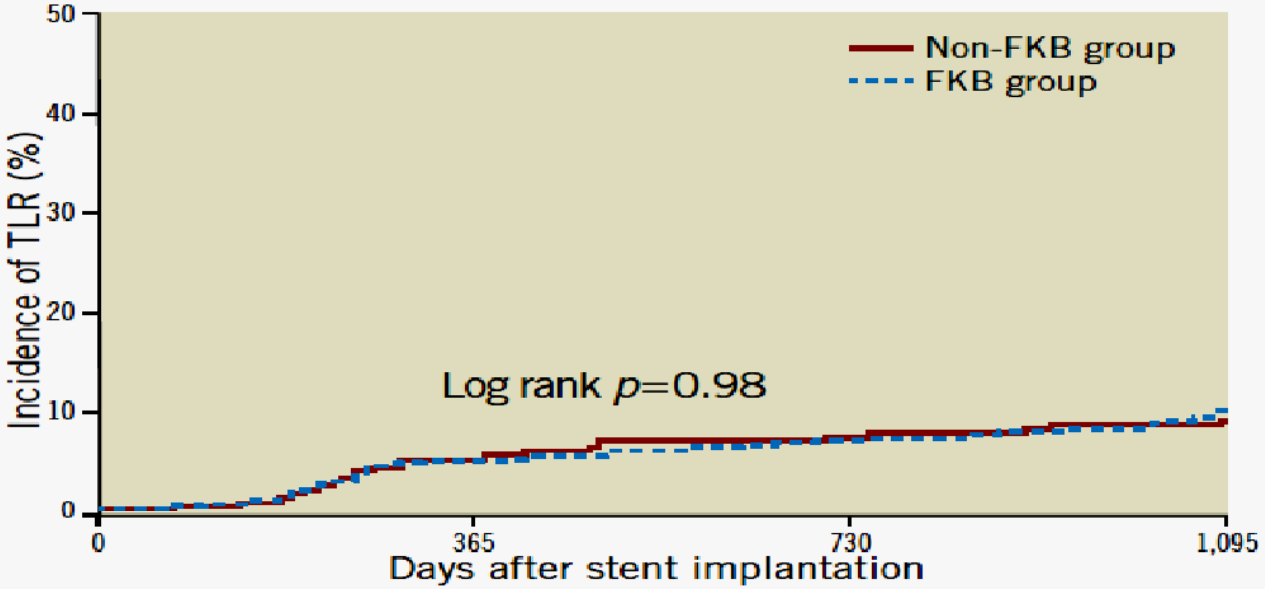



| Interval (Days) | 0 | 365 | 730 | 1,095 |
|---|---|---|---|---|
| **Elective** | | | | |
| Cumulative incidence (%) | | 0.78 | 1.3 | 1.3 |
| Number of events | | 2 | 3 | 3 |
| Number of lesions at risk | 272 | 253 | 179 | 69 |
| Number of patients at risk | 263 | 244 | 172 | 65 |
| **Provisional** | | | | |
| Cumulative incidence (%) | | 0.41 | 0.41 | 0.61 |
| Number of events | | 8 | 8 | 10 |
| Number of lesions at risk | 1,978 | 1,851 | 1,428 | 673 |
| Number of patients at risk | 1,870 | 1,752 | 1,354 | 642 |

Tamura, EuroIntervention 2011;7:588-596

# 3-year outcome of SES in coronary bifurcation lesions: provisional SB stenting approach vs elective 2-stent

**TLR in the FKB group and the non-FKB group in lesions treated with a 1-stent strategy**



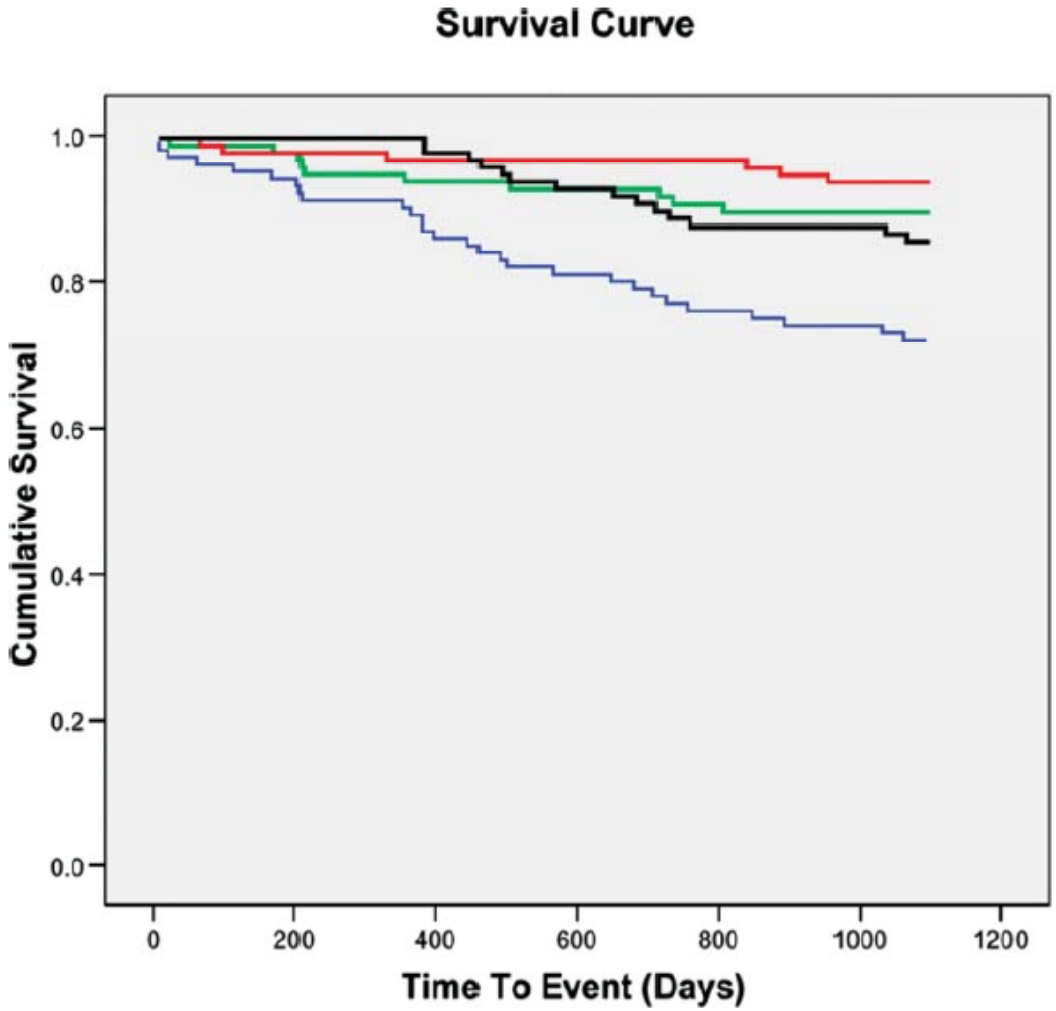

| Interval (Days) | 0 | 365 | 730 | 1,095 |
|---|---|---|---|---|
| **Non-FKB** | | | | |
| Cumulative incidence (%) | | 5.4 | 7.4 | 9.2 |
| Number of events | | 48 | 63 | 71 |
| Number of lesions at risk | 933 | 816 | 606 | 281 |
| Number of patients at risk | 904 | 815 | 623 | 286 |
| **FKB** | | | | |
| Cumulative incidence (%) | | 5.1 | 7.1 | 9.9 |
| Number of events | | 46 | 61 | 74 |
| Number of lesions at risk | 938 | 847 | 648 | 294 |
| Number of patients at risk | 903 | 787 | 590 | 273 |



