# Bifurcation Anatomy and Implications on Outcomes: Bifurcation Angle and Complexity Criteria

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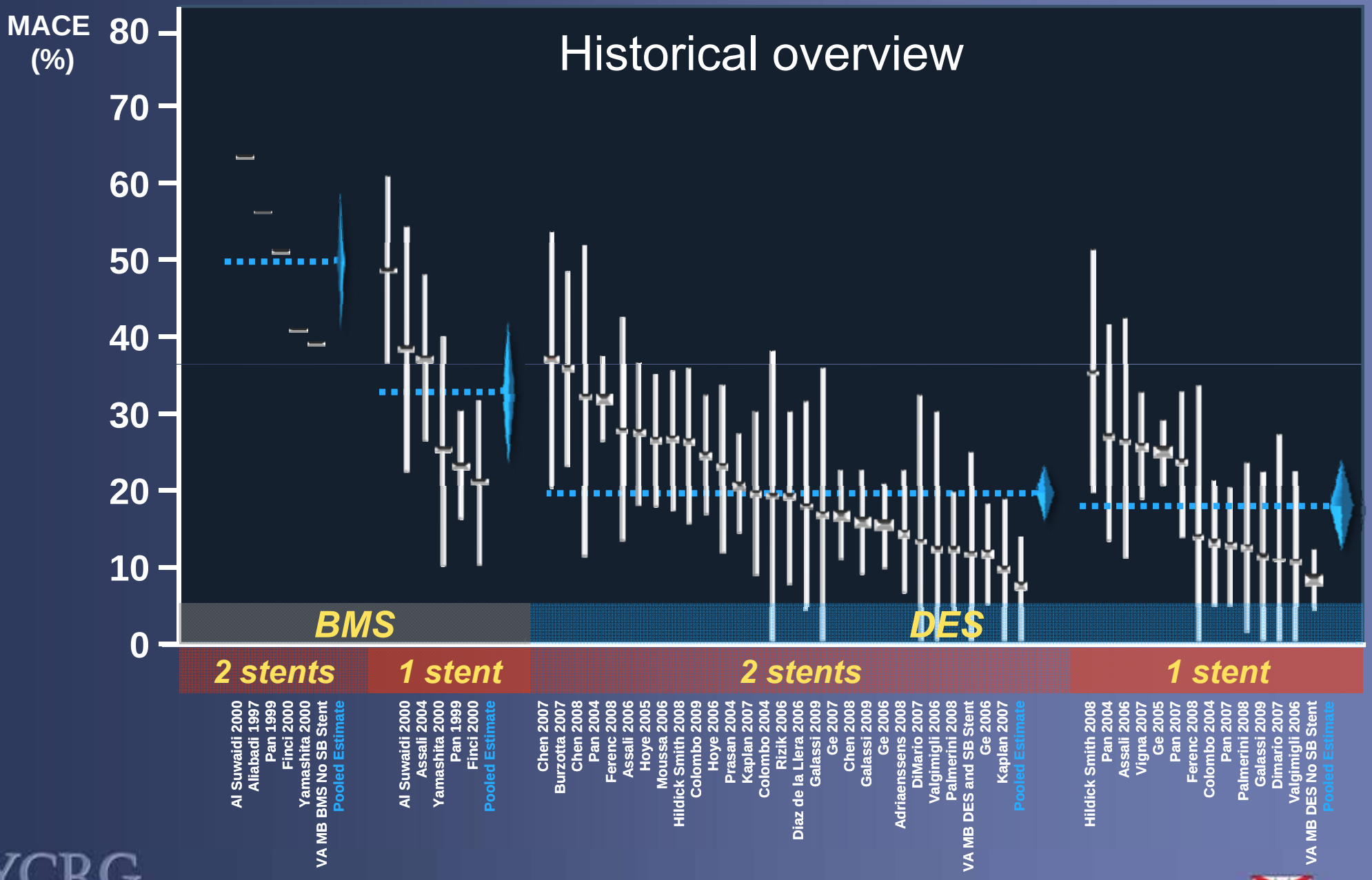
# Disclosure Statement of Financial Interest

I DO NOT have a financial interest/arrangement or affiliation with one or more organizations that could be perceived as a real or apparent conflict of interest in the context of the subject of this presentation.

# Simple vs. Complex Bifurcation stenting

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Payman Zamani, CCI 2011

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# Bifurcation Geometry
# Oval and Asymmetric Rather than Round

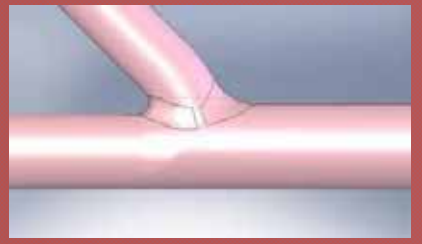
*Courtesy of Mary Russel, MD, PhD*

Example: Side Branch of RCA



Sketches of ostium

conical taper

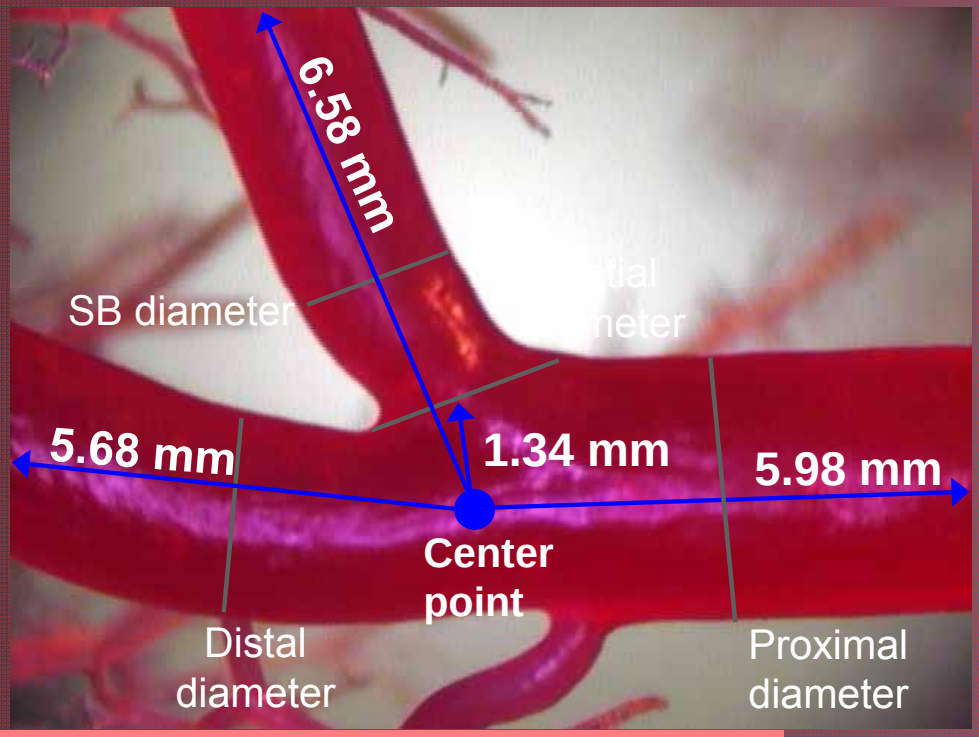


elliptical

# Understanding Ostial geometry: Transition Zone Taper Greater by 3-fold

*Courtesy of Mary Russel, MD, PhD*

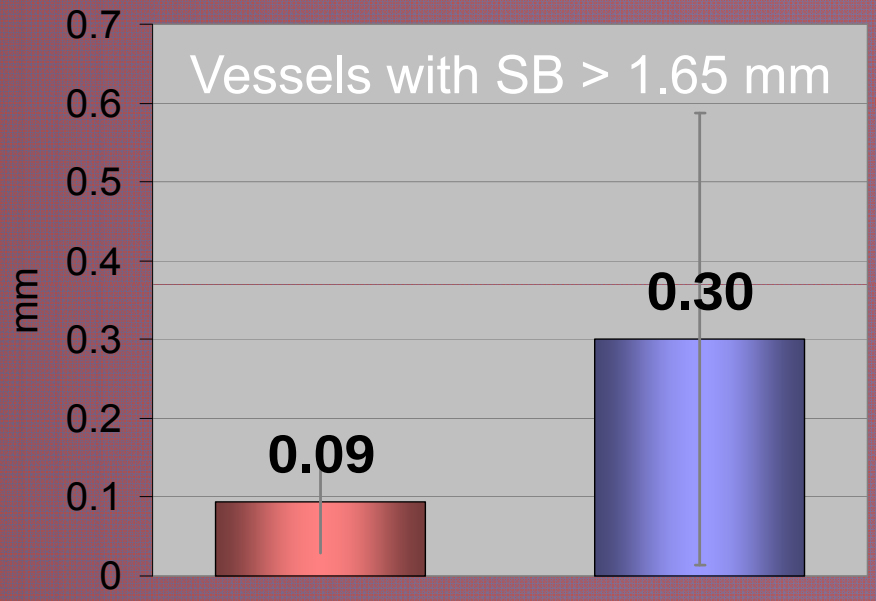
## Example of Diameter Measurements




| | At 3 mm | At 6 mm |
|---|---|---|
| Proximal diameter | 3.14 | 3.15 |
| Distal diameter | 2.44 | 2.56 |

| | At ostium | At 3 mm | At 6mm |
|---|---|---|---|
| Side branch diameter | 2.50 | 1.96 | 2.03 |

