Why Does Stent Platform Matter to Perform a Good PCI

HS (Hyo-Soo) Kim
MD/PhD/FAHA

Cardiovascular Center,
Seoul National University Hospital,
Seoul, Korea

Evolution of PCI
Historical Perspective

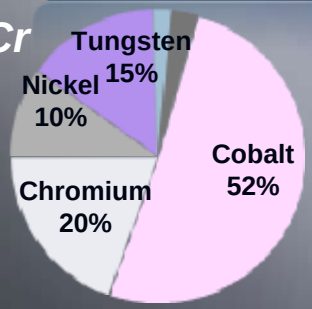
1977	1987	2003
POBA	BMS	DES
“Getting Artery Open”	“Keeping Artery Open”	“Decrease Restenosis”
Acute closure ~50% restenosis rates	~30% restenosis rates	~5% restenosis rates

Current generation DES

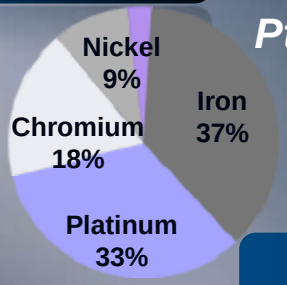
5 Key Design Factors continue to Evolve

Stent Design Alloys

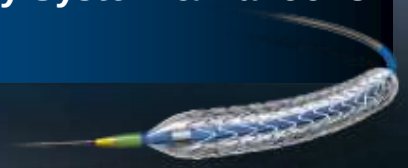
CoCr



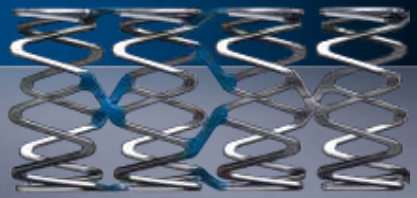
PtCr



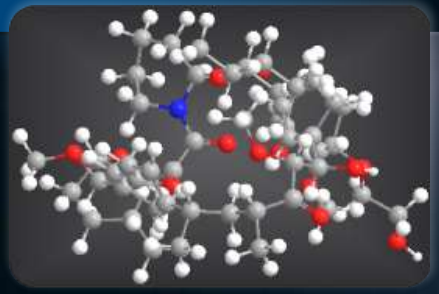
Delivery System & Balloons



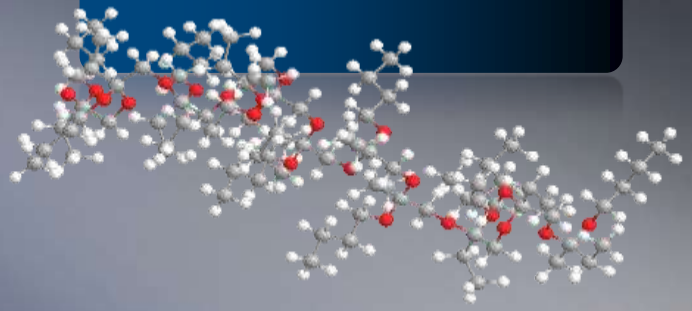
Stent Design Architecture



Drug



Polymer Carrier



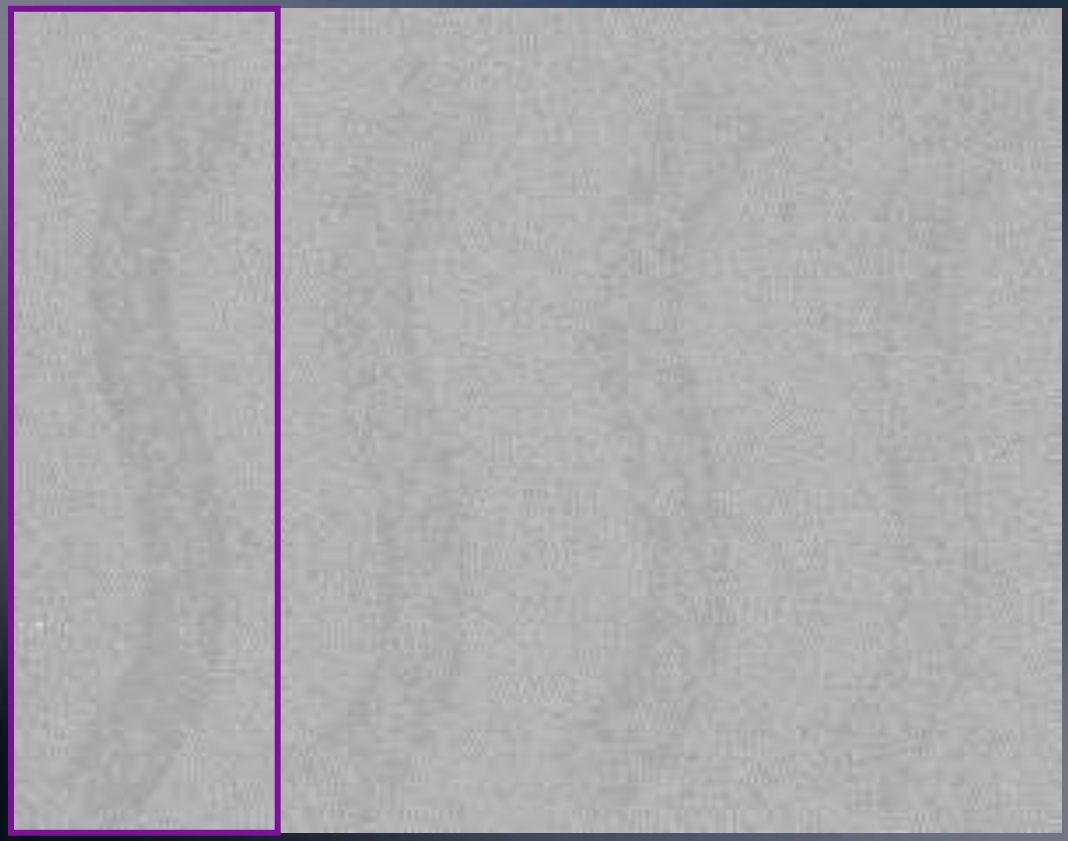
Modified from presentation at TCT

Stent Materials Are NOT the Same!

	Drug	Stent	Strut Thickness	Polymer	Polymer Thickness
Cypher	Sirolimus	Stainless steel	140 μm	PEVA/PBMA	13.7 μm
Taxus	Paclitaxel	Stainless steel	97 μm	SIBS	17.8 μm
Endeavor	Zotarolimus	Cobalt Nickel	91 μm	Biolinx	4.8 μm
Xience	Everolimus	Cobalt Chromium	81 μm	PVDF	7.8 μm
Promus	Everolimus	Platinum Chromium	81 μm	PVDF	8 μm
Resolute	Zotarolimus	Cobalt Chromium	89 μm	Biolinx	6 μm
Biomatrix	Biolimus A9	Stainless Steal	120 μm	PDLLA	10 μm
Osiro	Sirolimus	Cobalt Chromium	60 μm	PLLA	7 μm
SYNERGY	Everolimus	Platinum Chromium	74 μm	PLGA	8 μm