Tamura, EuroIntervention 2011;7:588-596

# 3-year FU of 100 consecutive coronary bifurcation lesions treated with Taxus stents and the Crush technique

**True bifurcation: 93%**

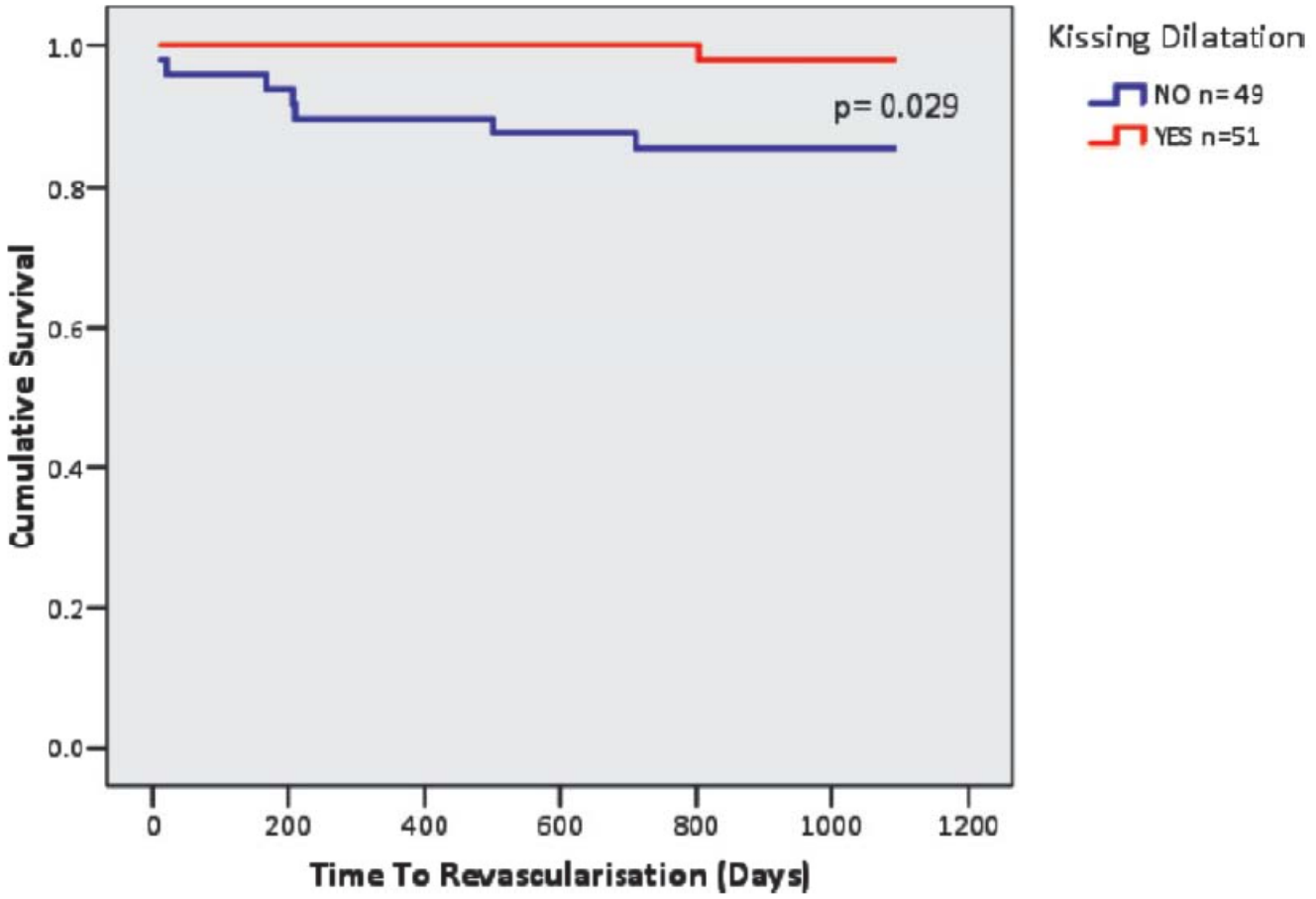



Freedom from cardiac death (red), TVR (green), non-fatal MI (black) and MACE (blue)

Chue, CCVI 75:605–613 (2010)

# 3-year FU of 100 consecutive coronary bifurcation lesions treated with Taxus stents and the Crush technique

**Freedom from TLR according to presence of final kissing balloon dilatation**






Chue, CCVI 75:605–613 (2010)