## Average Taper



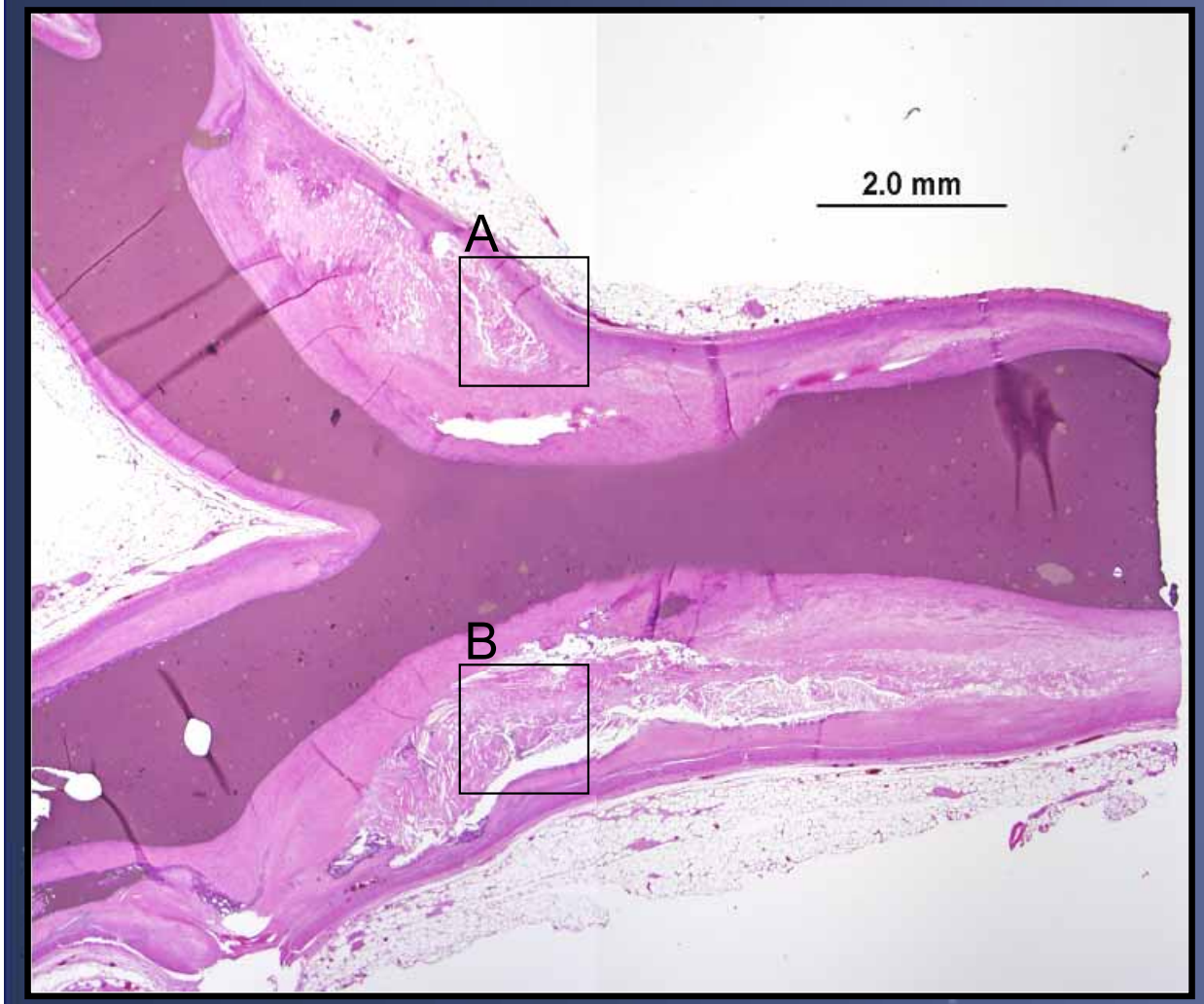

Main Vessel
Tapers 0.56 mm over 6.00 mm distance

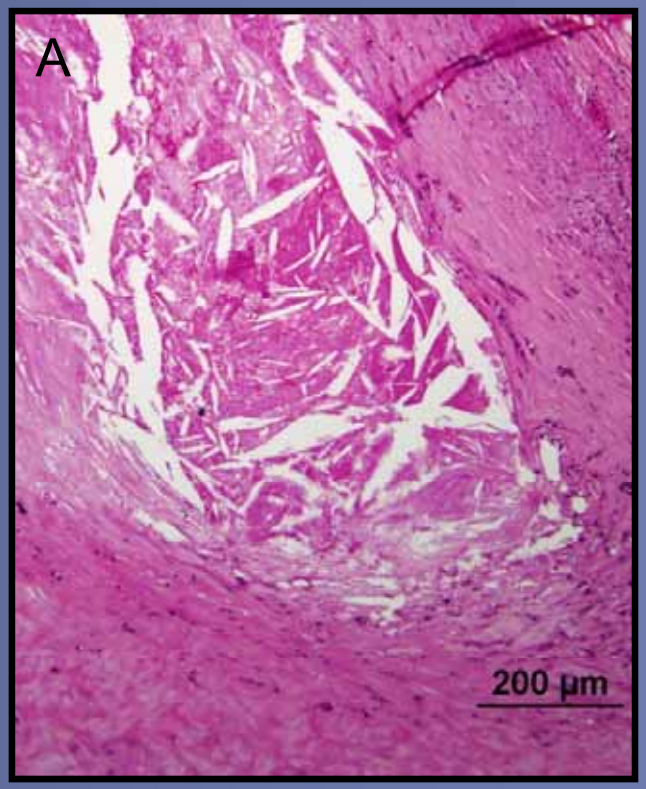
Side Branch
Tapers 0.53 mm over 1.75 mm distance

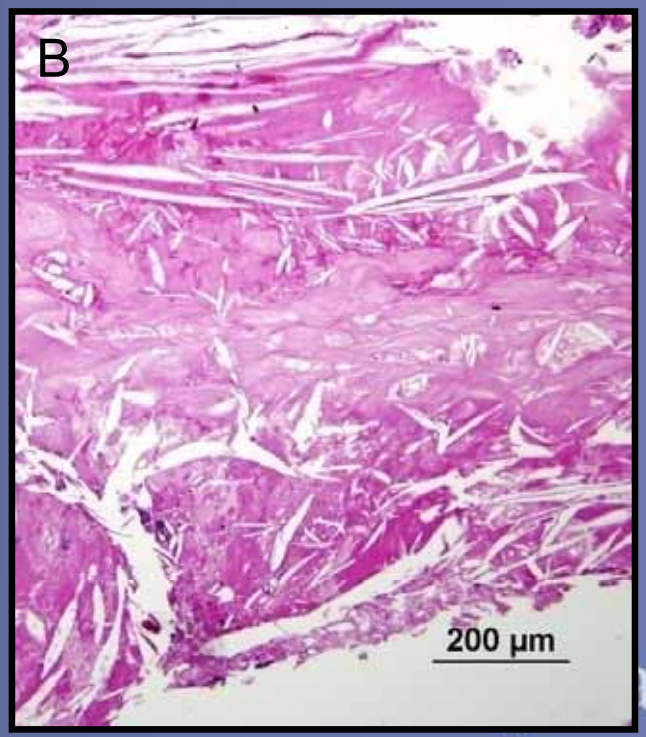
# Non Left Main Bifurcation Lesion

Nakazawa G, et al. *J Am Coll Cardiol.* 2010;55:1679-1687.

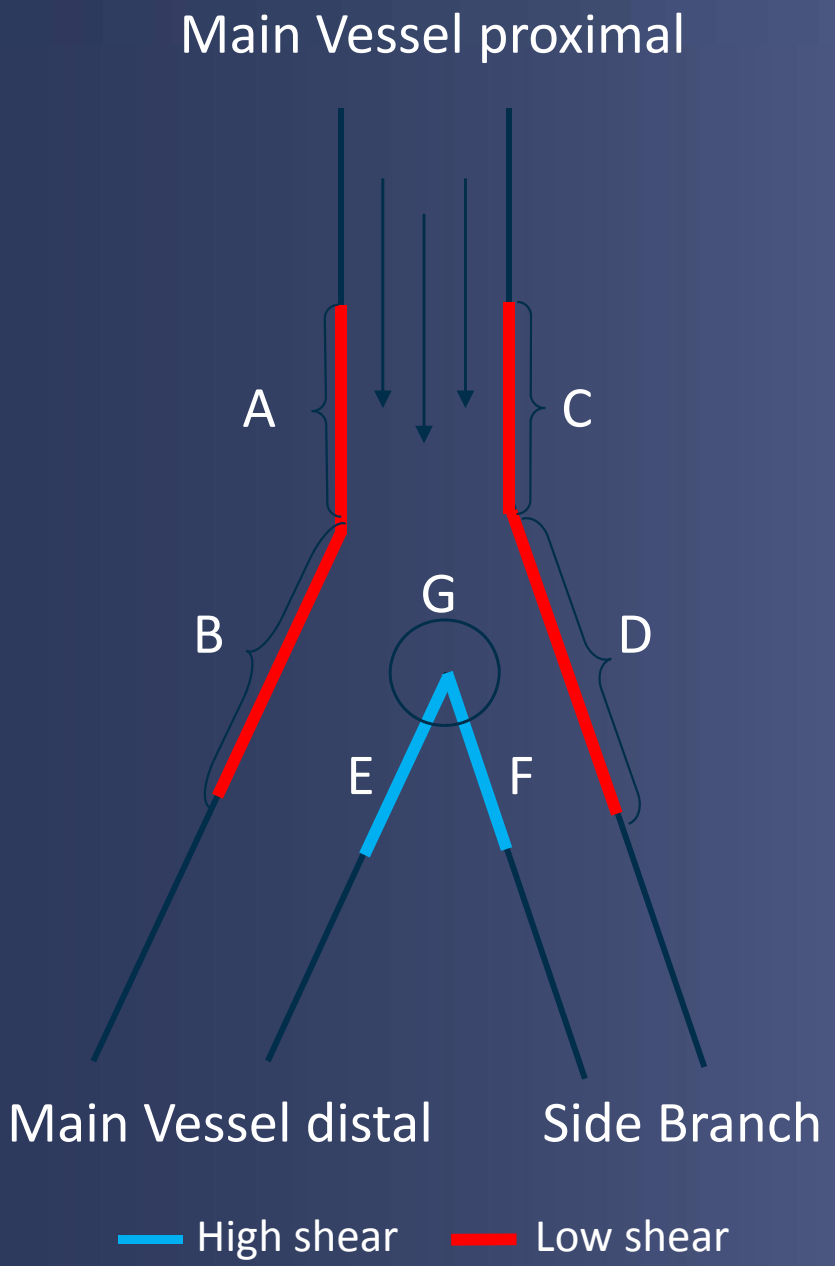
## LCX / LOM Bifurcation Lesion

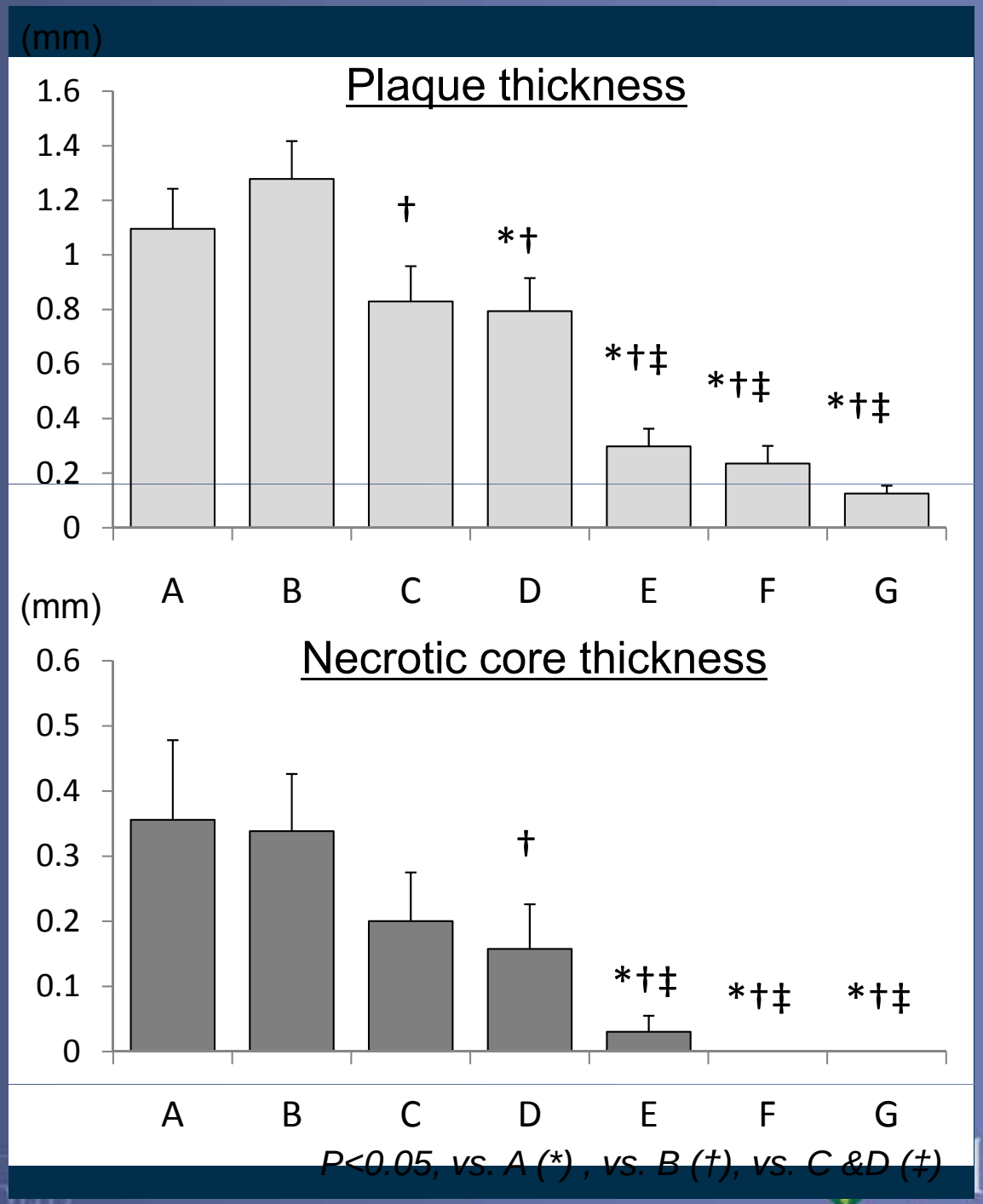


# Distribution of Coronary Plaques at Bifurcation Site




Nakazawa G, et al. *J Am CollCardiol.* 2010;55:1679-1687.