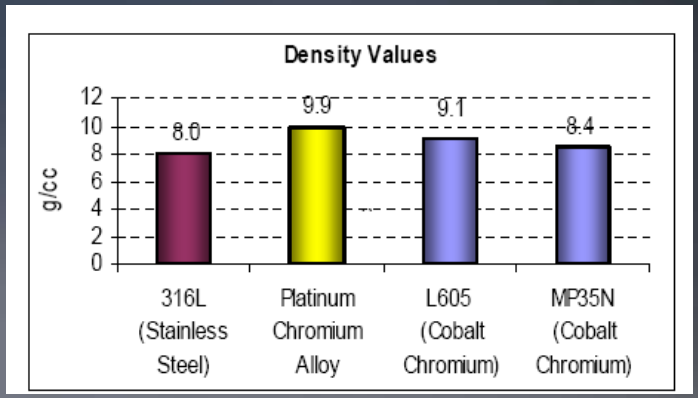
Platinum Chromium Alloy[1]
Enhanced Visibility

Visibility Bench Test Comparison



PtCr PROMUS Element Stent 0.0032”	CoCr Xience V® Stent 0.0032”	CoCr Xience Prime™ Stent 0.0032”	CoNi Endeavor™ Stent 0.0036”

The properties of PtCr alloy provide stent designers greater flexibility to reduce thickness without comromising radiopacity



1. Data on file at Boston Scientific. Based on 2.50 mm stents. Copper phantom to simulate body mass. Photographs taken by Boston Scientific. Bench test results may not necessarily be indicative of clinical performance.
Images taken by Boston Scientific. 2.50 mm stents.

Evolution of Stent Alloy

1994
Introduction of Stainless Steel

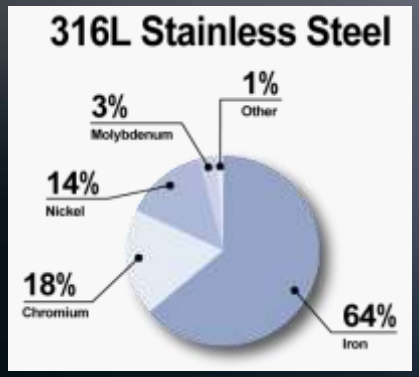
- Enables thinner struts
- Retains radial strength
- Minimizes recoil
- Poor visibility

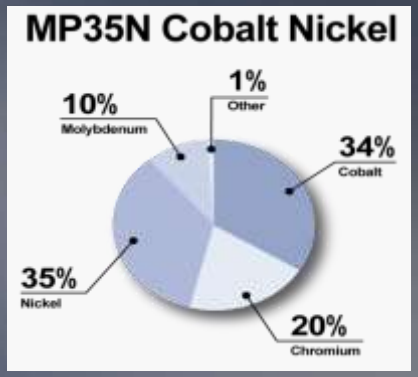
2003
Introduction of Cobalt Chromium and Cobalt Nickel

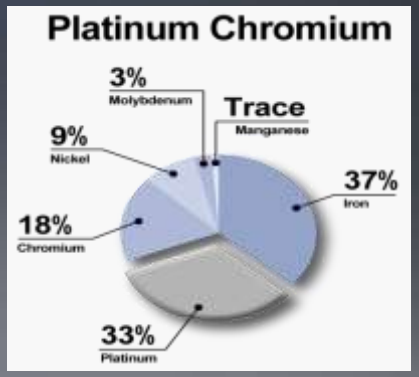
- Enables thinner struts
- Improved visibility
- Poor radial strength
- Prone to recoil

2009
Introduction of Platinum Chromium

- Enables thinner struts
- Outstanding visibility
- Good radial strength
- Lowest recoil



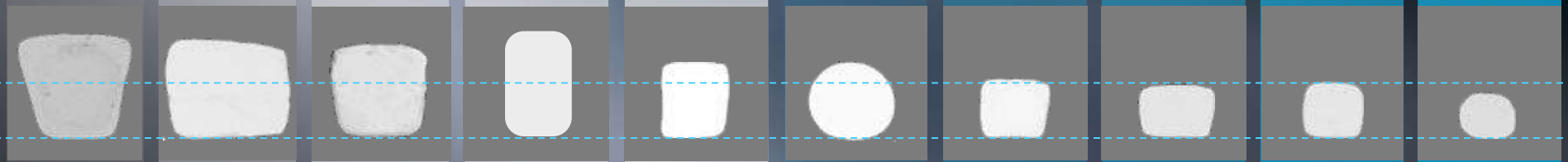




Strut Thickness

Stent Evolution

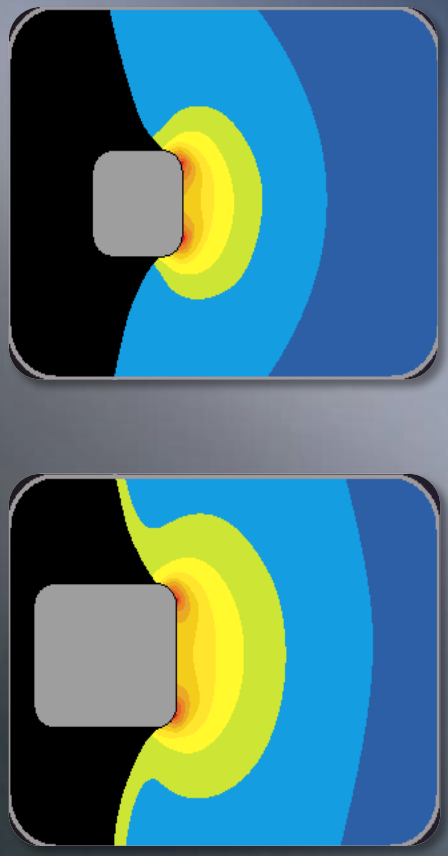
Improved healing. Thinner struts.



Cypher™ Stent	Nobori™ Stent	Biomatrix™ Stent	Express™ Stent	Liberté™ Stent	Endeavor™ Stent	XIENCE V™ Stent	XIENCE™ Prime™ Stent	Element™ Stent	Synergy™ Stent
Bx Velocity™ Stent **0.140 mm** (0.0055") Stainless Steel	Nobori™ Stent **0.124 mm** Stainless Steel	Biomatrix™ Stent **0.120 mm** Stainless Steel	Express™ Stent **0.132 mm** (0.0052") Stainless Steel	Liberté™ Stent **0.096 mm** (0.0038") Stainless Steel	Driver™ Stent **0.091 mm** (0.0036") Cobalt Chromium	Multi-Link Vision™ Stent 0 **.081 mm** (0.0032") Cobalt Chromium	XIENCE Prime™ Stent **0.081 mm** (0.0032") Cobalt Chromium	Element™ Stent **0.081 mm** (0.0032") Platinum Chromium	Synergy™ Stent **0.074mm** (0.0029") Platinum Chromium

This material is not intended for use in the US or Japan. Please see glossary.