# Three-Year Outcome of DES Implantation for Coronary Artery Bifurcation Lesions

**Procedural Characteristics**

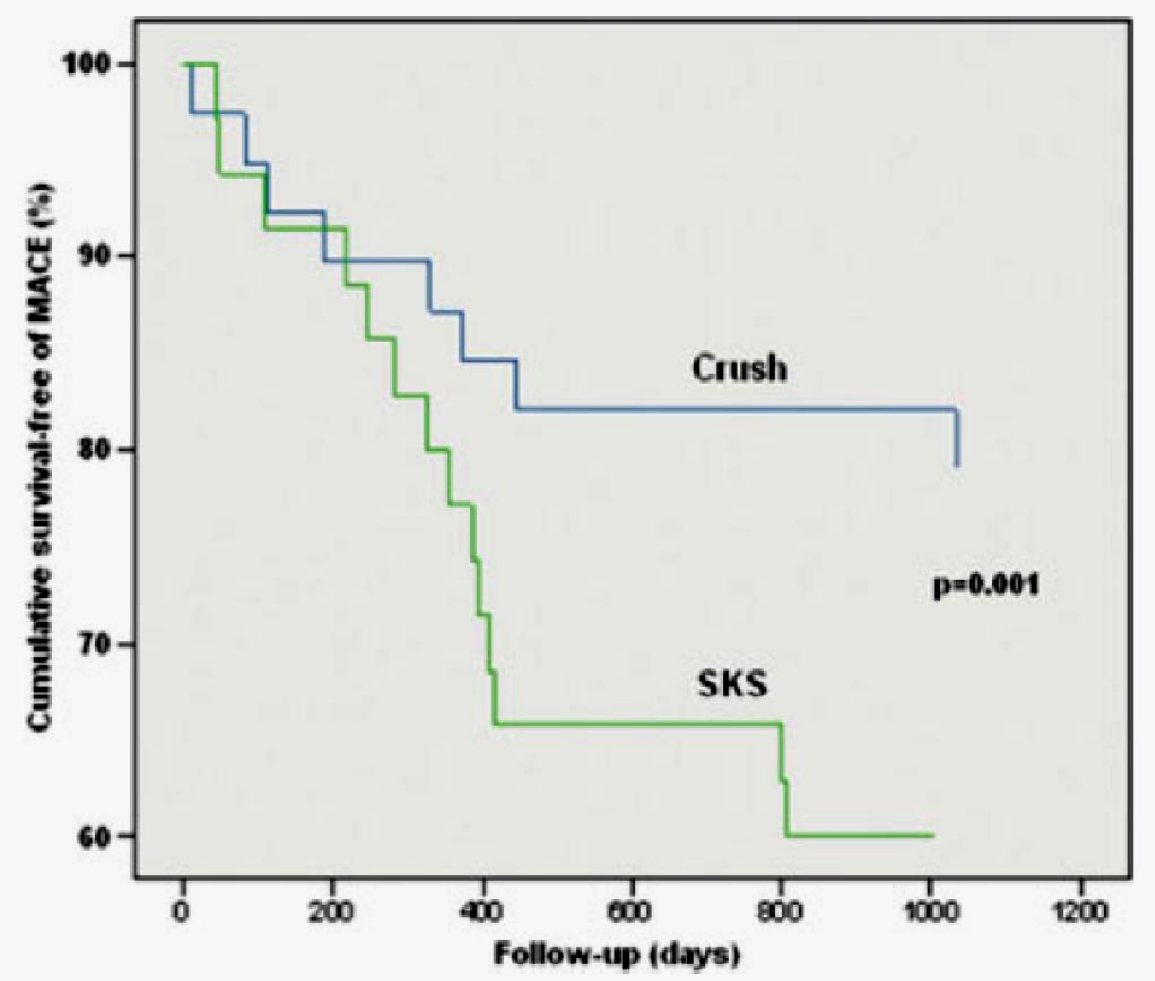
| Variable | SKS ($n = 35$) | Crush ($n = 39$) | $P$-value |
|---|---|---|---|
| LAD/diagonal | 17 (48.6%) | 34 (87.2%) | <0.001 |
| LCX/OM | 6 (17.1%) | 5 (12.8%) | 0.74 |
| LCX/Ramus | 3 (8.6%) | — | 0.10 |
| PDA/PLB (Other) | 9 (25.7%) | — | <0.001 |



Stinis, CCVI 75:309–314 (2010)

# Three-Year Outcome of DES Implantation for Coronary Artery Bifurcation Lesions

**Survival Free of MACE**

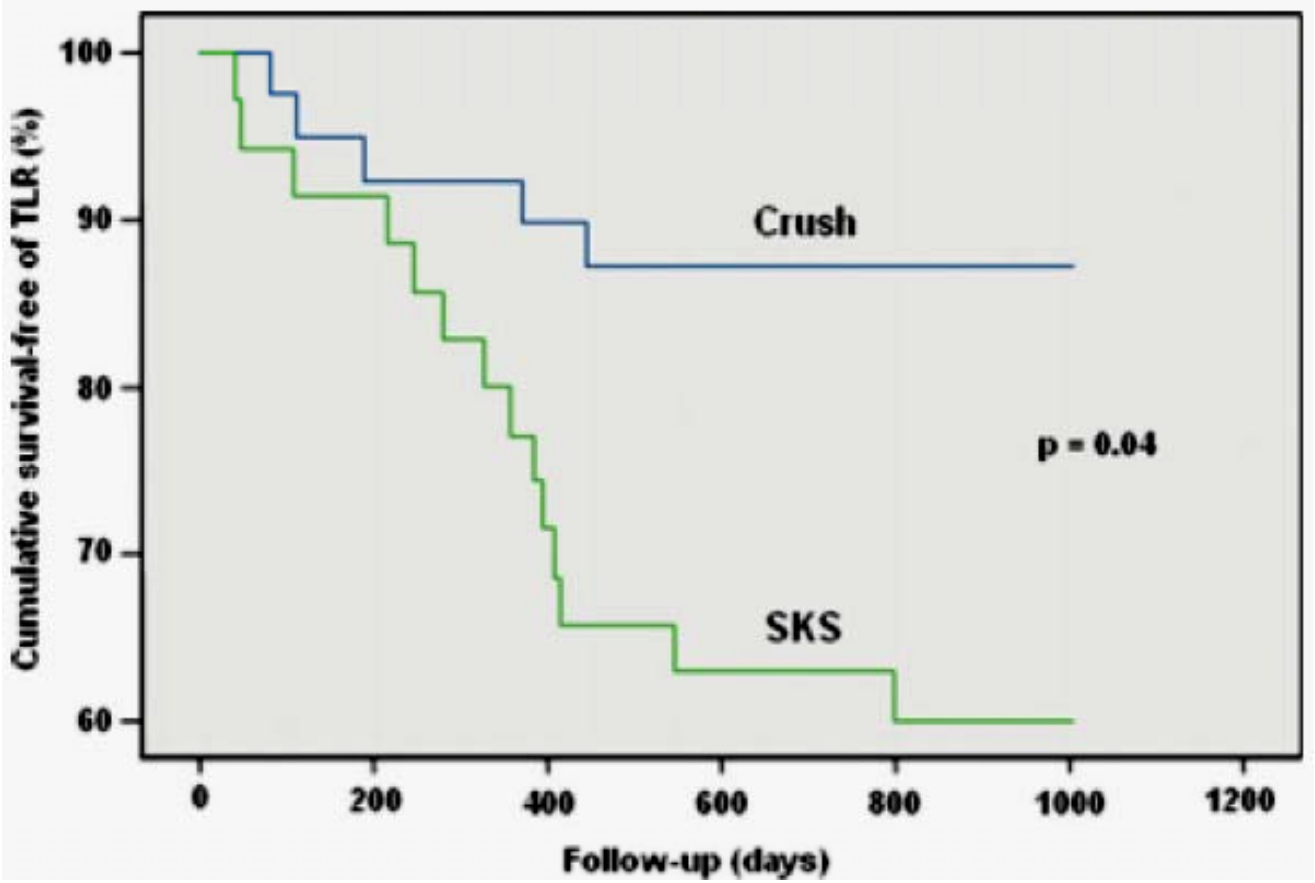





Stinis, CCVI 75:309–314 (2010)

# Three-Year Outcome of DES Implantation for Coronary Artery Bifurcation Lesions

**Survival Free of TLR**




Stinis, CCVI 75:309–314 (2010)