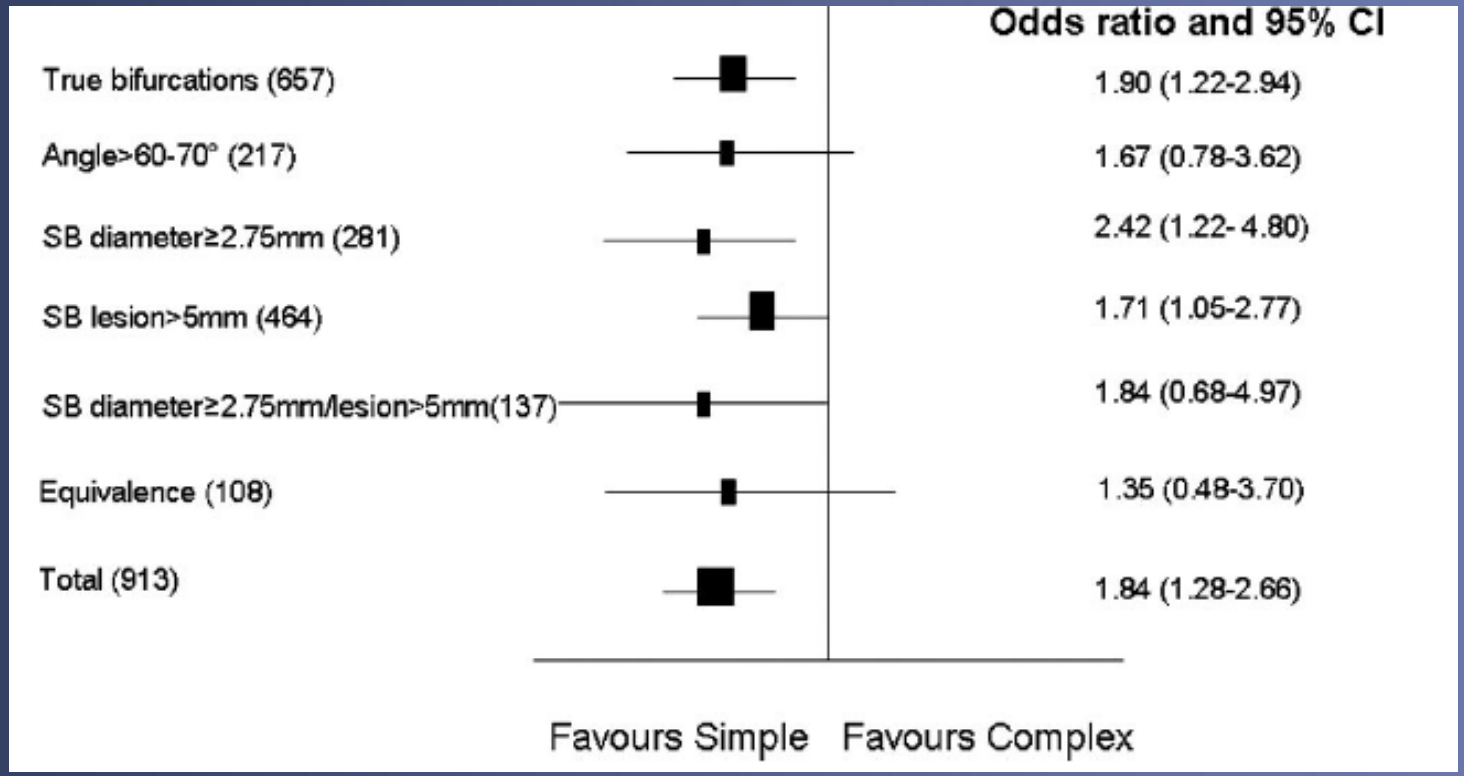
# Pooled Analysis of Provisional vs Complex Stenting Techniques: NORDIC, BBC1, CACTUS (N=1263)

| Outcomes 6-9 mo | Pooled Complex | Pooled Provisional | Pooled All |
|---|---|---|---|
| Death | 0.8% (5/633) | 0.6% (4/630) | 0.7% (9/1262) |
| Cardiac | 0.5% (2/383) | 0.5% (2/380) | 0.5% (4/763) |
| MI | 11% (47/427) | 5.4% (23/423) | 8.2% (70/850) |
| NQMI | 10.1% (56/553) | 5.0% (29/576) | 7.5% (85/1129) |
| QMI | 0.5% (1/206) | 0.0% (0/207) | 0.2% (1/413) |
| TLR | 3.8% (24/633) | 4.3% (27/630) | 4.0% (51/1263) |
| TVR | 4.4% (28/633) | 4.8% (30/630) | 4.6% (58/1263) |
| Stent Thrombosis | 1.3% (8/633) | 0.6% (4/630) | 1.0% (12/1263) |

# Simple or Complex Stenting for Bifurcation Coronary Lesions

## A Patient-Level Pooled-Analysis of the Nordic Bifurcation Study and the British Bifurcation Coronary Study

Miles W. Behan, DM, MRCP; Niels R. Holm, MD; Nicholas P. Curzen, PhD, FRCP; Andrejs Erglis, MD; Rodney H. Stables, MD, FRCP; Adam J. de Belder, MD, FRCP; Matti Niemelä, MD; Nina Cooter, MSc; Derek P. Chew, MPH, FRACP; Terje K. Steigen, MD; Keith G. Oldroyd, MD, FRCP; Jan S. Jensen, MD; Jens Flensted Lassen, MD; Leif Thuesen, MD; David Hildick-Smith, MD, FRCP




Behan et al, Circ CardioVasc Int 2011

# Provisional Stenting is the Default Treatment for Bifurcations Lesions

| Trial | Criteria for provisional stenting | Crossover rate(%) |
|---|---|---|
| CACTUS | Residual stenosis>50% or Type B dissection or TIMI 0-1 | 31% |
| BBK | Flow limiting dissection or Residual stenosis > 75% | 18.8% |
| Nordic Bifurcation | TIMI 0 | 4.3% |
| BBC ONE | TIMI0-2 or Residual stenosis>70% or Type A dissection | 3.0% |


Colombo A et al, Circulation 2009;119:71-78
Ferenc M et al, Eur Heart J 2008;29:2859-2867
Steigen TK, Erglis A et al Circulation 2006;114:1955-1961
Hildick-Smith D, Circulation 2010; 121:1235-1243

# Side Branch Compromise / Occlusion (TIMI 0) After Provisional Stenting of Bifurcation Lesions

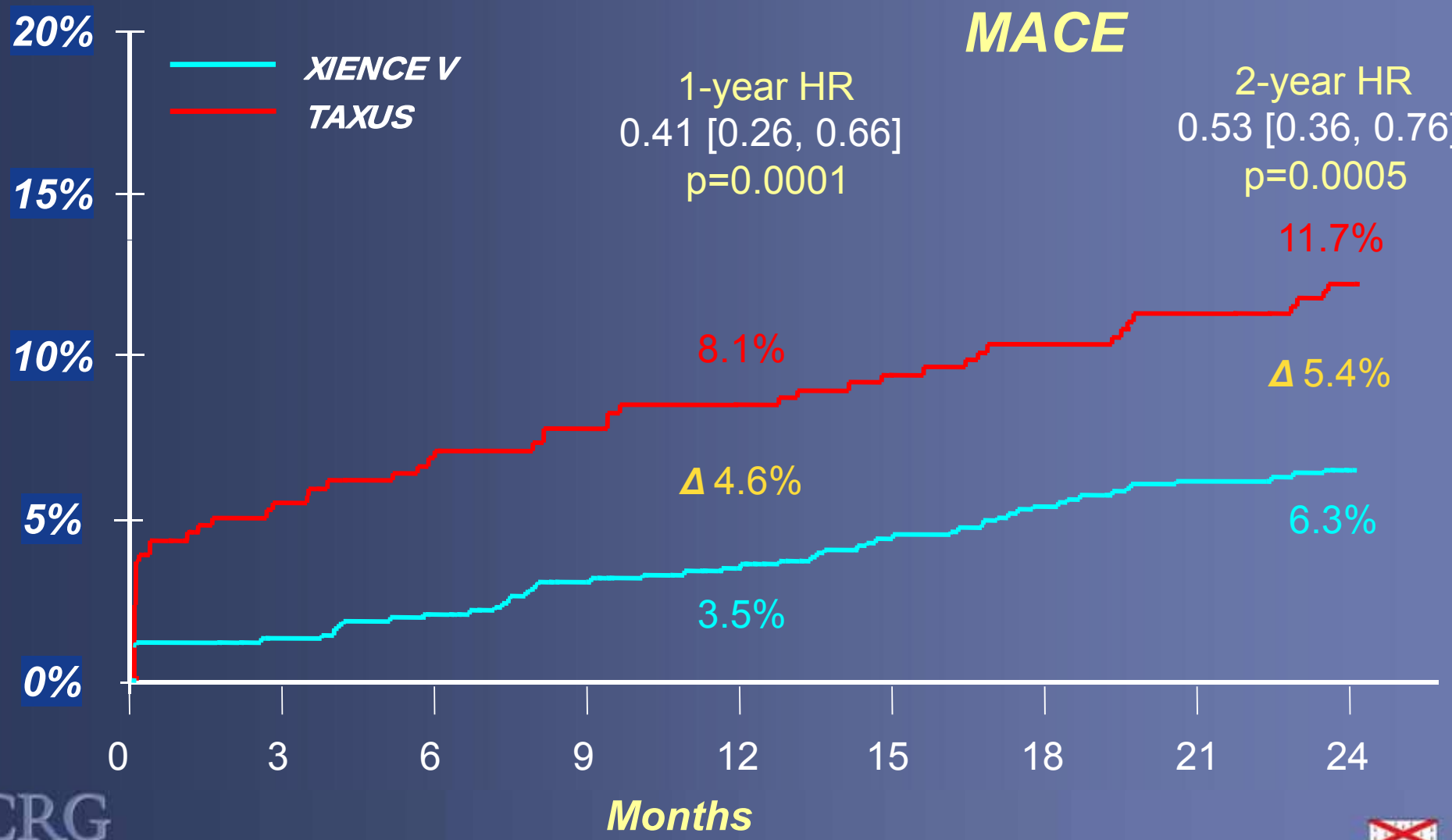
- Side branch occlusion (SBO) after PCI of bifurcation lesions is common (~ 3-20%) and is associated with increased incidence of non-Q wave MI.
- SBO occurs more often in complex bifurcations and increases with increasing severity of the side branch stenosis.