Thicker Struts and Restenosis



ISAR STEREO[1]

6 month binary restenosis

- Thin, Binary Restenosis (6 months), 15%
- Thick, Binary Restenosis (6 months), 26%

ISAR STEREO[2]

6 month binary restenosis

- Thin, Binary Restenosis (6 months), 18%
- Thick, Binary Restenosis (6 months), 31%

[1]ISAR STEREO II JACC Vol. 41, No. 8, 2003 April 16, 2003:1283-8. [2]ISAR STEREO I Circulation June 12, 2001

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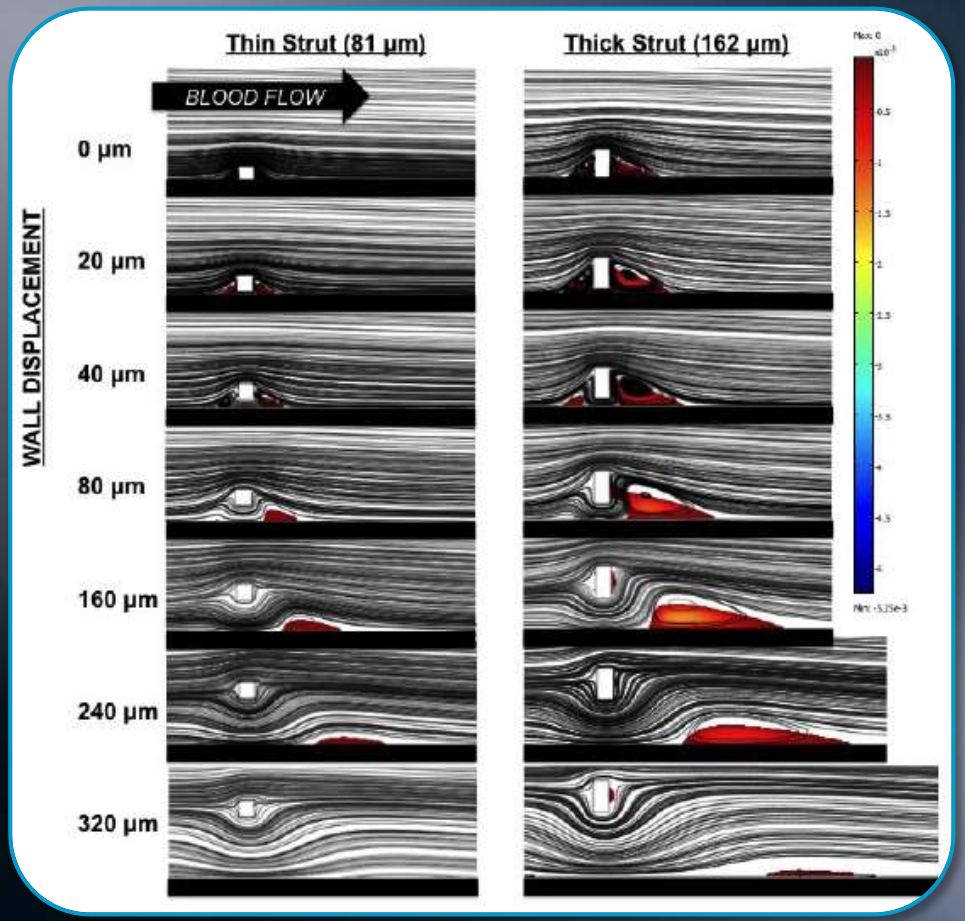
Turbulent flow and thrombogeneity

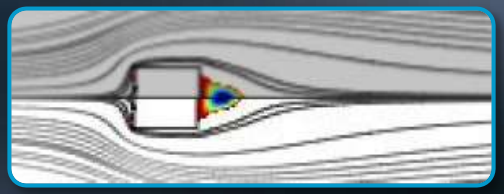
Strut positioning relative to the vessel wall modulates thrombogenicity

Lessons from Computational Modeling

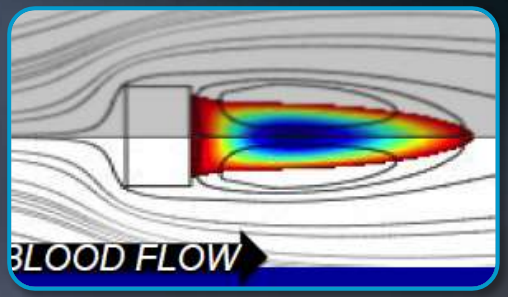


CENTERLINE DISPLACEMENT

Thin Strut (81µm)



Thin Strut (162µm)