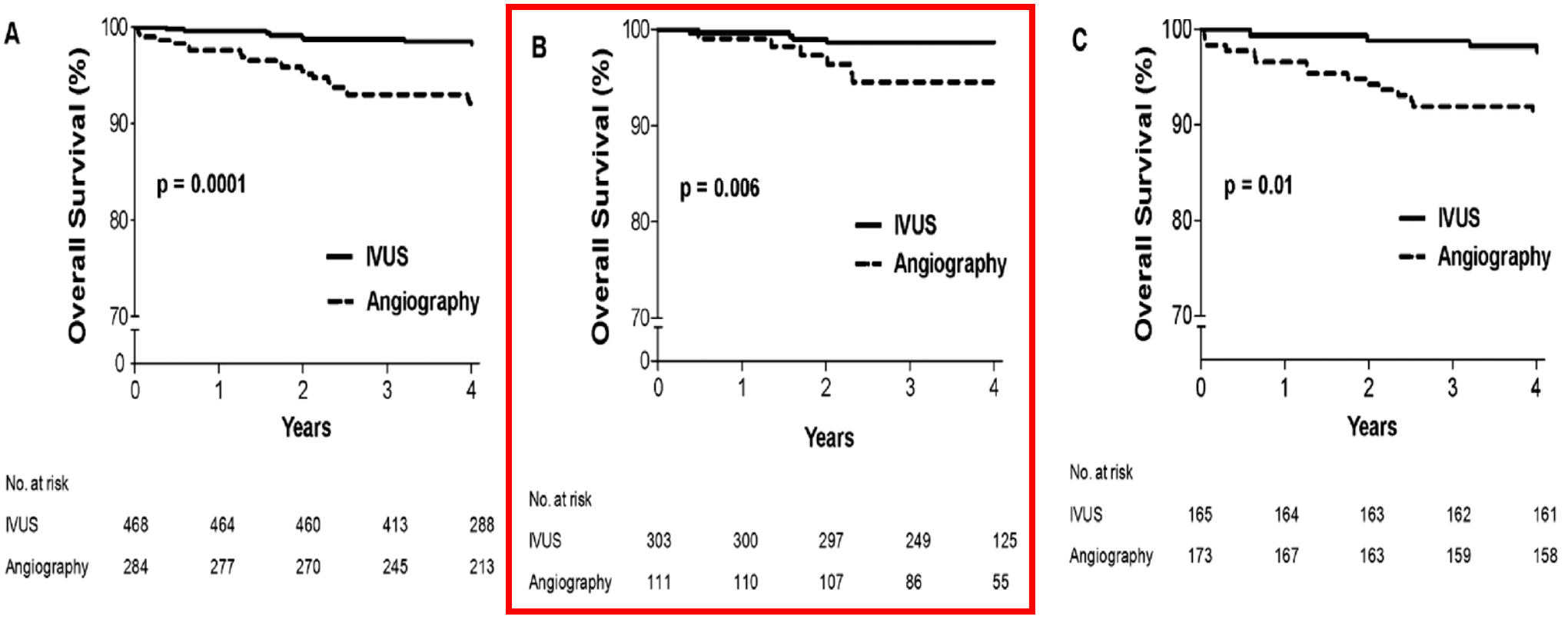
# Influence of technique

- MACE and TLR rates at ≥ 3 years lower with provisional SB stenting strategy with 1 or 2 stents
- Worst outcome with Crush (without FKB), and SKS
- More ST with non provisional strategies ?

# Long term outcome: influence of IVUS guidance

# Long-Term Outcomes of IVUS-Guided Stenting in Coronary Bifurcation Lesions

Survival rates in (A) all patients, (B) patients with **DES**, (C) and patients with BMS






Kim, Am J Cardiol 2010;106:612– 618

# Long-Term Outcomes of IVUS-Guided Stenting in Coronary Bifurcation Lesions

**Clinical outcomes after IVUS-guided compared to angiographically guided stenting**

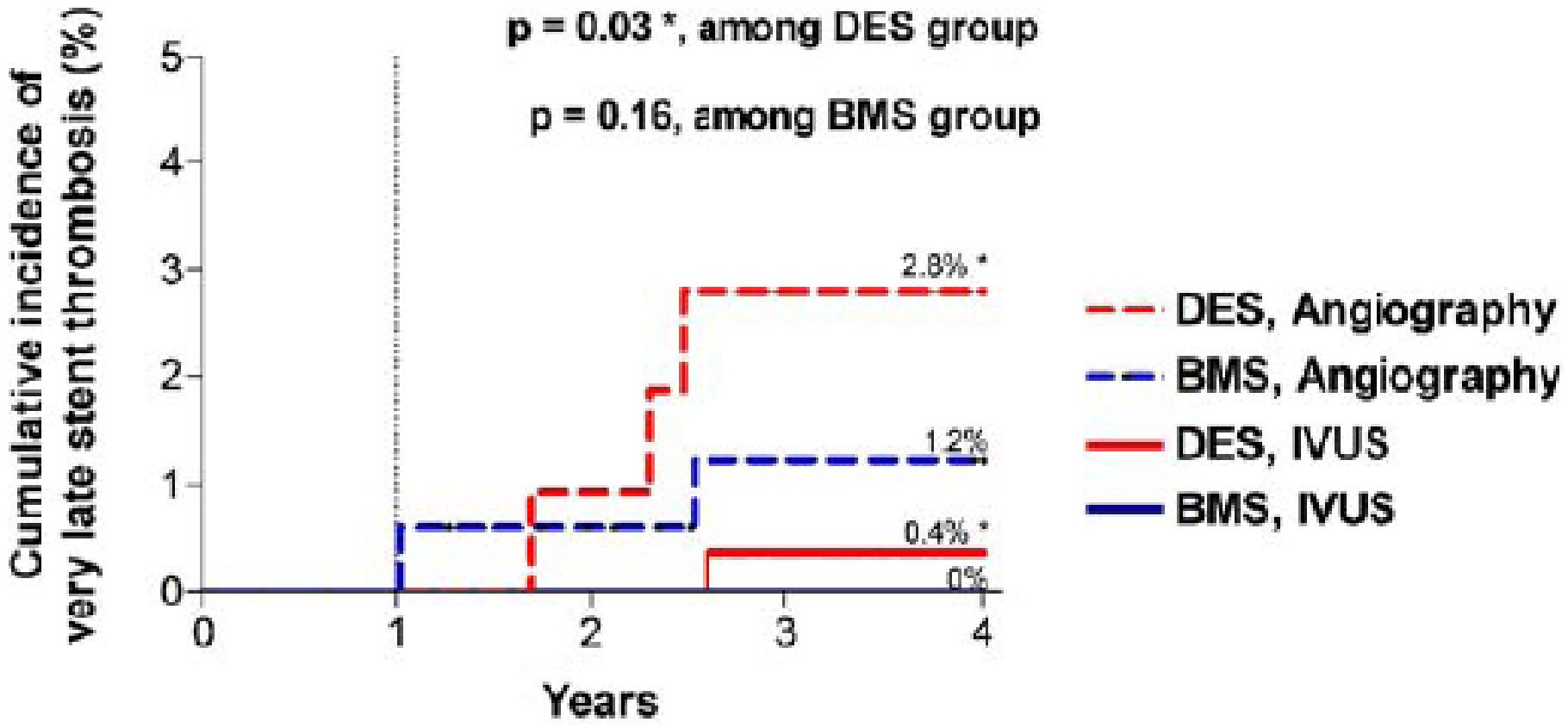
| Outcome | Overall Group | | DES Group | | BMS Group | |
|---|---|---|---|---|---|---|
| | HR (95% CI) | p Value | HR (95% CI) | p Value | HR (95% CI) | p Value |
| Unadjusted | | | | | | |
| Death | 0.22 (0.10–0.50) | <0.001 | 0.21 (0.06–0.72) | 0.01 | 0.27 (0.09–0.81) | 0.02 |
| Stent thrombosis | 0.45 (0.16–1.30) | 0.14 | 0.27 (0.06–1.22) | 0.09 | 0.78 (0.17–3.48) | 0.74 |
| Target lesion revascularization | 1.36 (0.77–2.41) | 0.29 | 0.94 (0.39–2.24) | 0.88 | 2.13 (1.00–4.55) | 0.05 |
| Multivariate adjusted | | | | | | |
| Death | 0.31 (0.13–0.74) | 0.008 | 0.24 (0.06–0.86) | 0.03 | 0.41 (0.13–1.26) | 0.12 |
| Stent thrombosis | 0.48 (0.16–1.43) | 0.19 | 0.35 (0.08–1.64) | 0.18 | 1.09 (0.22–5.34) | 0.92 |
| Target lesion revascularization | 1.47 (0.79–2.71) | 0.21 | 0.92 (0.38–2.25) | 0.86 | 2.27 (0.99–5.25) | 0.05 |
| Propensity score adjusted | | | | | | |
| Death | 0.13 (0.03–0.66) | 0.01 | 0.21 (0.06–0.73) | 0.01 | 0.4 (0.1–1.2) | 0.11 |
| Stent thrombosis | 0.30 (0.07–1.32) | 0.11 | 0.28 (0.06–1.25) | 0.10 | 1.0 (0.2–4.9) | 0.98 |
| Target lesion revascularization | 0.63 (0.23–1.72) | 0.36 | 0.90 (0.33–2.54) | 0.84 | 1.67 (0.75–3.72) | 0.21 |