Poerner T et al. Circulation 2001
Blankenship J. et al, JACC 2001 CY
Cho et al, CCI 2001

# Side Branch Jailing: Stent Type Counts

SPIRIT IV: 38% overall SB Jailing , XIENCE V vs TAXUS (N=3690)

Included SB were <2 mm or ≥2 mm in diameter with an ostial stenosis ≤50%

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*Lansky et al. AJC 2013*

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# SPIRIT IV: Jailed Side Branch Clinical Outcomes at 2 Year

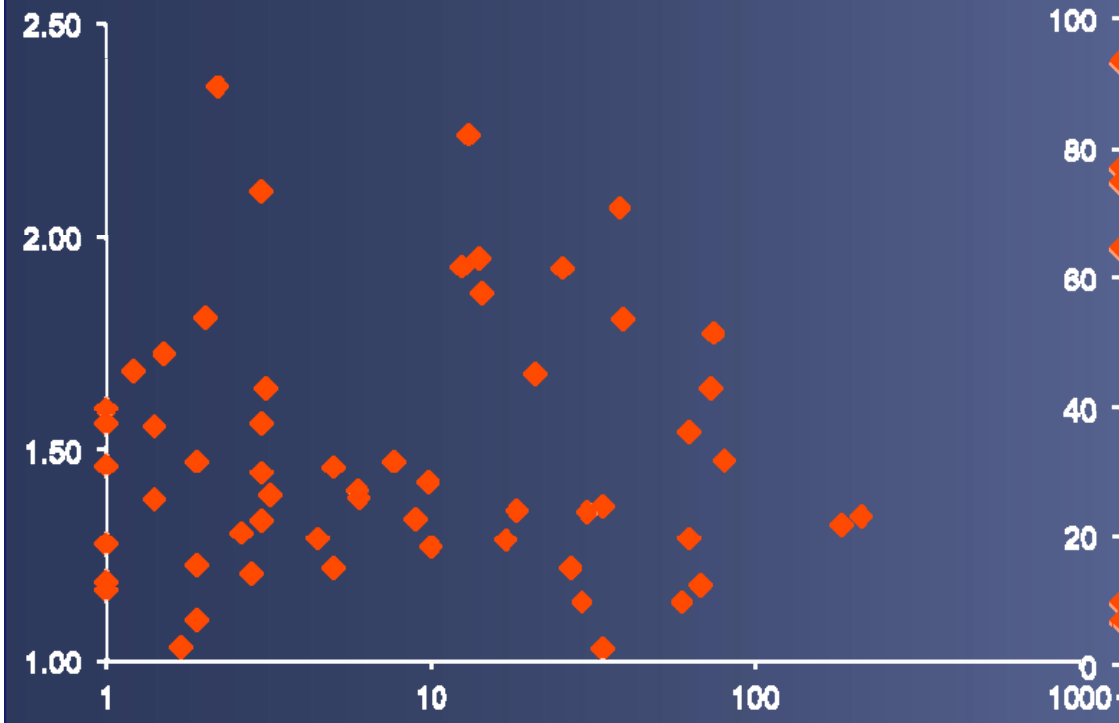
| | Target lesions with side branches | | |
|---|---|---|---|
| | XIENCE V (N=963) | TAXUS (N=463) | p-Value |
| TLF | 6.5% | 11.9% | 0.001 |
| Cardiac Death | 1.0% | 1.4% | 0.58 |
| TV-MI | 2.0% | 5.4% | 0.001 |
| ID-TLR | 4.1% | 7.9% | 0.004 |
| MACE | 6.6% | 12.2% | 0.0008 |
| Stent Thrombosis (ARC def/prob) | 0.6% | 2.8% | 0.001 |

*Lansky et al. AJC 2013*

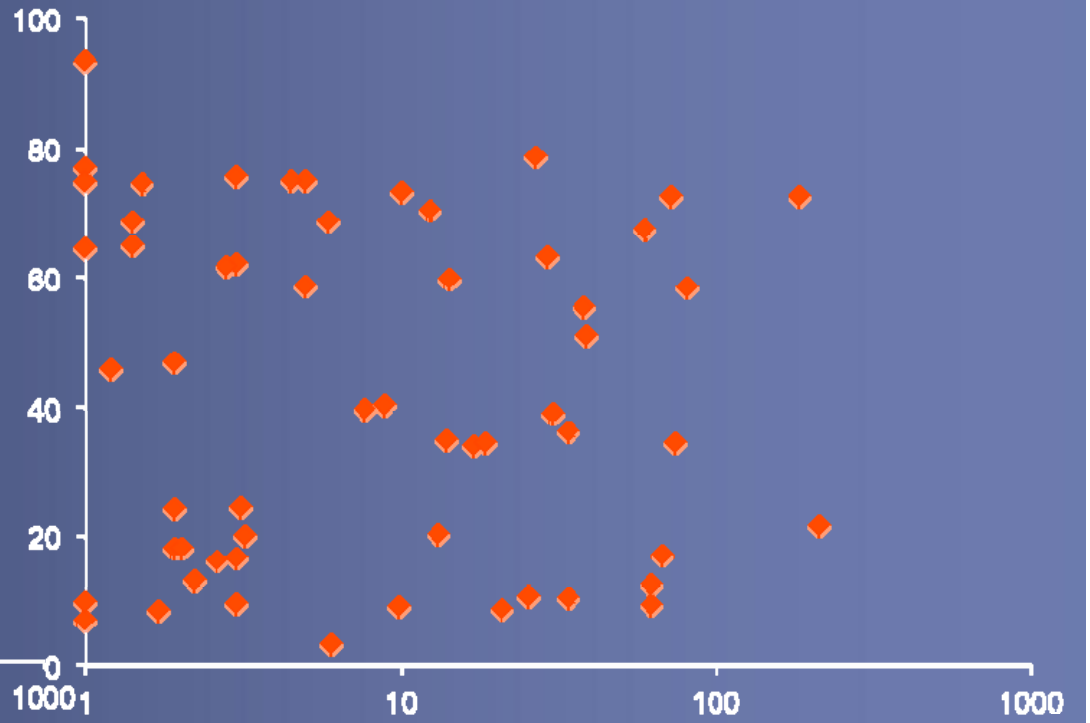
# *SPIRIT IV Jailed Side Branch Analysis:*

## No Side Branch Size or %DS threshold associated with CK MB release

**Side Branch Mean RVD**




**Baseline Max. SB % DS**




**Max. In-Hospital CK-MB**

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*Lansky et al. AJC 2013*

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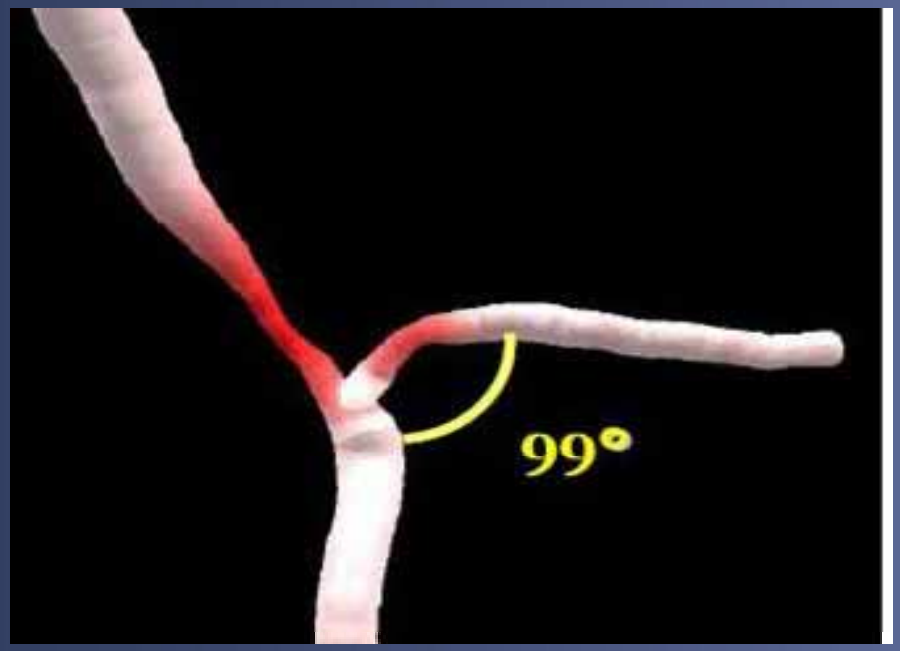
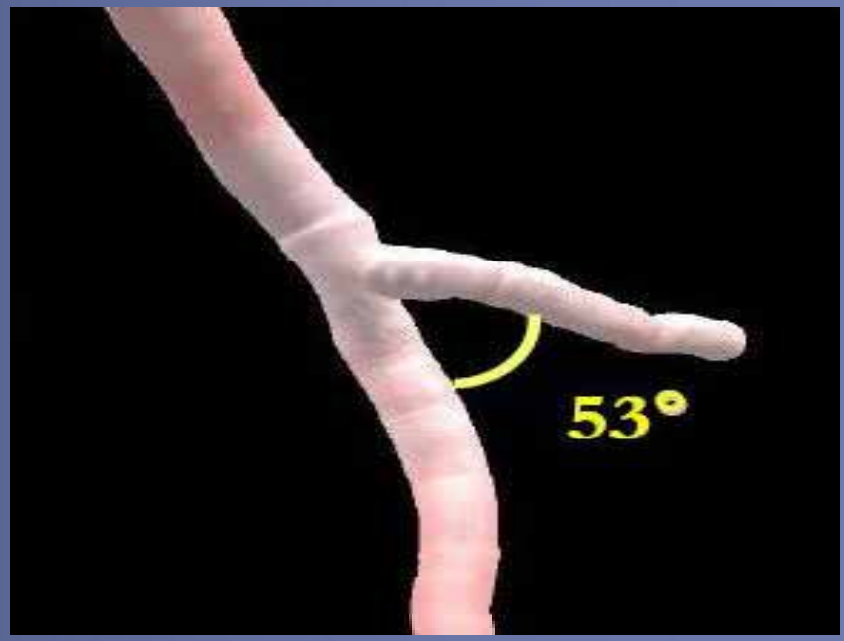
# Bifurcation Angle and Outcomes

| | *Wide or T* | *Narrow or Y* |
|---|---|---|
| |   |   |
| *SB access* | *More Difficult* | *Easier* |
| *Plaque shift* | *Less* | *More* |

# Angiographic Predictors of Procedural SB Occlusion with Crush Stenting

*Dzavik V et al. Am Heart J. 2006*

| | Occlusion | No occlusion | P |
|---|---|---|---|
| Patients (n) | 10 | 156 | - |
| Calcifications (%) | 0 | 16 | NS |
| Lesion eccentricity (%) | | | |
| Concentric | 0 | 12.9 | |
| Excentric IPSI | 80 | 49 | 0.143 |
| Excentric Contro | 20 | 38.1 | |
| Angle A (degree) | 140 ± 19 | 137 ± 26 | NS |
| Angle B (degree) | 42 ± 22 | 60 ± 22 | 0.033 |
| Stenosis main branch (%) | 58 ± 10 | 62 ± 12 | NS |
| side branch (%) | 46 ± 20 | 38 ± 21 | NS |