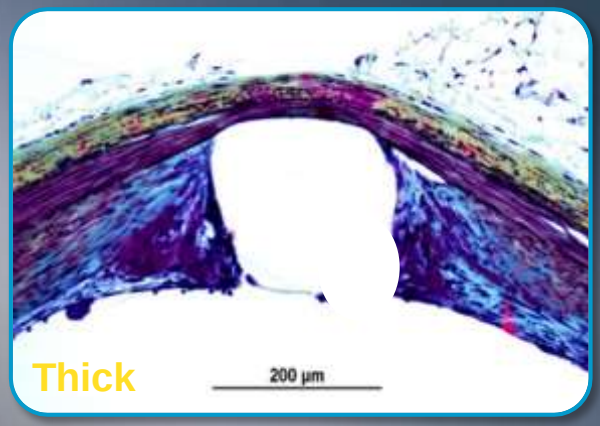


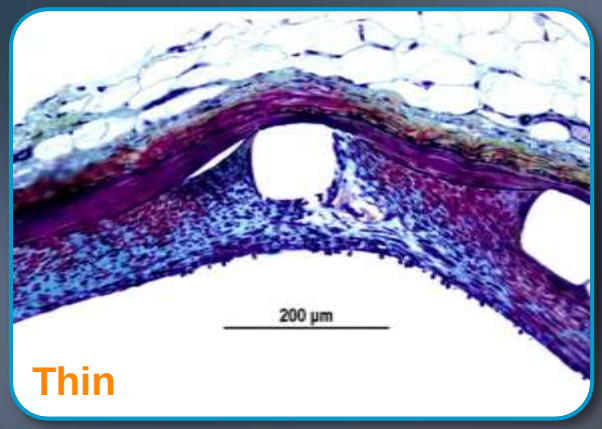
Apposed

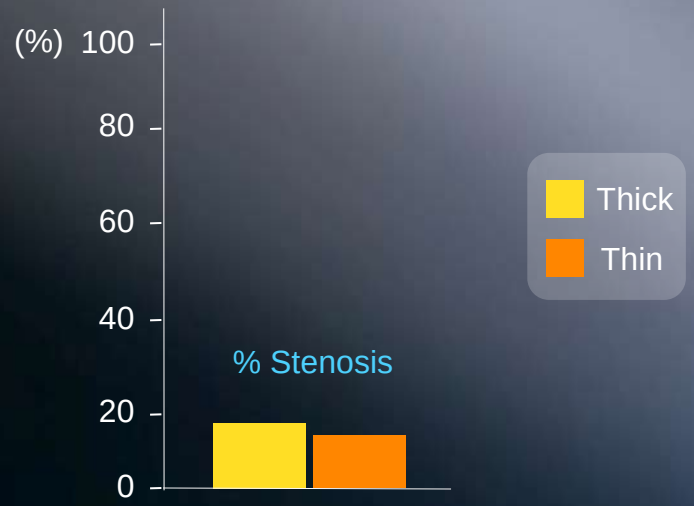
Severely Malapposed

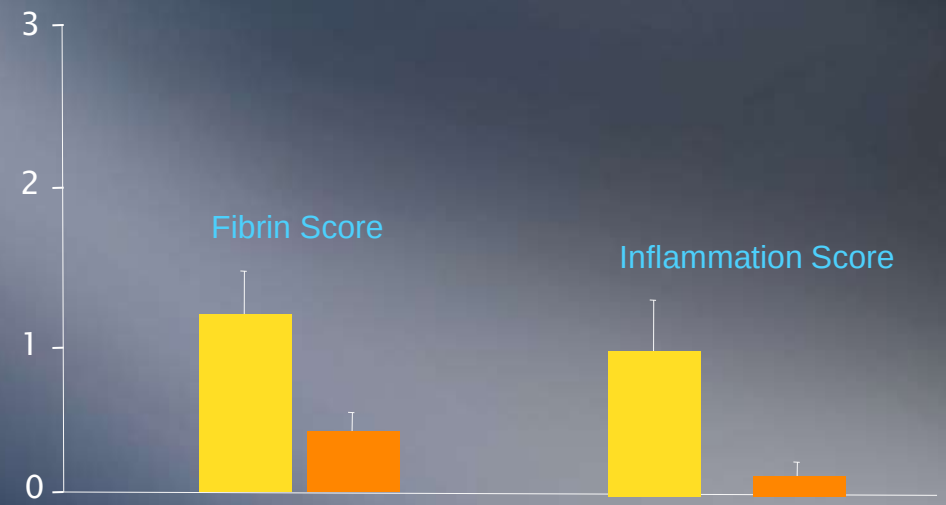
Kolandaivelu et al. Circulation 2011; 5;123(13):1400-9.

Optimization of Strut Thickness Leads to Reduction of Inflammation









Ron Waksman, MD, FACC, FSCAI, Beijing China 2010

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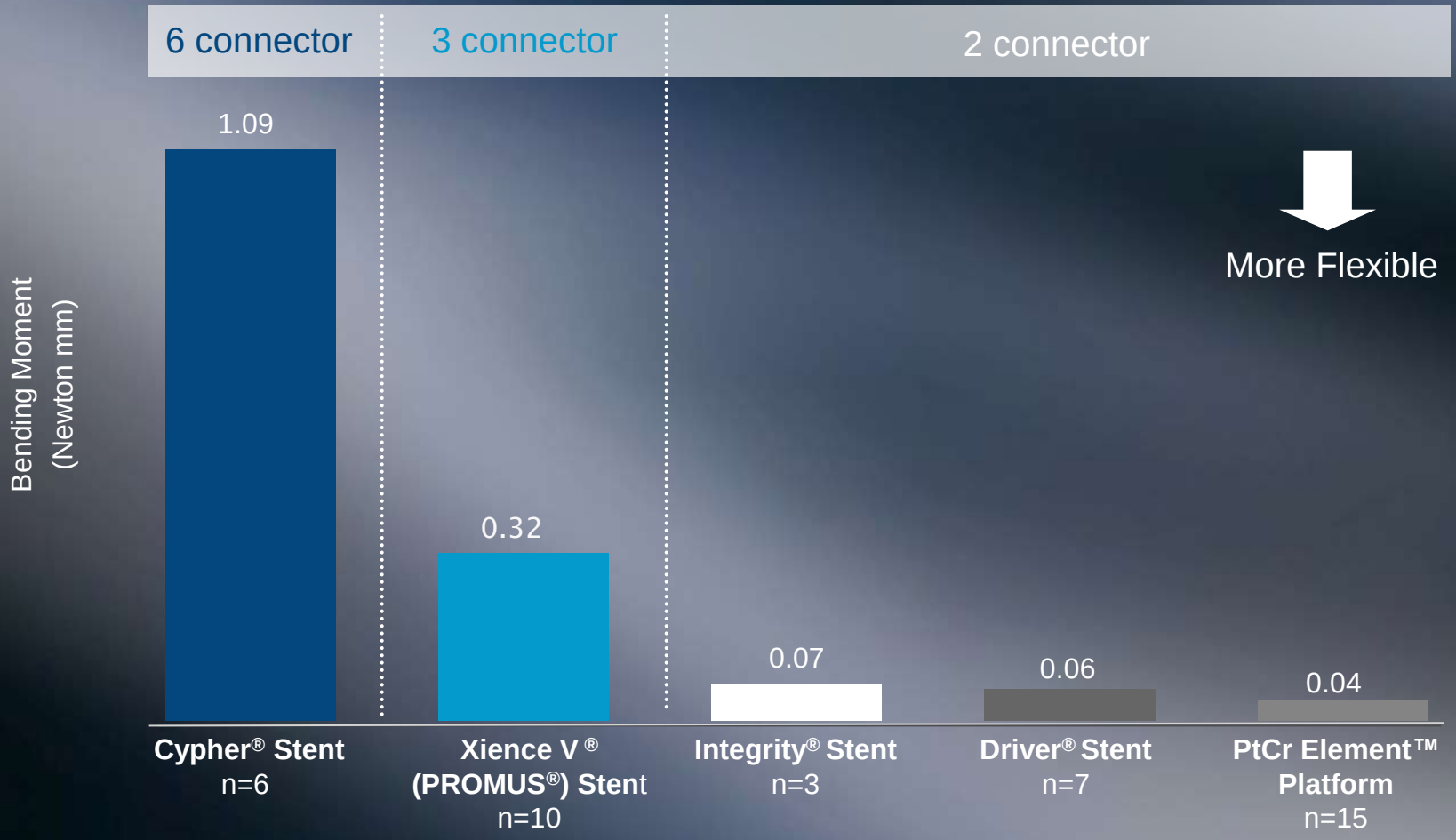
Tests performed by and data on file at Abbott Vascular

Connectors & Segments

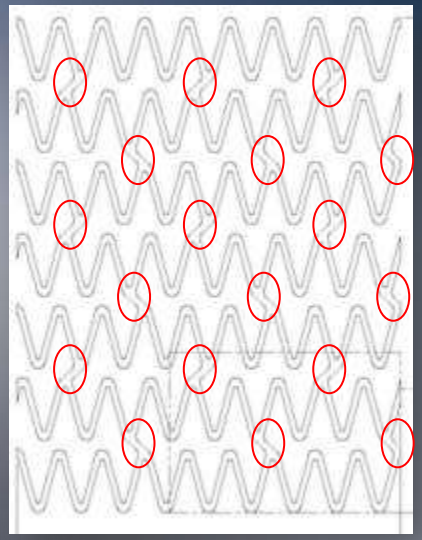
Connectors are Critical to Delivery and Conformability

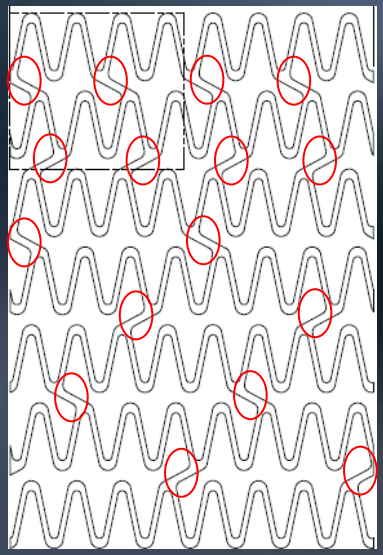


Benchtest results may not necessarily be indicative of clinical performance. Data on file at BSC

This material is not intended for use in the US or Japan. Please see glossary.