Kim, Am J Cardiol 2010;106:612– 618

# Long-Term Outcomes of Intravascular Ultrasound-Guided Stenting in Coronary Bifurcation Lesions

**Unadjusted cumulative incidence of very late stent thrombosis in patients implanted with DES under IVUS guidance and angiographic guidance**





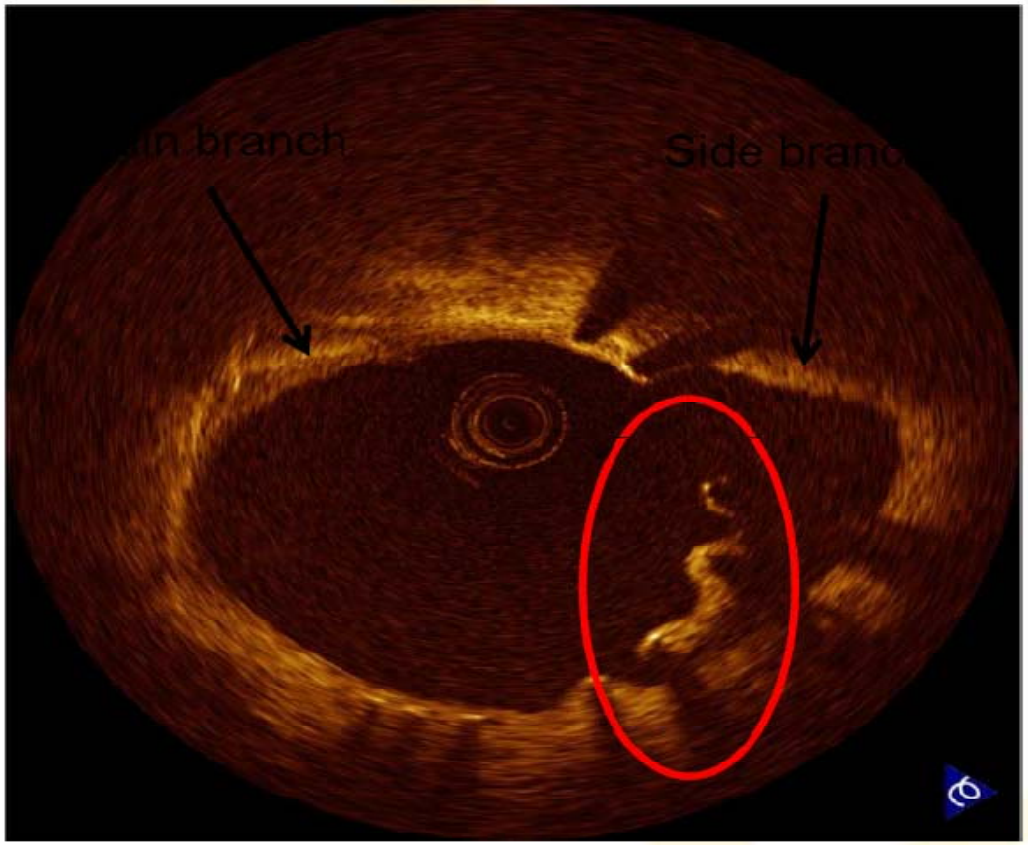

Kim, Am J Cardiol 2010;106:612– 618

# Conclusion (1)

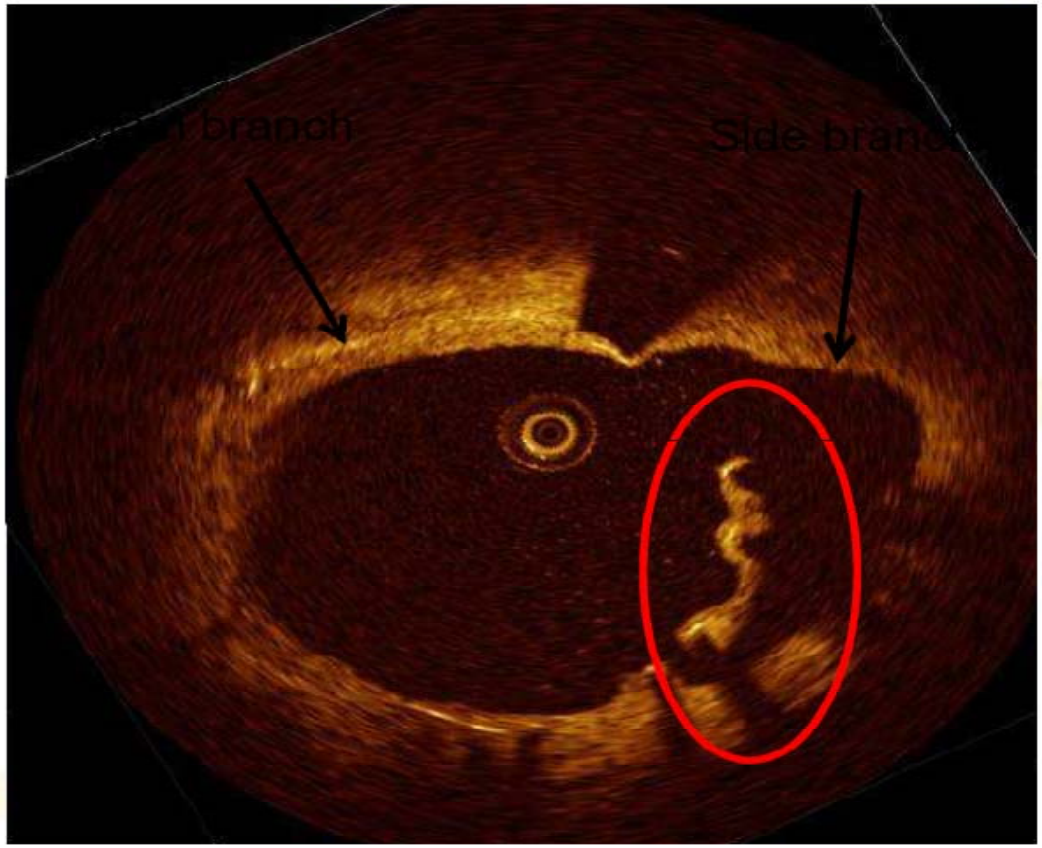
- Long term outcome after bifurcation stenting may be similar to non bifurcated lesions:
  - Begin with main vessel stenting
  - Second stent when necessary
  - Kissing balloon for single stenting ?
  - FKB mandatory for double stenting
  - IVUS guidance to reduce the risk of very late ST ?