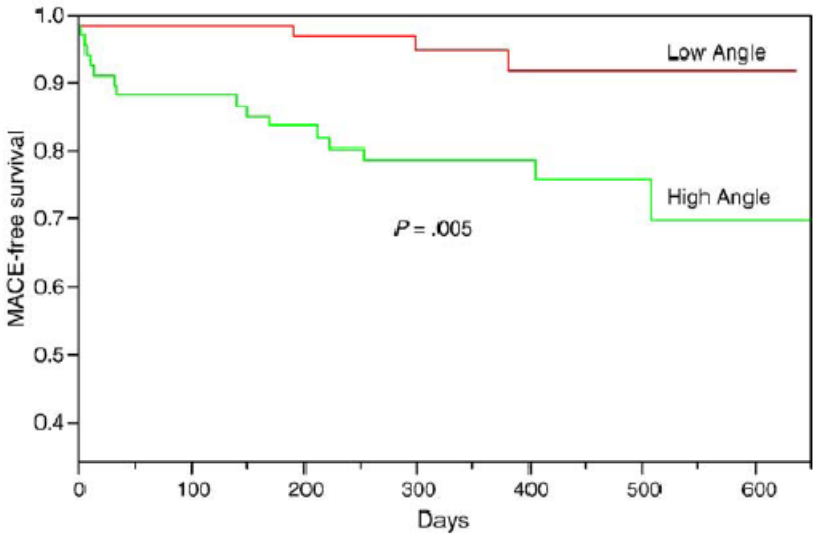
# Greater Bifurcation Angle associated with higher mortality and MACE with Crush Stenting

133 pts undergoing crush stenting:

- 66 pts with low angle (<50 degrees)
- 67 pts with high angle (>50 degrees)

**MACE**

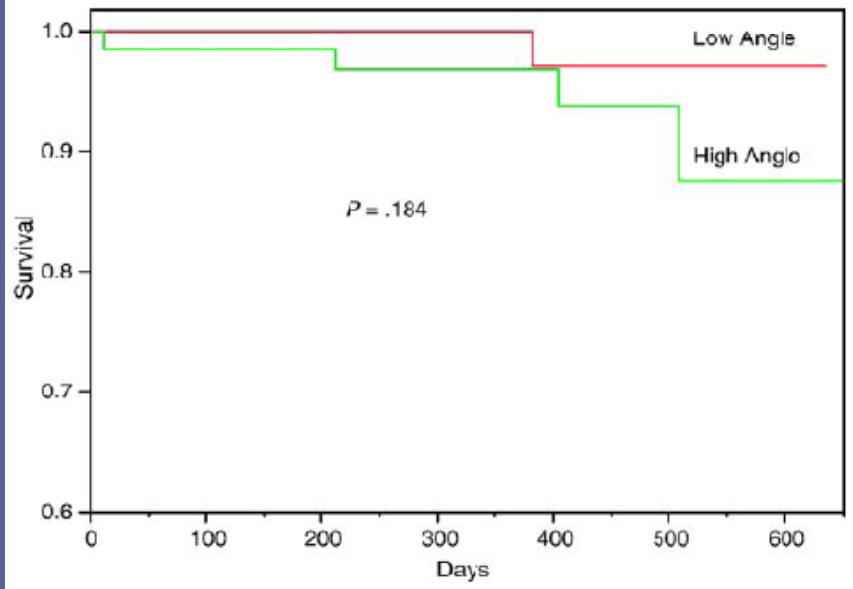
**Figure 3**




Kaplan-Meier plot comparing MACE-free survival up to 648 days between the low-angle group (BA <50° and high-angle group (BA ≥50°).

**Survival**

**Figure 4**




A Kaplan-Meier plot indicating survival up to 648 days in the low-angle (BA <50°) and high-angle group (BA ≥50°).

*Dzavik V et al. Am Heart J. 2006*

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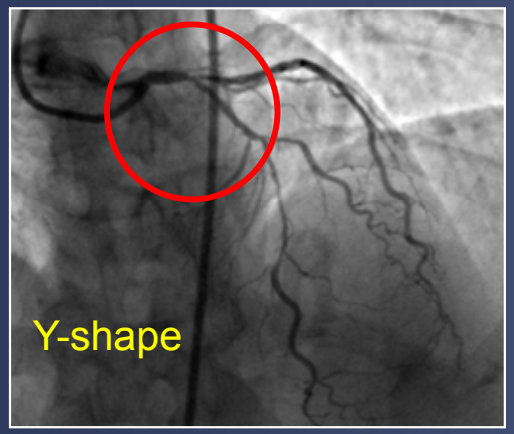
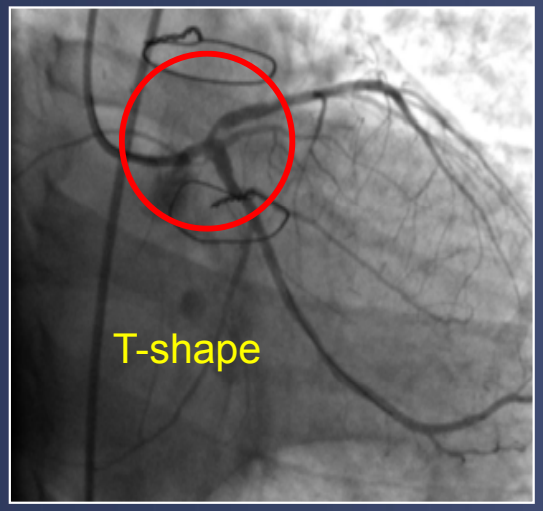
# French Left Main Taxus Registry

## Role of Bifurcation Angle following Provisional T in 92%




## Role of Bifurcation Angle

| 2-years FU | Y-Shape (137) | T-Shape (84) | *P value* |
|---|---|---|---|
| Stent thrombosis* (%) | 0 | 2.3 | <0.05 |
| TVR (%) | 8.7 | 8.3 | 0.41 |
| Cardiac death (%) | 2.9 | 9.5 | 0.021 |
| Death (%) | 4.4 | 17.8 | 0.001 |

- **Definite and probable stent thrombosis according to ARC definition**
- **T shaped bifurcation was an independent predictor of Death at 2 years**

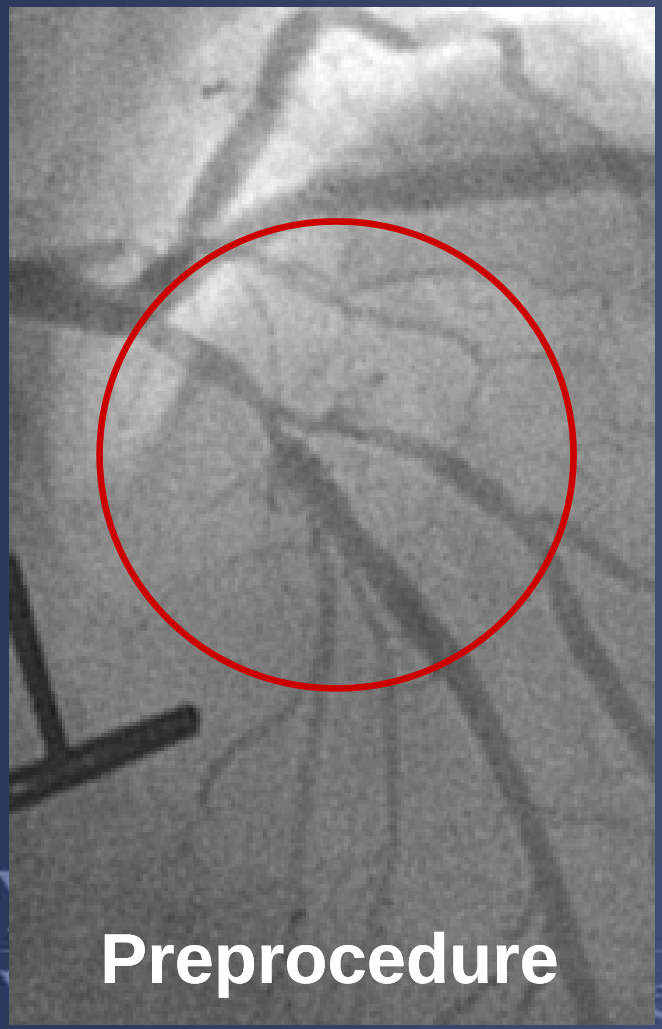
# Increasing distal angle predicts restenosis after Cullotte Stenting

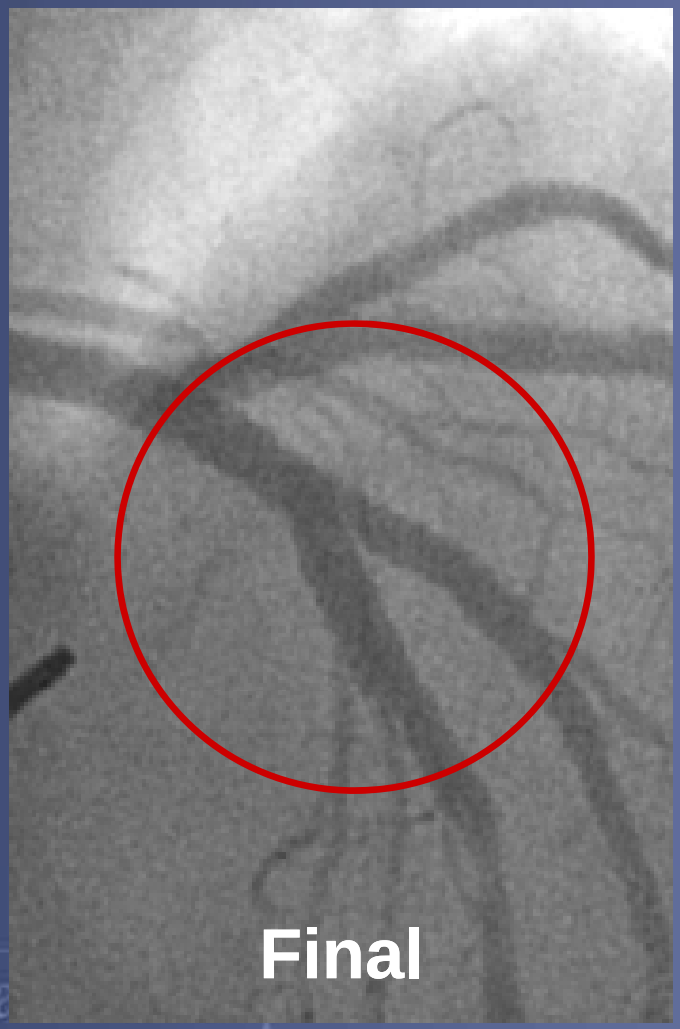
| Independent predictors of binary restenosis | Odds ratio (95% CI) | p value |
|---|---|---|
| Age (increase of 10 years) | 2.38 (1.21-4.96) | 0.01 |
| Bifurcation angle (increase of 10˚) | 1.53 (1.04-2.23) | 0.03 |
| Baseline main vessel DS (increase of 10%) | 1.47 (1.03-2.09) | 0.03 |
| SB ref. vessel diameter (decrease by 1mm) | 31.83 (1.71-592.77) | 0.02 |
| Kissing balloon post-dilatation | 0.37 (0.13-1.10) | 0.07 |