Design Approaches





Reinforce entire stent length

- 3 or 4 connectors throughout
- Pursue overall axial strength
- Tradeoffs to conformability and fatigue resistance

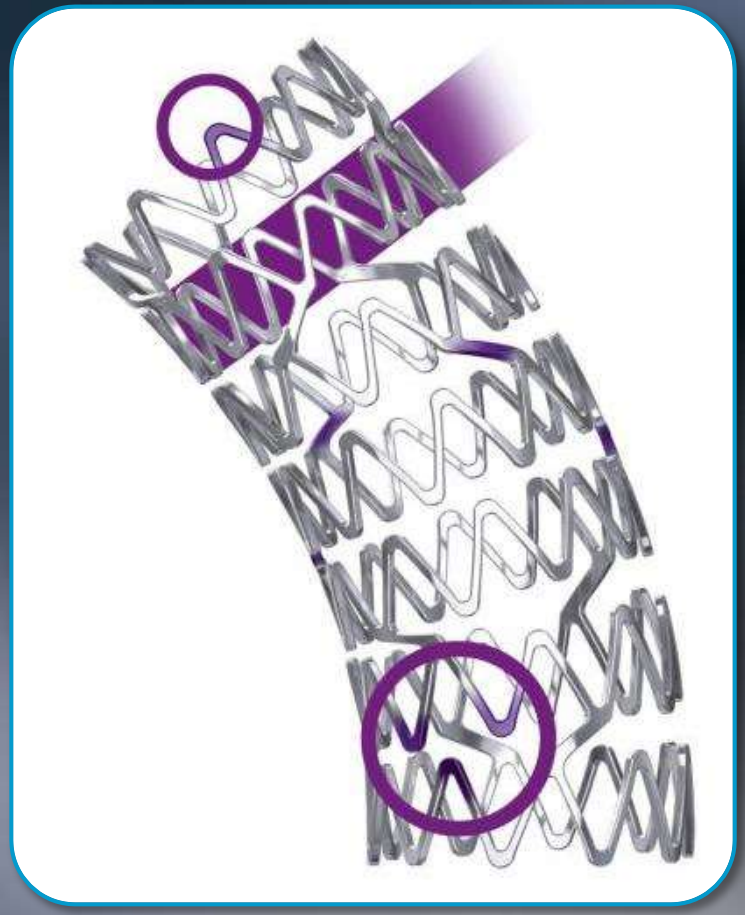
Reinforce stent end

- 4 or 5 connectors at proximal end
- Targeted increase in strength
- Maintain Element properties in rest of stent

Offset Connector Designs

Provide improvements in:

- Flexibility (in the crimped state)
- Less risk of catch points (in the crimped & deployed state)
- Apposition
- Improved vessel scaffolding (on a bend)



DES Design Comparisons
Offset Connector Designs

Medtronic recently moved to offset peak design to improve performance

Endeavor Resolute

Resolute Integrity

Peak to peak can cause overlap areas

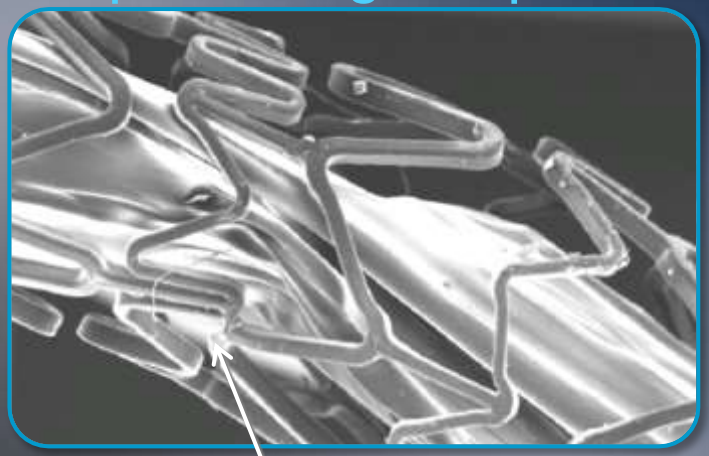
Endeavor Resolute

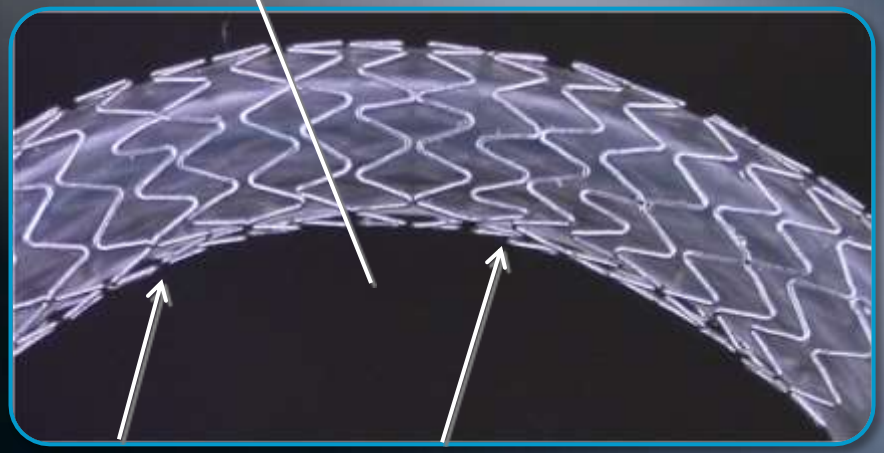
Resolute Integrity

All images are for illustrative purposes only. Data on file at Boston Scientific

Offset peaks Vs Alligned

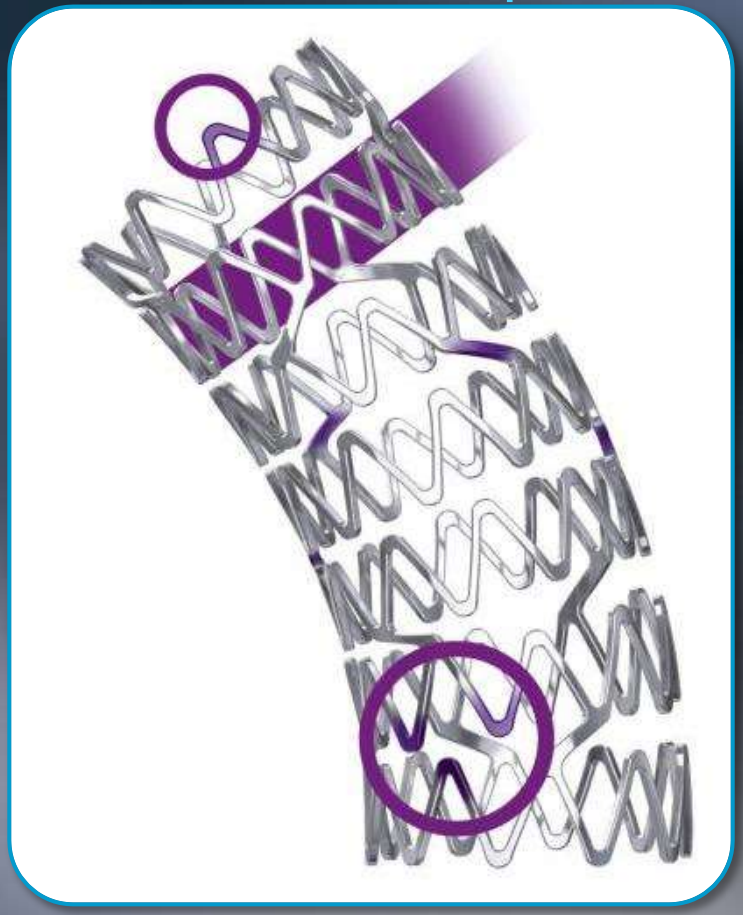
Express aligned peaks





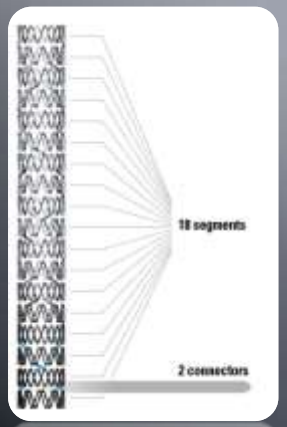
Pinch/Overlap on tight bends w/non offset