# Repetitive OCTs in bifurcation lesions stented with DES

***Serial changes of neointimal thickness and coverage***



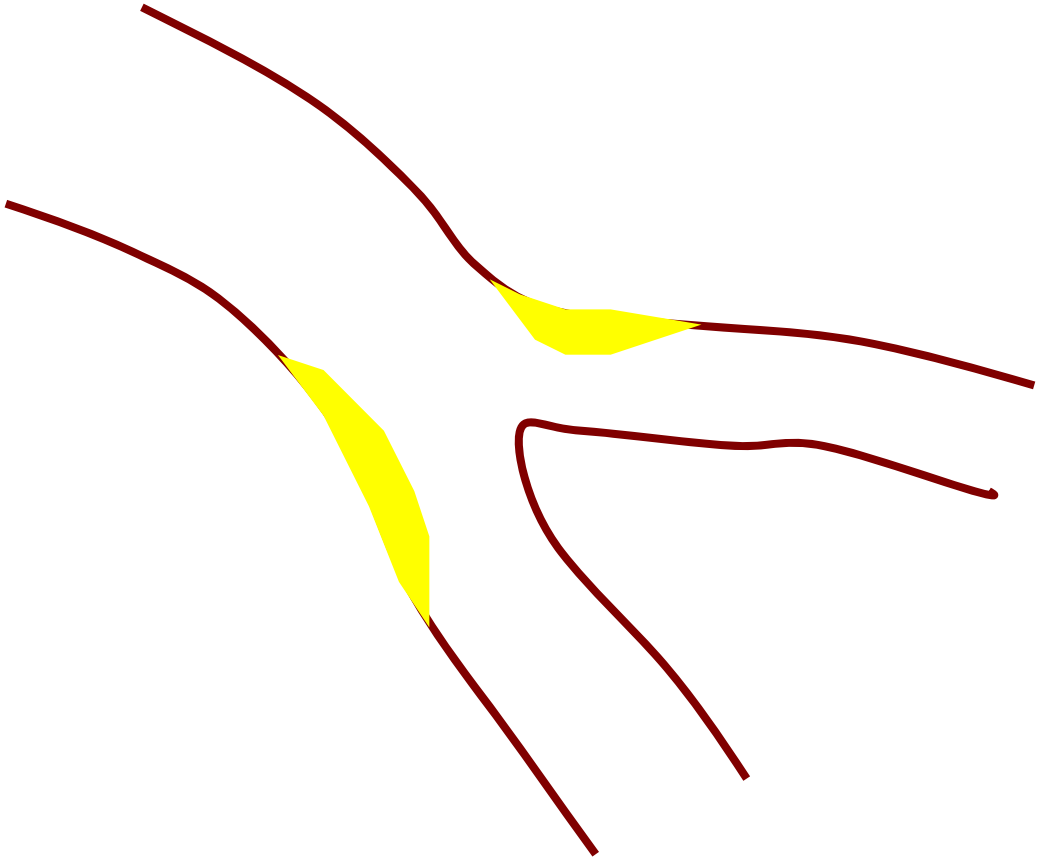

**9 months later**

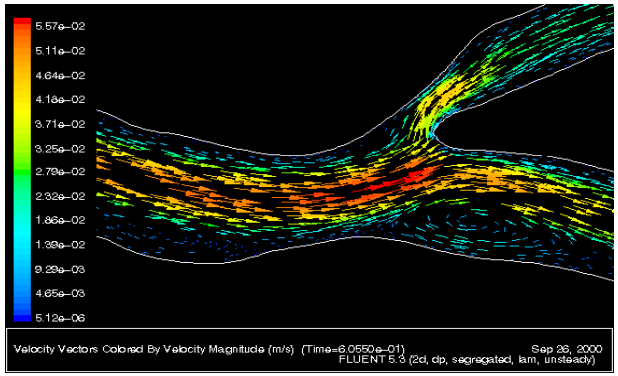


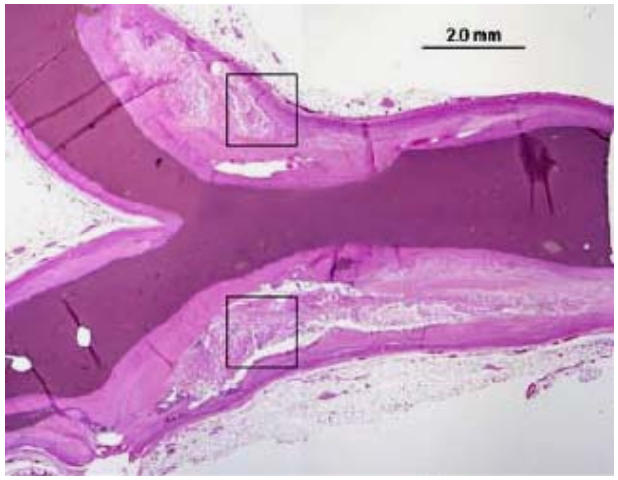

**20 months later**

Courtesy of Kinoshita

# Low wall shear stress and atheroma in bifurcation





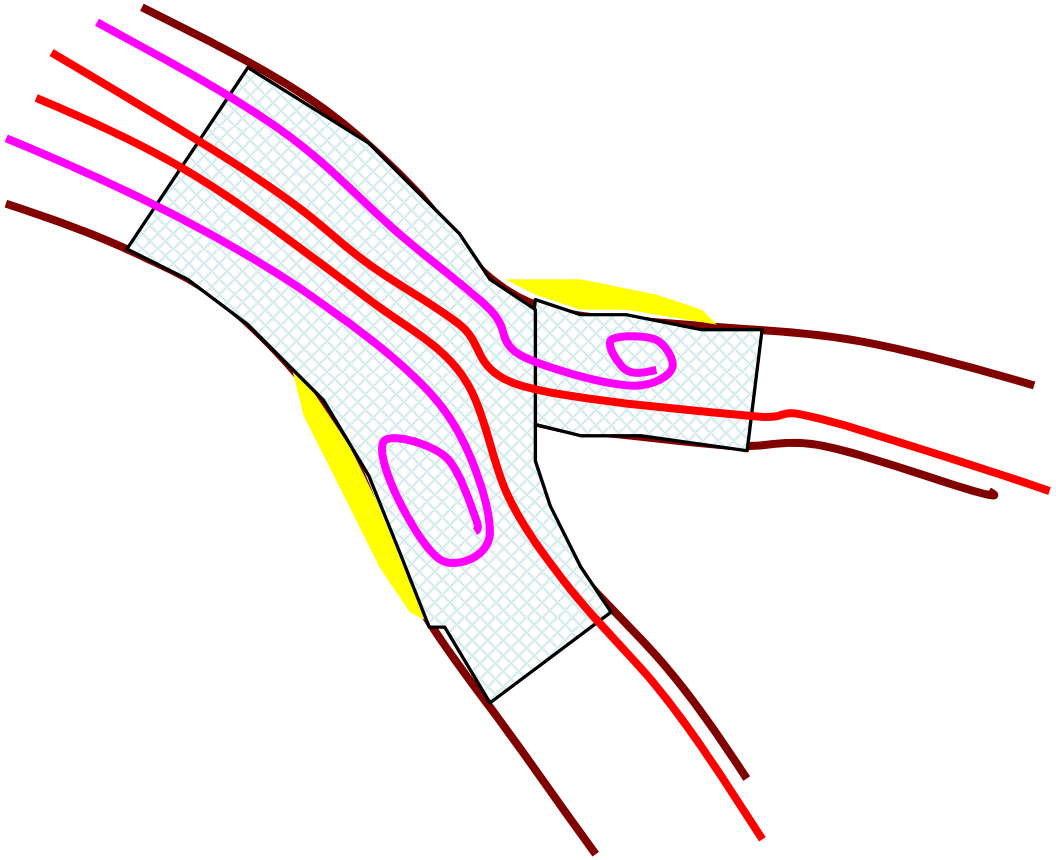