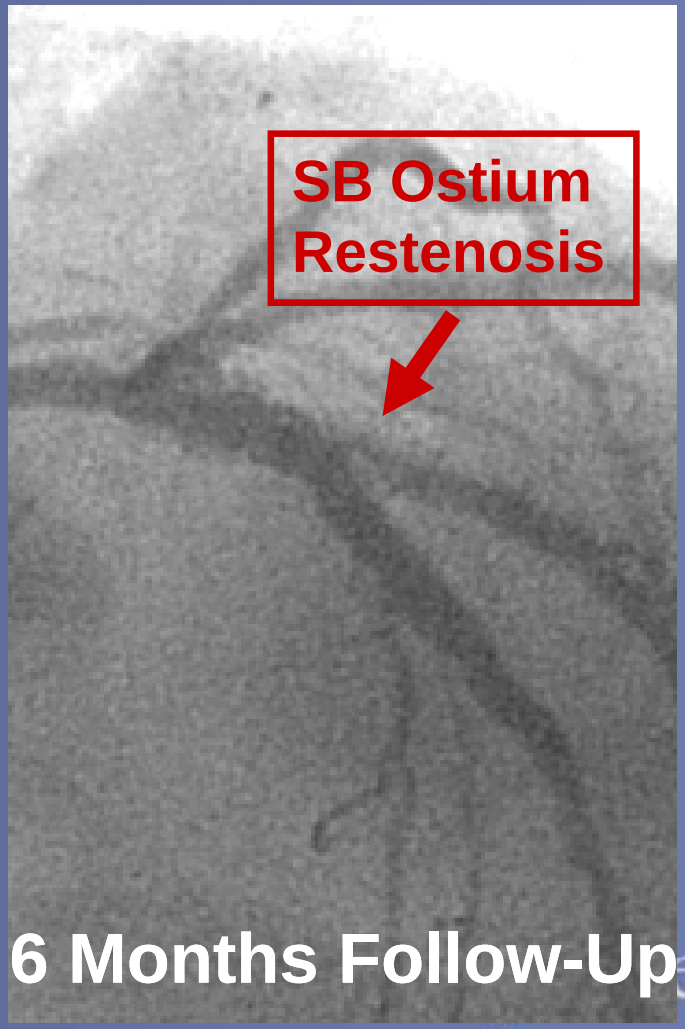
*Adriaenssens EHJ 2008*

# Anatomy and Long Term Outcomes

## After Bifurcation PCI…A preponderance of Restenosis occurs in the SB Ostium

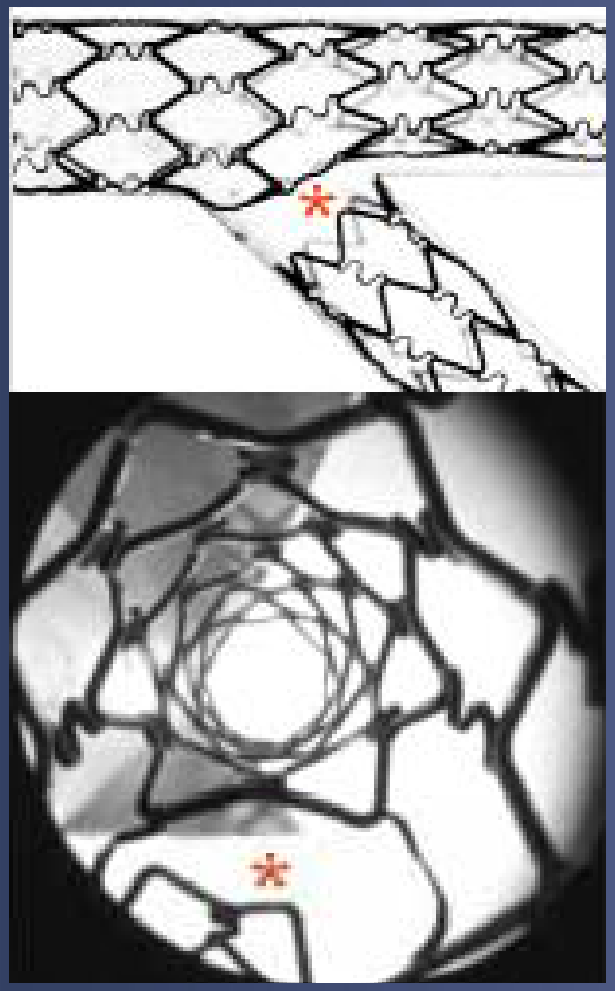

Preprocedure


Final

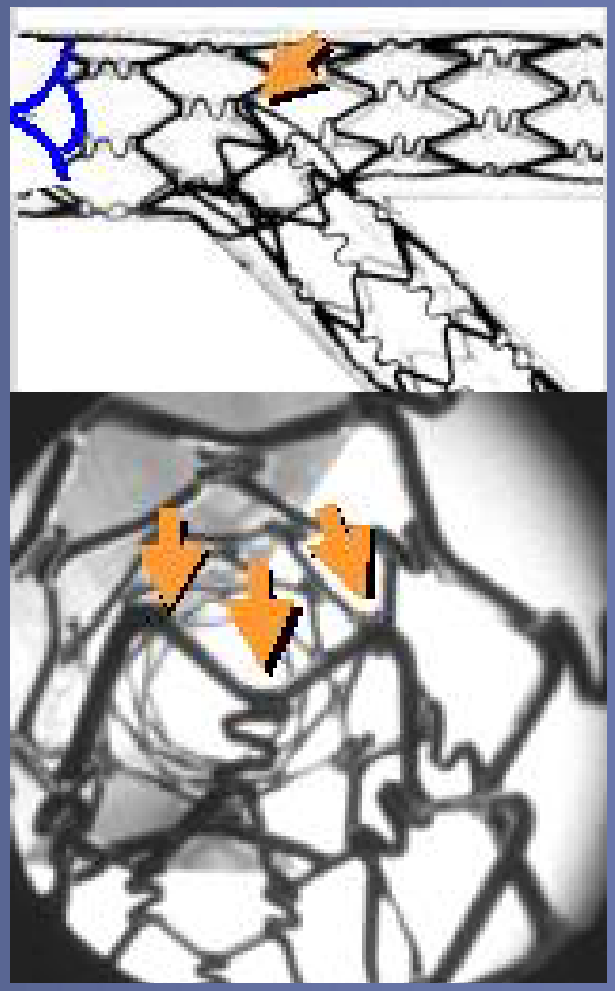


6 Months Follow-Up

# Identifiable factors so far

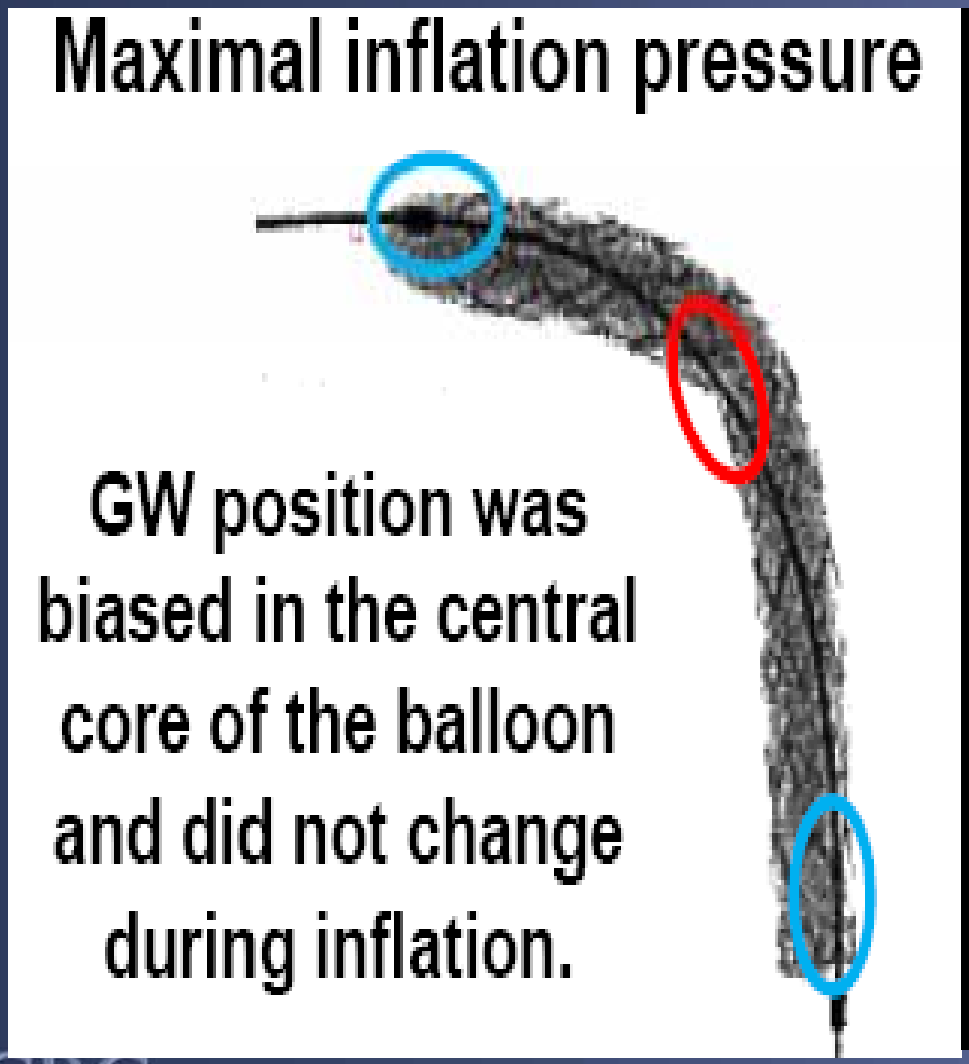


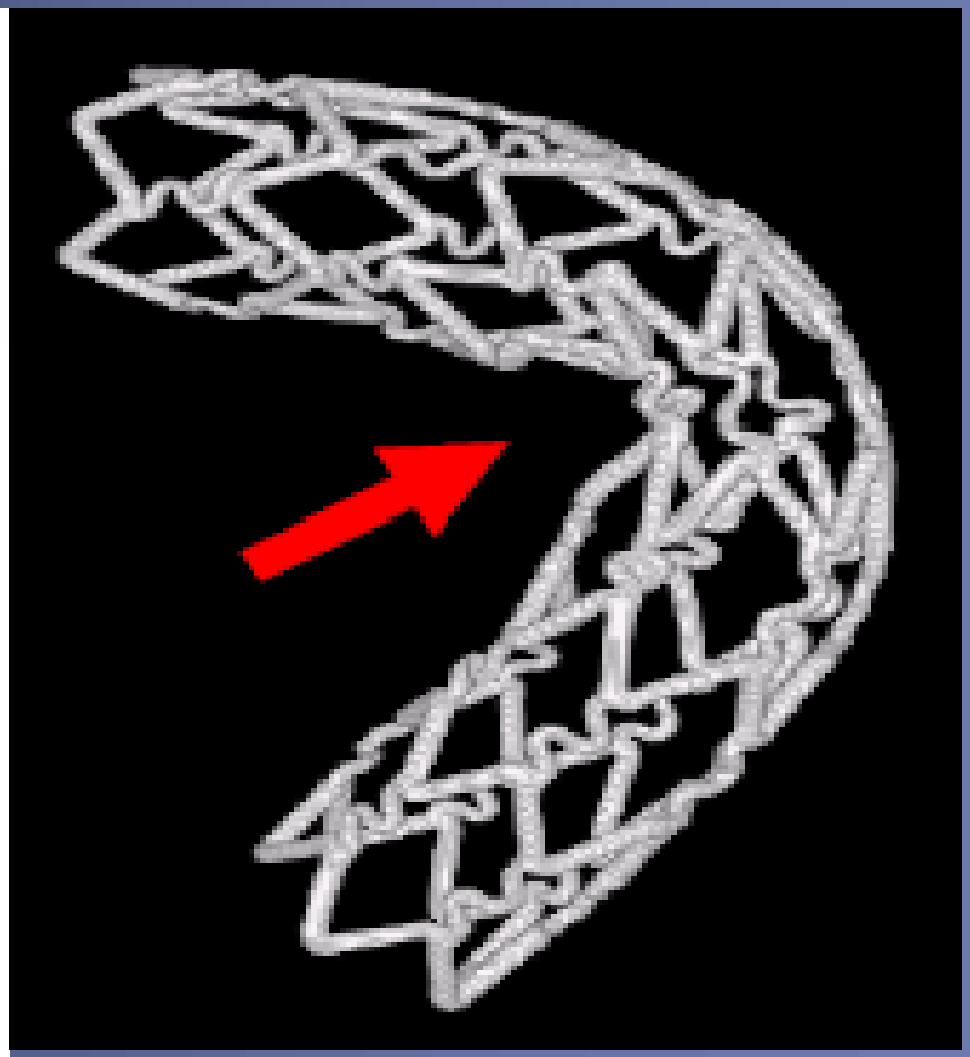
*Stent Gap*



*Stent Underexpansion*

# Stents Don't Like Large Bends Under expansion and deformation



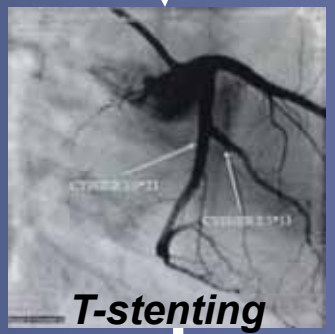
*Ormiston CCVI 2004*
*Murasato CCVI 2007*