Element offset peaks

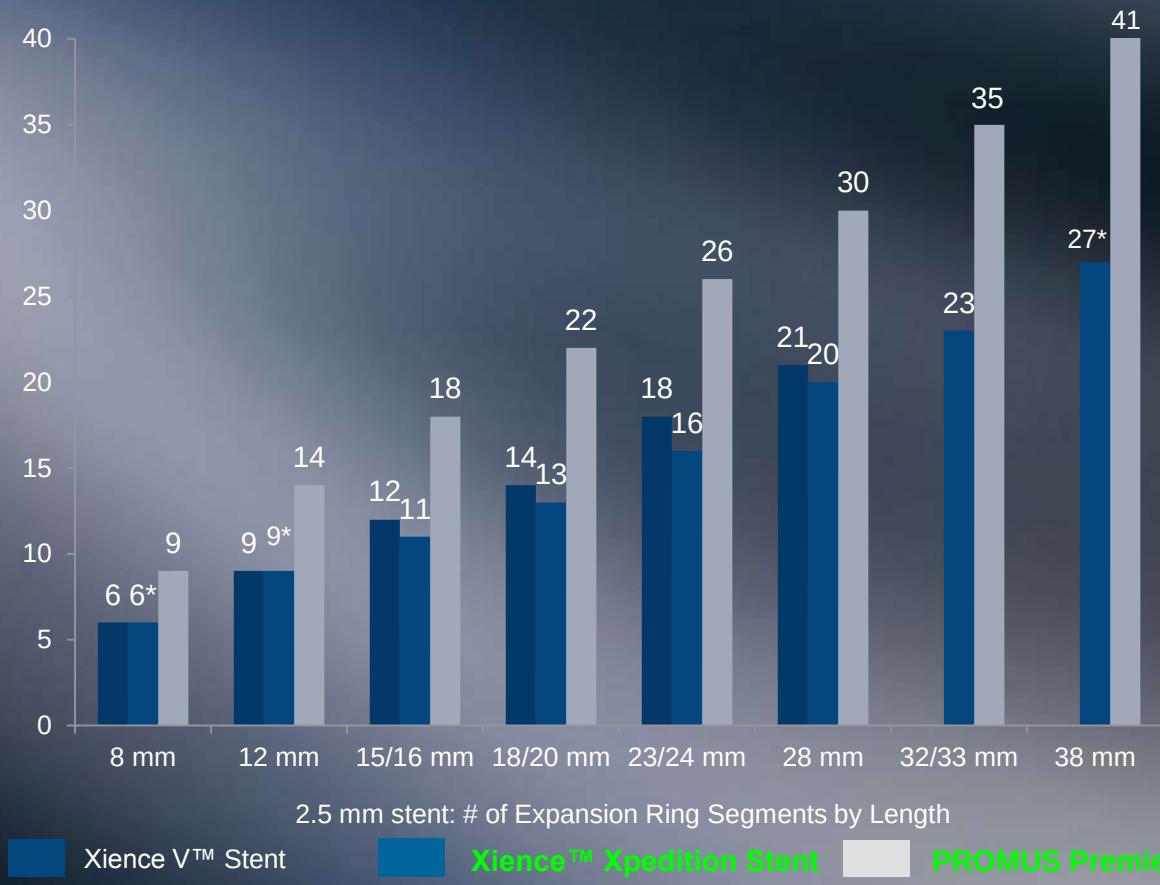


All images are for illustrative purposes only. Data on file at Boston Scientific

More Segments
= Conformability and Flexibility



Number of Expansion Rings



More Conformable

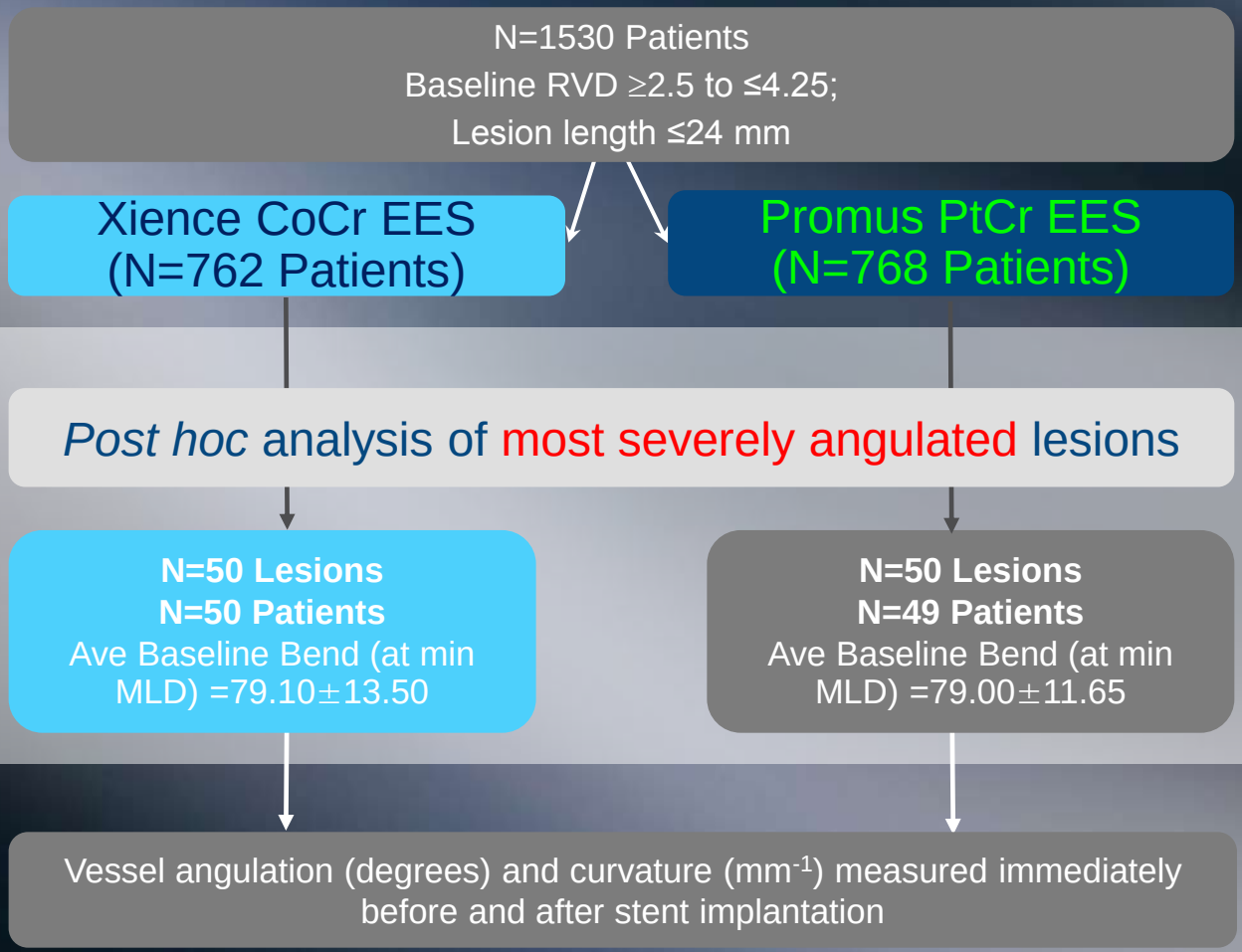
Testing by Boston Scientific. Data on File. Expansion ring measurement based on 2.5mm product. Data on File.
* Estimate for 8mm, 12mm, and 38mm Xpedition Sizes.