# Pathological Findings at Bifurcation Lesions: Impact of Flow Distribution on Atherosclerosis and Arterial Healing After Stenting

| | 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 |

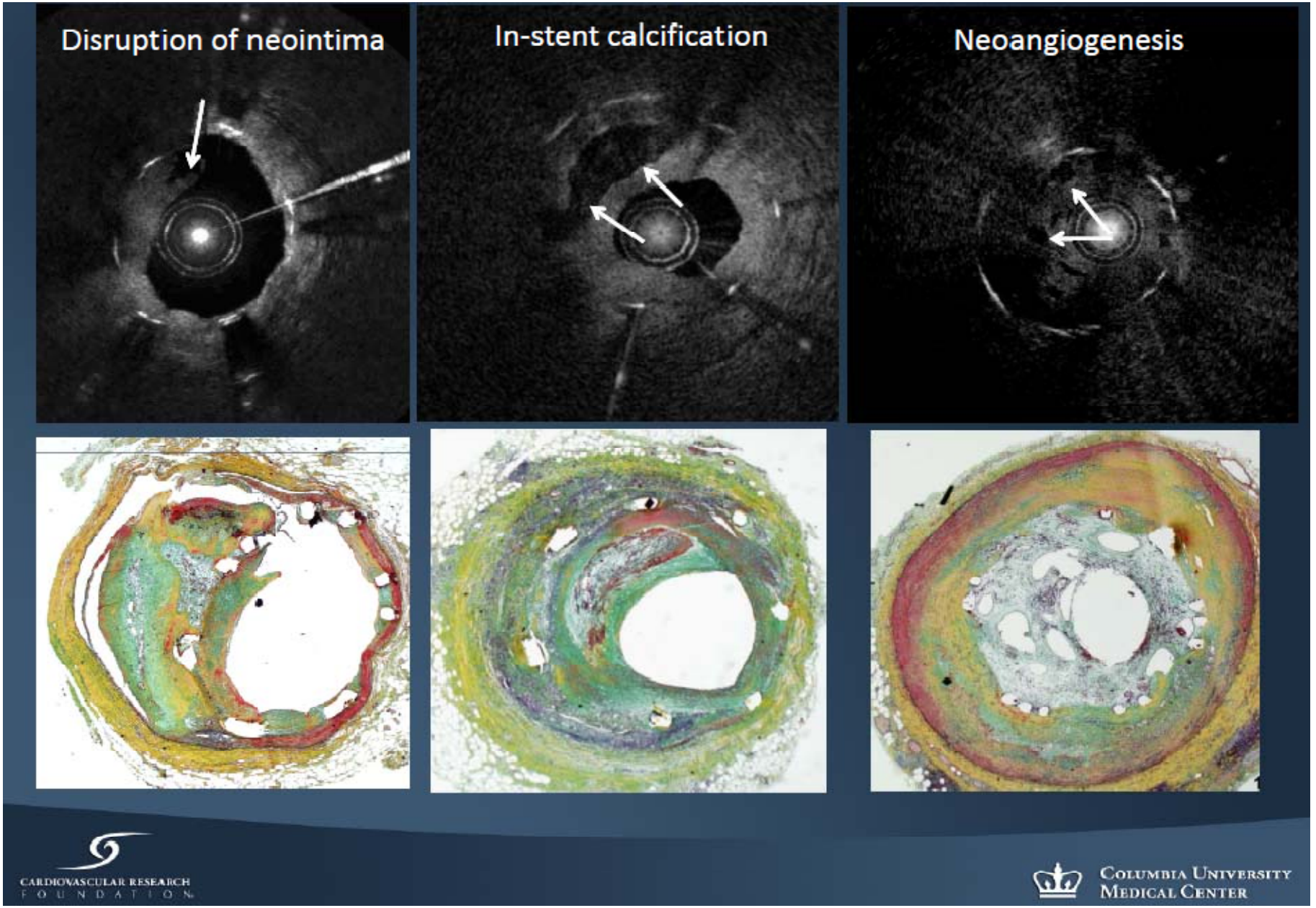


Nakazawa, J Am Coll Cardiol 2010;55:1679–87

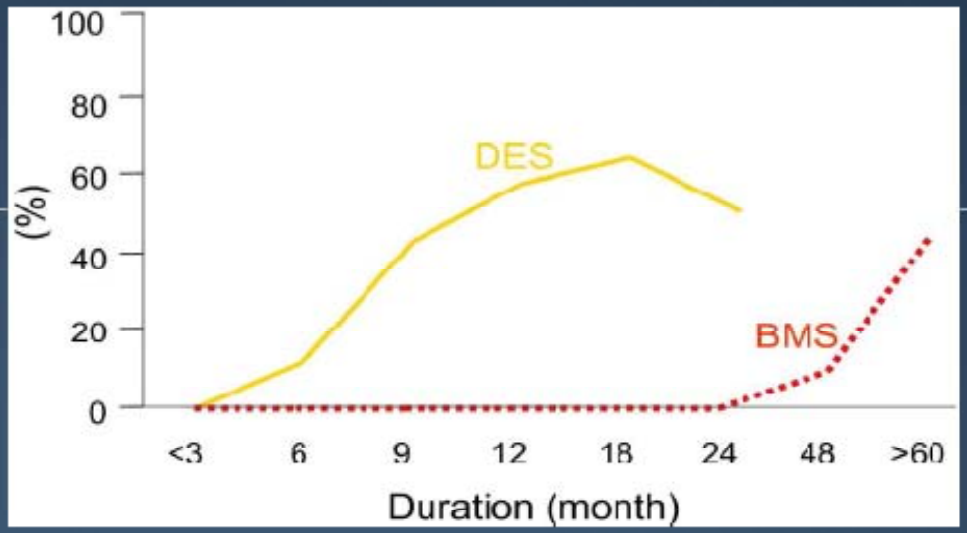
# Restauration of initial flow (+ stent turbulences)