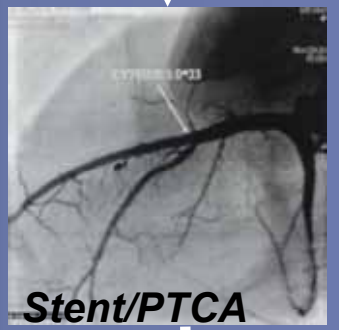
# Insights from Preclinical Evaluation

## Design

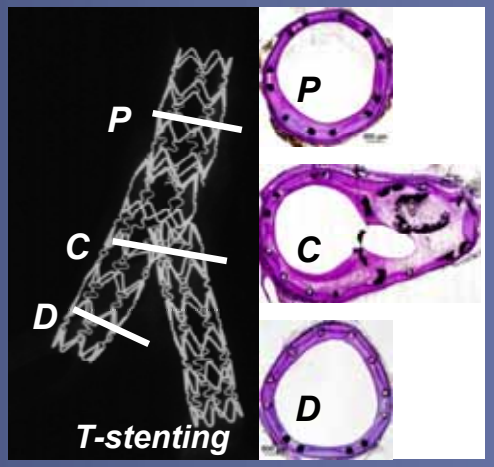
- **DESIGN:** Prospective, non-randomized, single-arm, preclinical evaluation
- **OBJECTIVE:** to evaluate the coronary arterial response to T-stenting with two DES versus one DES in the main vessel and side branch balloon angioplasty.
- Sirolimus-eluting stents (Cypher, Cordis, Miami Lakes, Florida) were used for this study

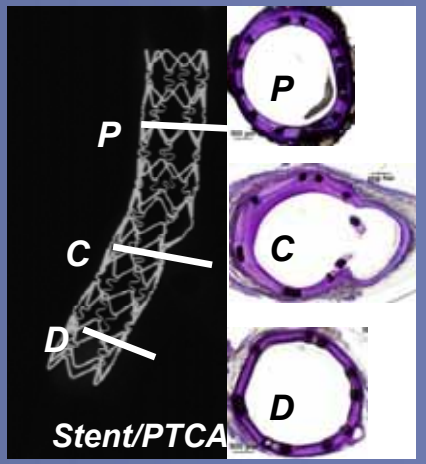
**15 purpose-bred sheep were enrolled**




**After 6 months, the proximal, carina and distal segments of the bifurcation underwent radiographic and histologic evaluation**




*Seung-Jin Oh, TCT 2013*

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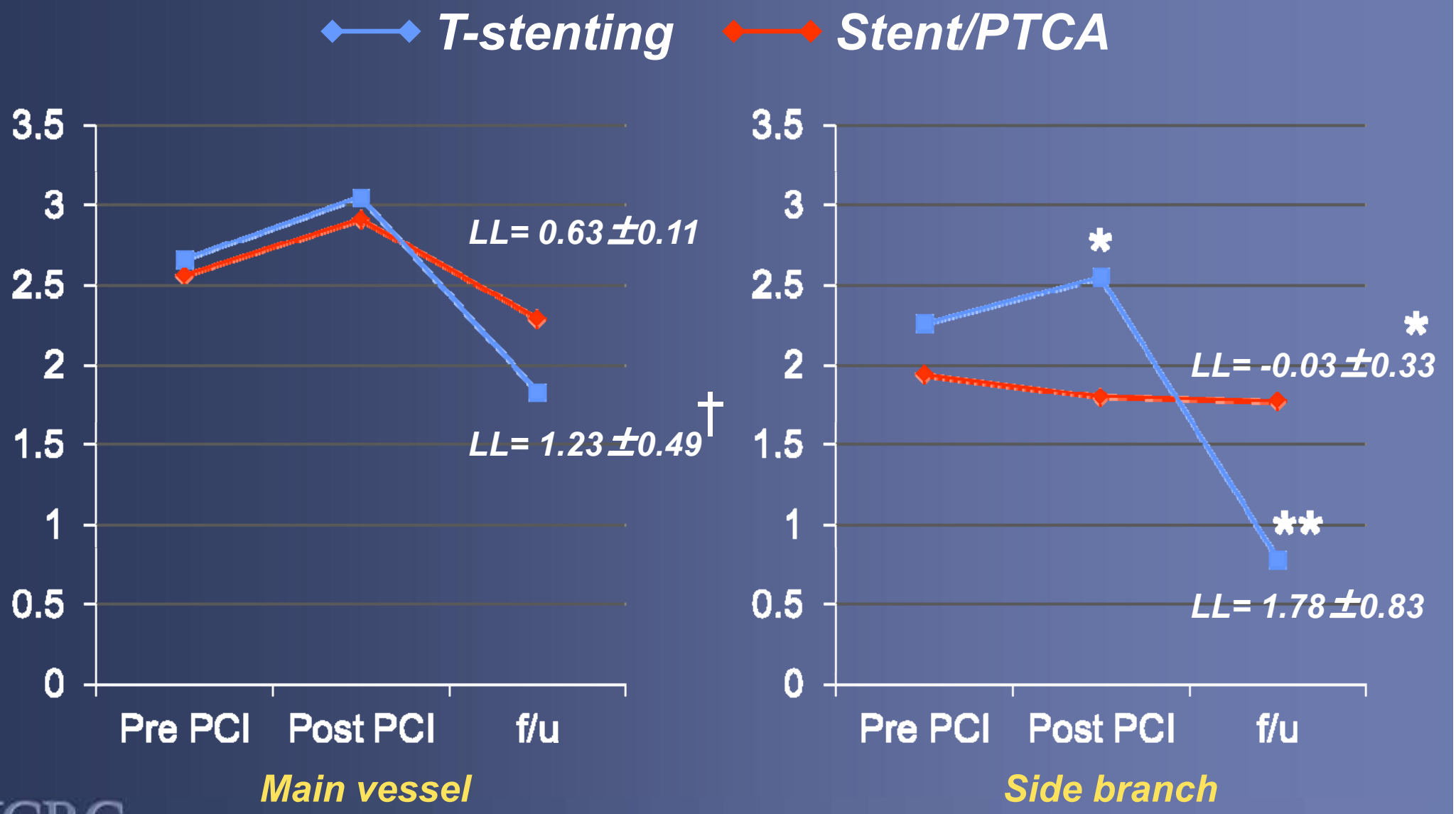
# Change of MLD (LLL)

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*: P < 0.001 **: P < 0.01 †: P = 0.01

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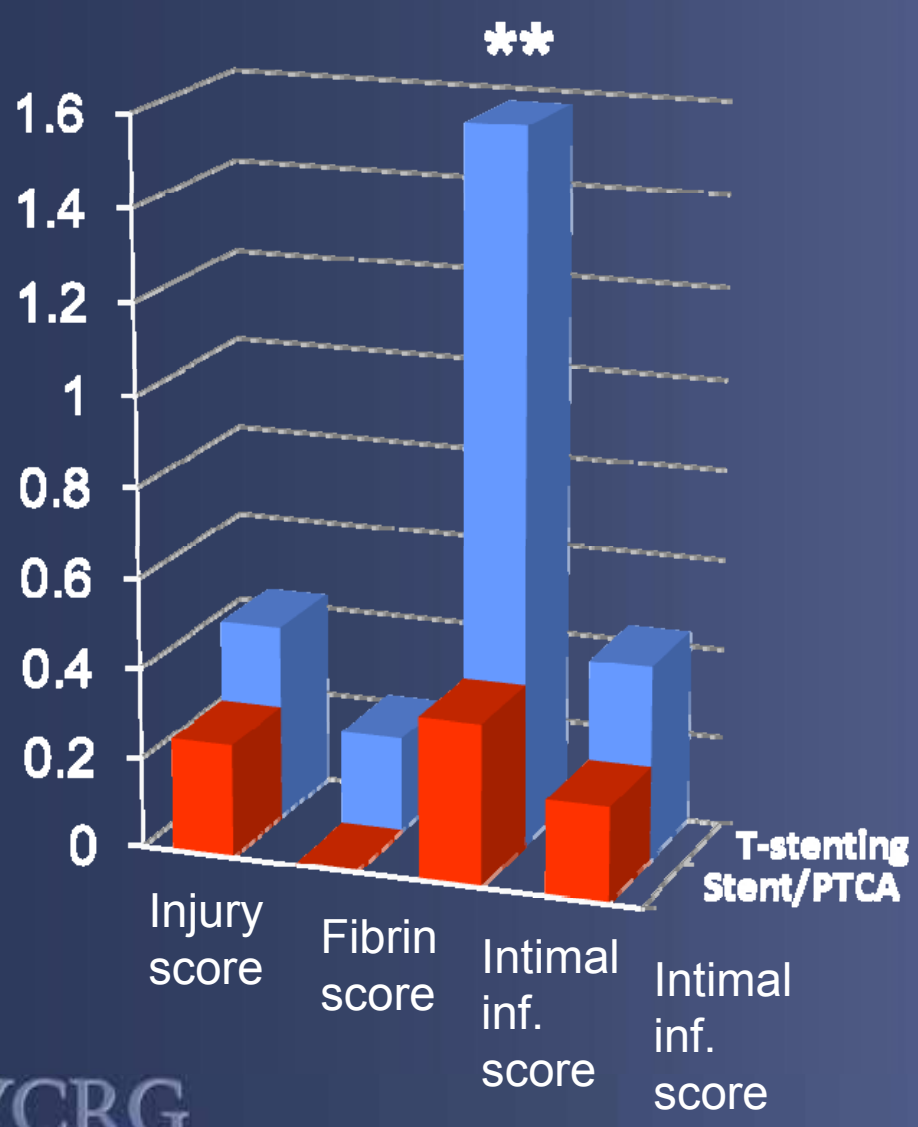
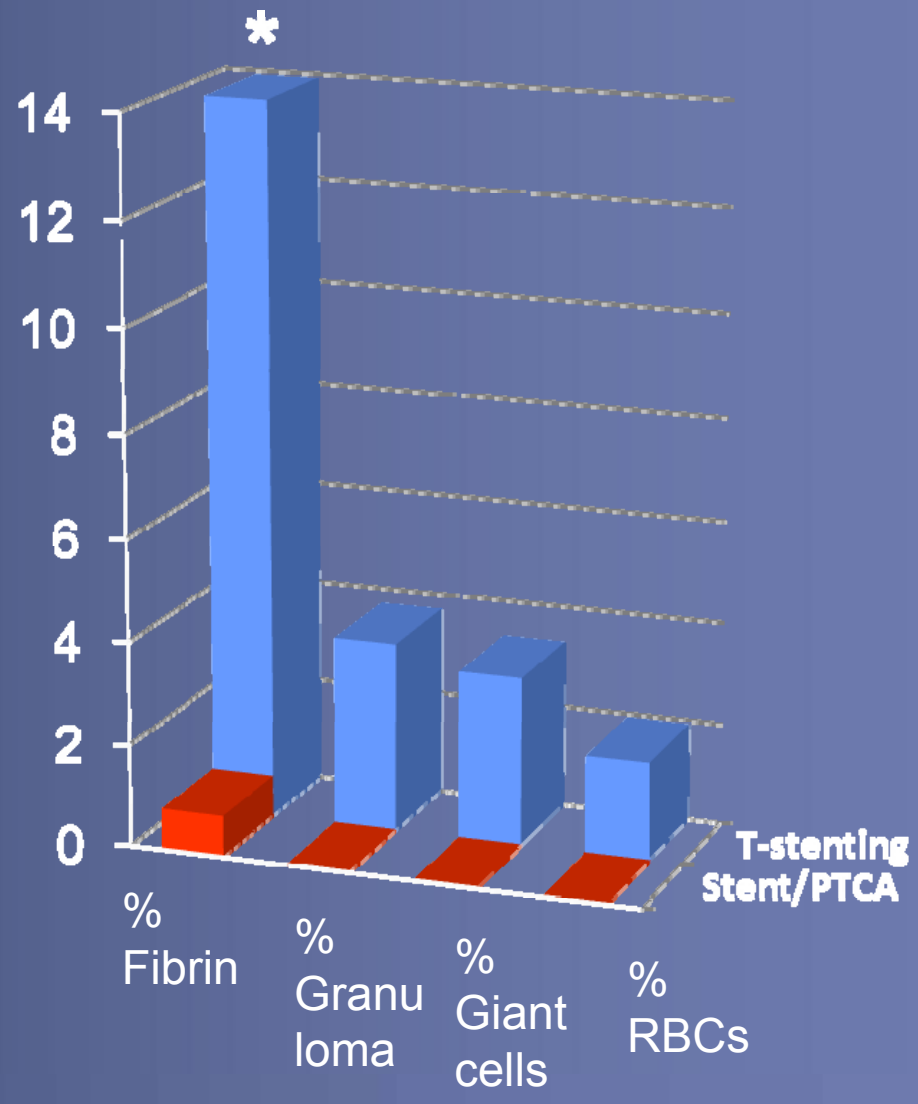
# Histological analysis