Importance of Conformability

Vessel Angulation and Straightening

Presented by Dr. Jeffrey Popma

Angiographic Analysis of Severely Angulated Lesions in the PLATINUM Trial



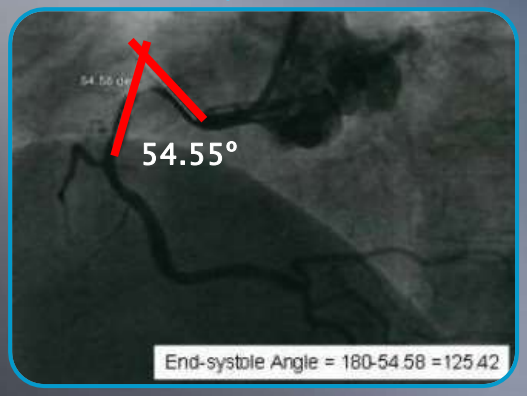
PLATINUM Clinical Trial Program studied the PROMUS Element™ Stent (Promus PtCr EES Stent) Definitions from Gomez-Lara et al, JACC CI 3(11):1190

Change in Angulation

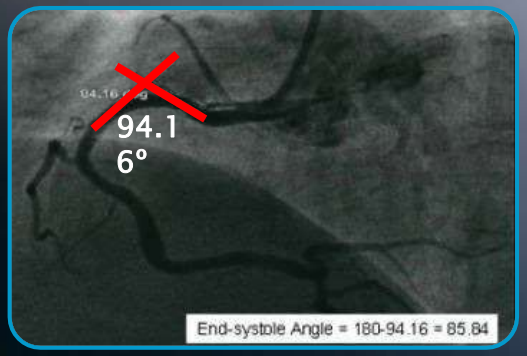
Promus PtCr EES Has Less Vessel Straightening

Xience CoCr EES

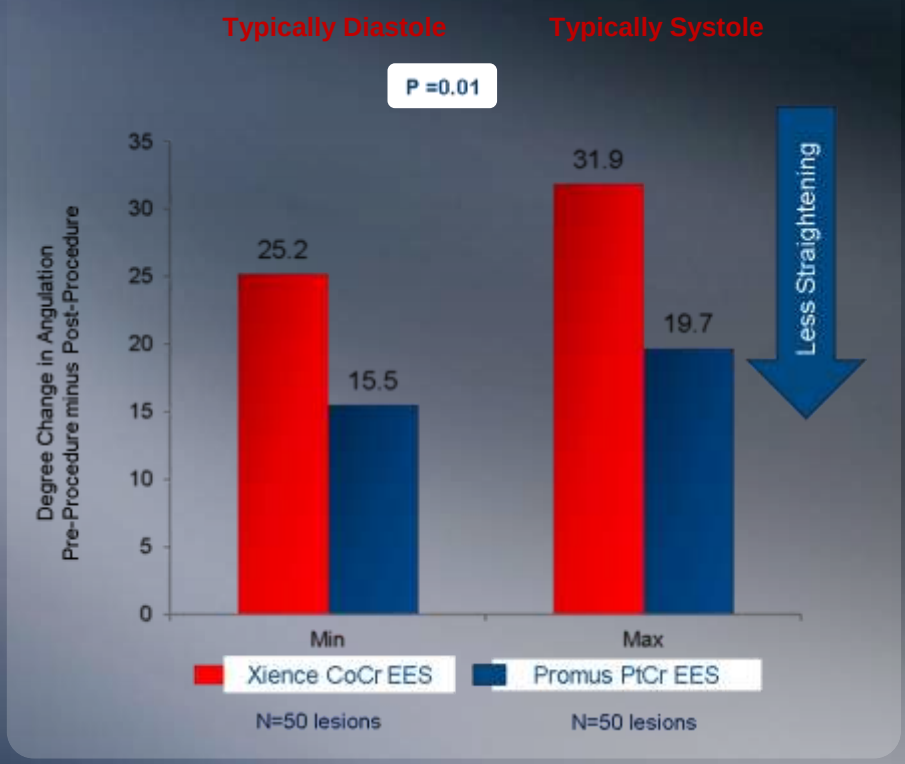
Pre-procedure



Post-procedure



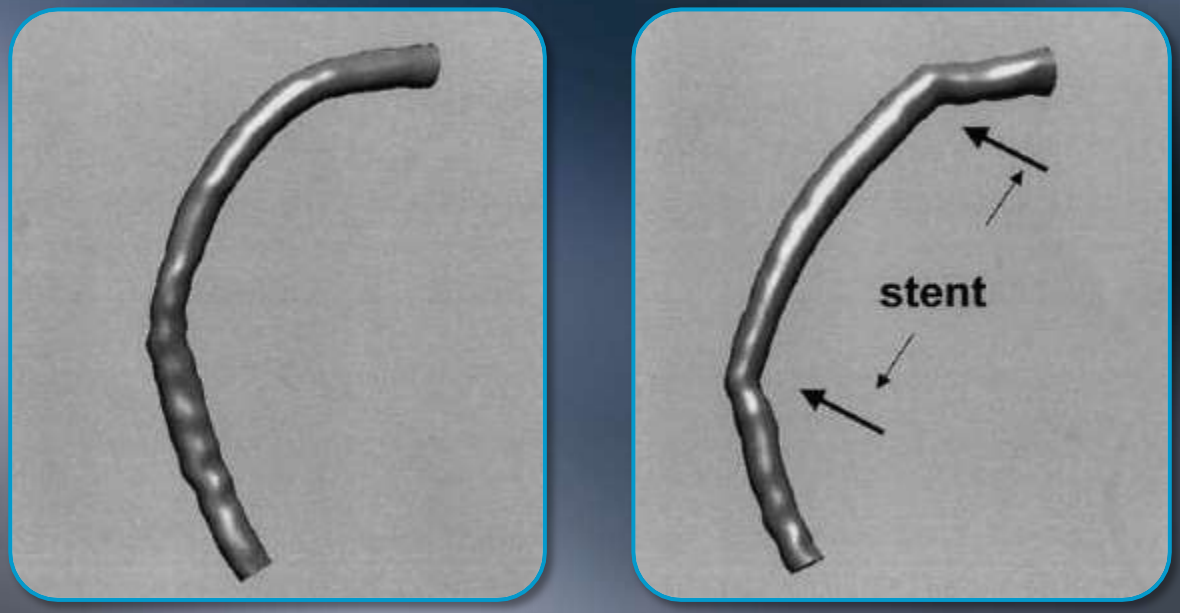
Promus PtCr EES has Significantly Less Vessel Straightening