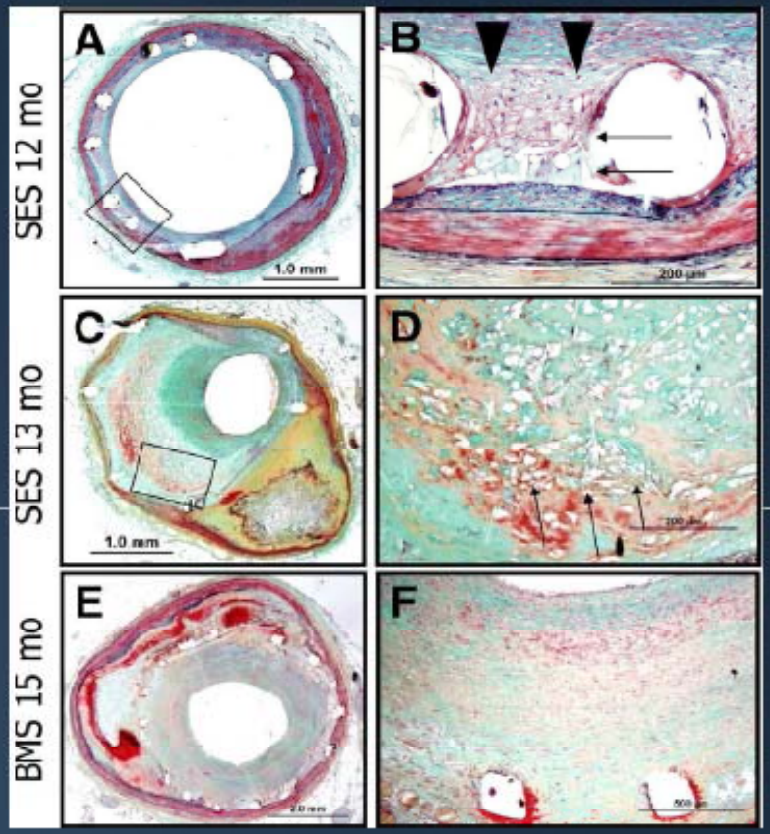


**WSS < 0.5 Pa =**
**risk of restenosis**


Disruption of neointima
In-stent calcification
Neoangiogenesis
CARDIOVASCULAR RESEARCH FOUNDATION
COLUMBIA UNIVERSITY MEDICAL CENTER

## Percentage of Patients With Atherosclerotic Changes in DES Versus BMS in Relation to Duration of Implant at Autopsy




Nakazawa et al. J Am Coll Cardiol Img 2009;2:625-8

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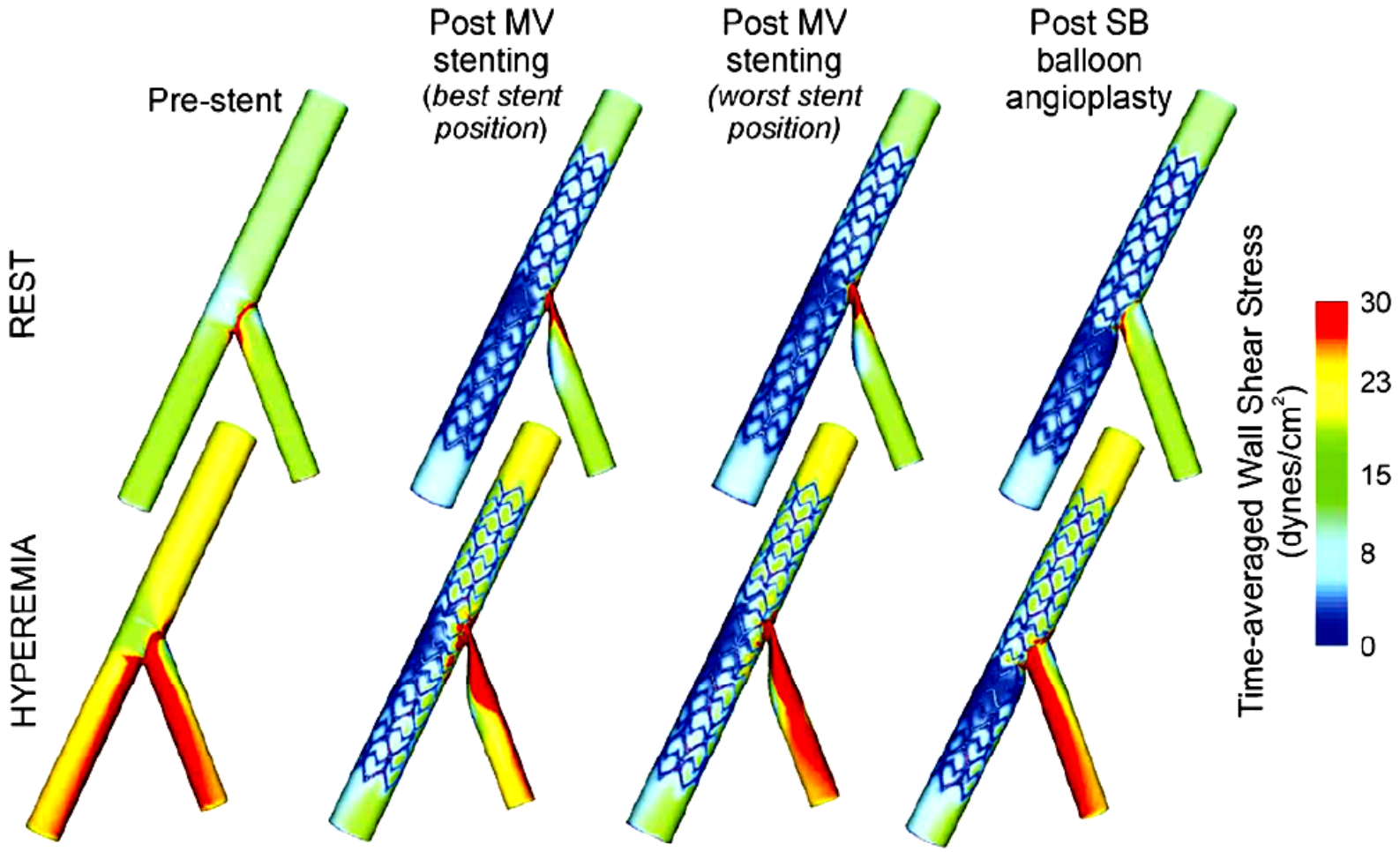
# Local hemodynamic changes caused by MB stenting and subsequent virtual SB balloon angioplasty in a representative coronary bifurcation




**Changes in time-averaged wall shear stress introduced by bifurcation stenting**

Williams J Appl Physiol (May 27, 2010)

# Conclusion (2)

- Principles of bifurcation stenting:

  - minimize number of stent: begin with MB

  - minimize turbulences: optimal stent deploiement, minimal overlapping

  - respect the anatomy of the bifurcation to respect the fonction