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*: P < 0.01 **: P < 0.05

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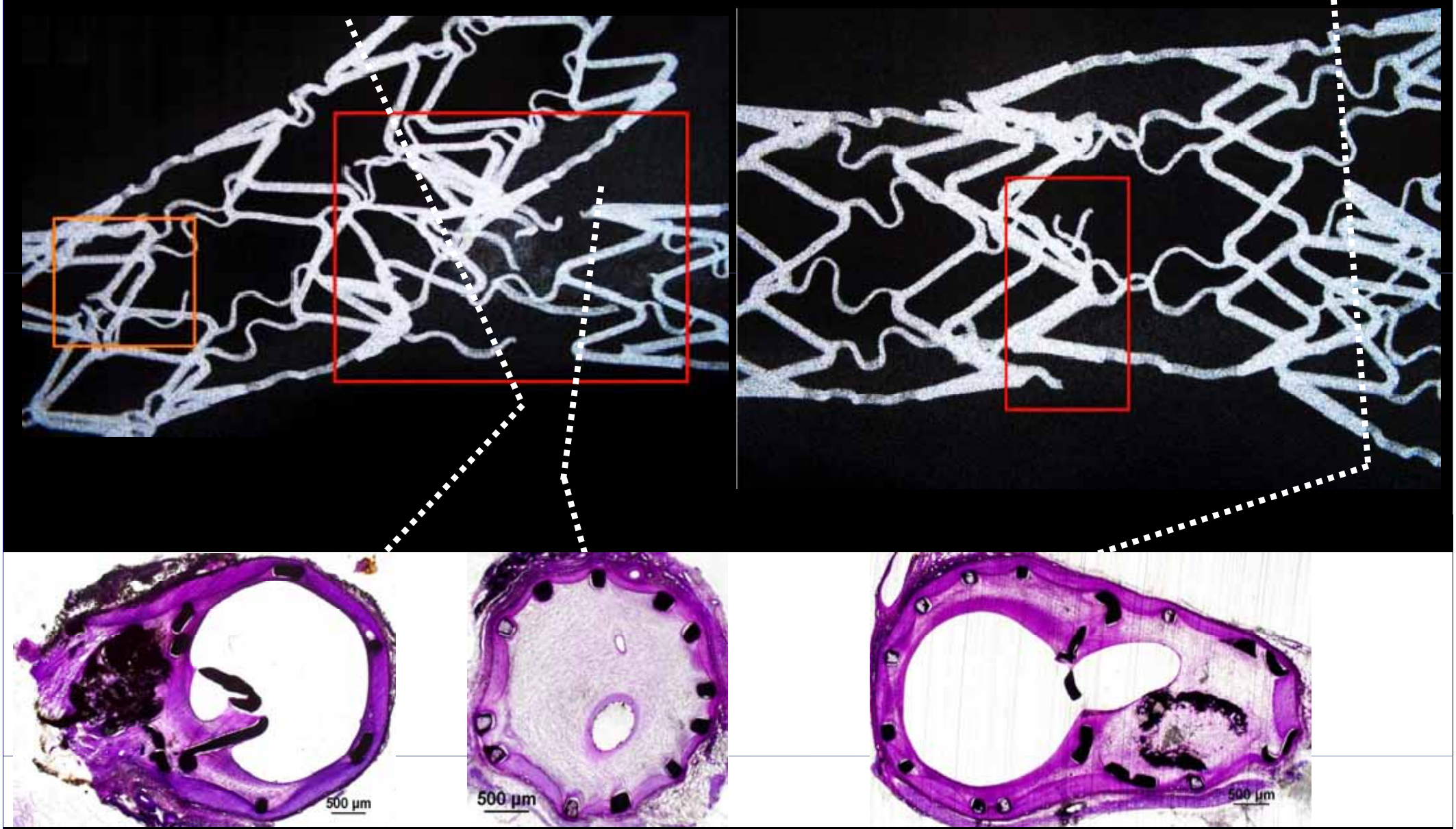
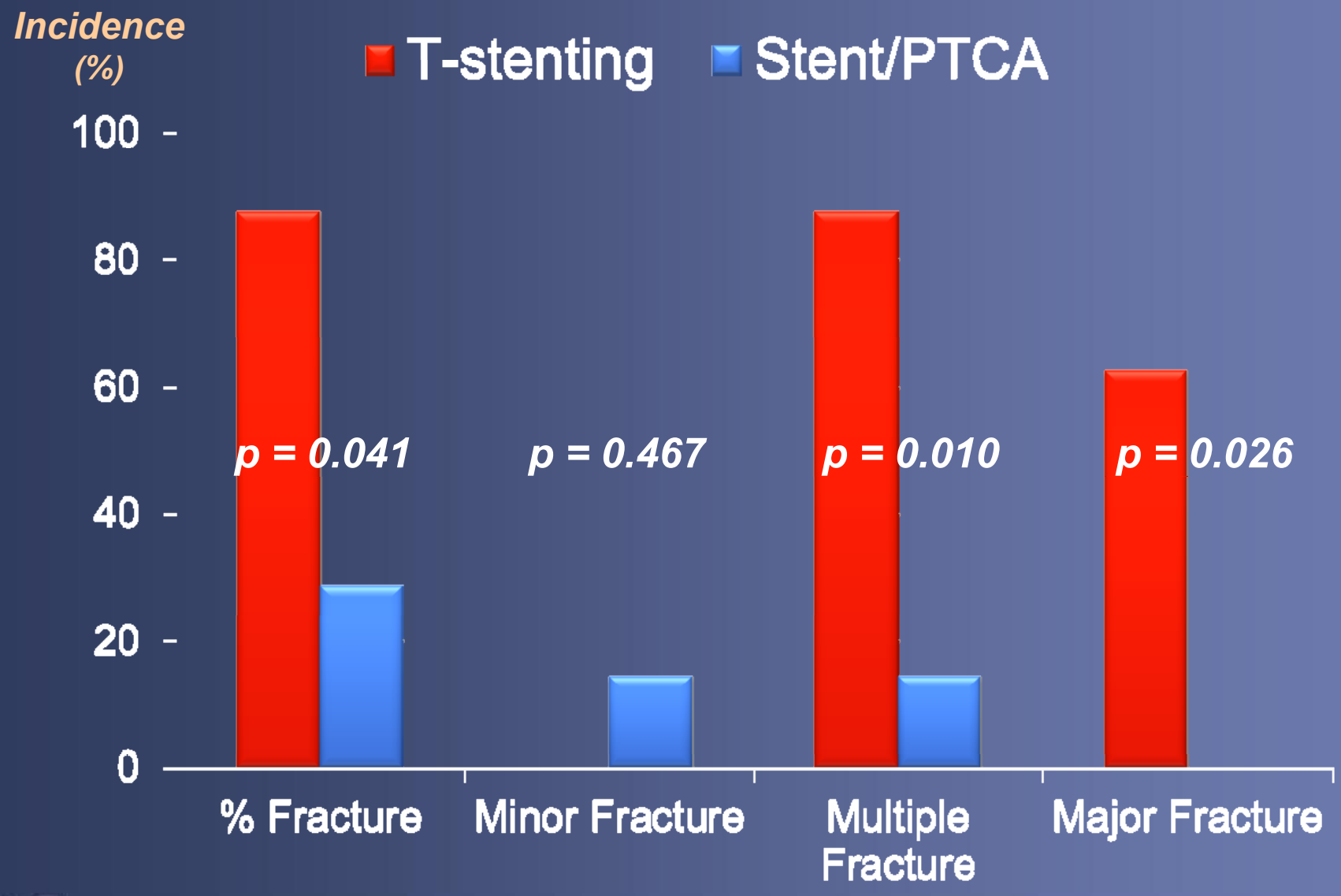
# Stent Fracture in T-stenting



# Stent fracture

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# Take Home

- Provisional stenting is the current default approach
  - Up to 20% SB compromise predicted by more severe SB dz
  - SBO increases peri-procedural MI
- Side Branch Jailing occurs in 25-38% of cases after elective main vessel stenting
  - Increases peri-procedural MI (x4) and ST
  - Stent selection is important favoring 2nd and 3rd Gen DES
- 2 stent technique associated with worse results
  - Lesion asymmetry and angulation
  - Stent underexpansion and fracture
  - Avoid ostial gaps
  - Need dedicated bifurcation stent

# Anatomy is everything in Bifurcations

- Predicts short and long term outcomes
- Disease burden (SYNTAX >33): CABG
- Side branch disease increases occlusion risk and periprocedural MI with provisional stenting
- Wide angles more likely to distort stent with underexpansion or fracture (more RS)
- Need dedicated stents for complex bifurcation