Presented by Jeff Popma, MD at ACC 2013 Definitions from Gomez-Lara et al, JACC CI 3(11):1190 PLATINUM Clinical Trial Program studied the PROMUS Element™ Stent (Promus PtCr EES Stent)

Vessel Straightening and Edge Effects

Change in Sheer Stress



Stent implantation changes 3D vessel geometry

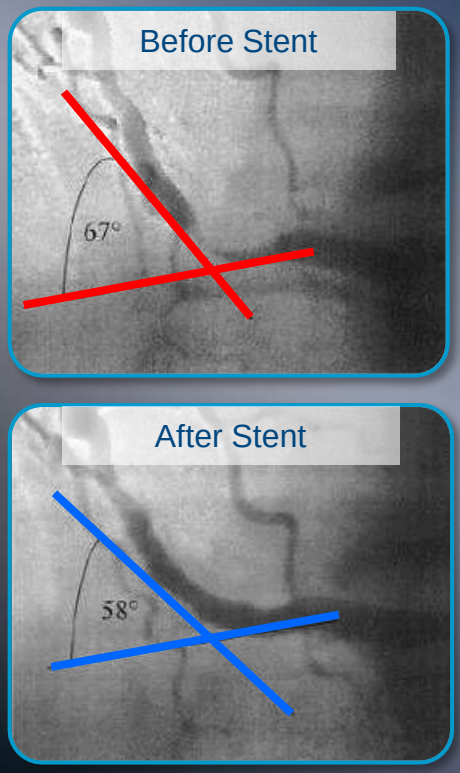
Changes in shear stress occur near stent edges and may result in restenosis

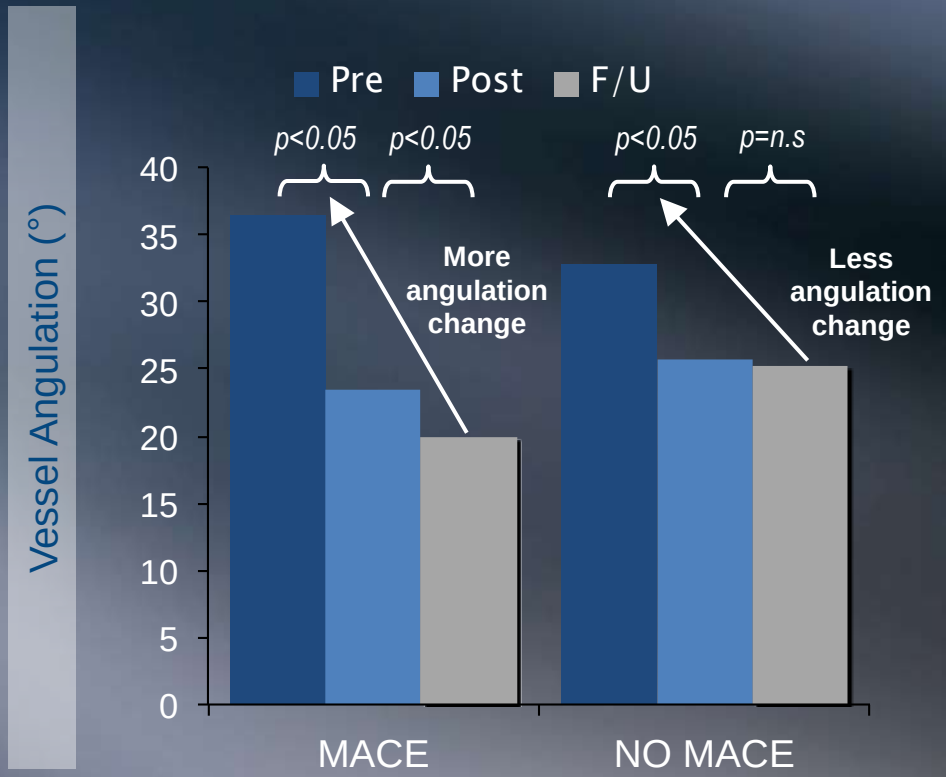
Wentzel et al. Jour Biomechanics 2000;33:1287-1295

Vessel Angulation and Straightening

Predictors of MACE Events

Measurement Methodology





Significant Predictors of MACE:
Pre-stent vessel angulation ≥33.5º | Change in vessel angulation post-stent ≥9.1º

MACE includes death, nonfatal MI, and revascularization | Gyongyosi et al, JACC 2000;35:1580-9

The Perfect Stent?

- **Balances multiple design factors**
- **Too stiff leads to…**
  - fracture
  - less conformable
  - less deliverable
  - Reduced healing
- The solution….Customised Architecture

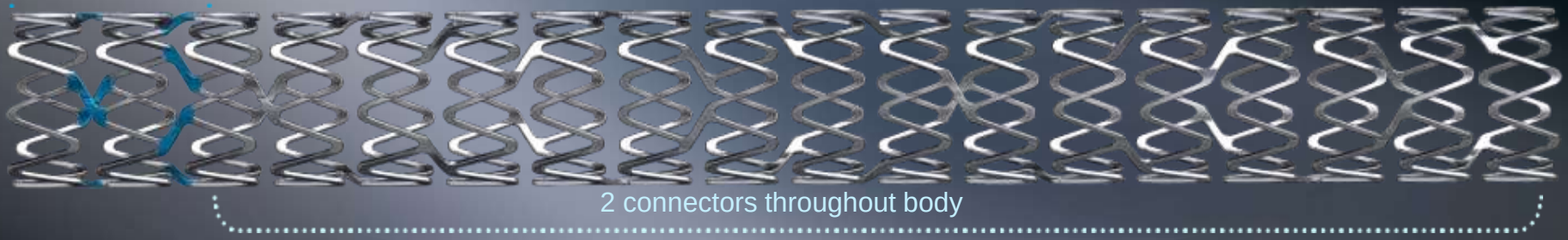
Promus PREMIER™ Stent

Customized Stent Architecture

Strength and Flexibility Where It Matters

Additional connectors on proximal two segments (4 or 5)

Proximal end more robust to provide ***increased axial strength***[1]

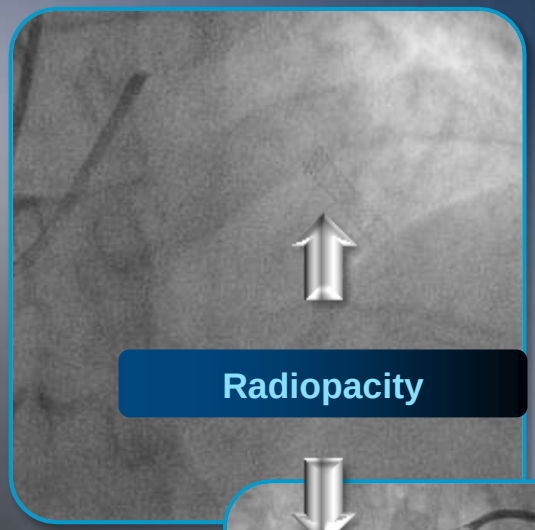


Overall design maintains ***flexibility, conformability and fracture resistance***[1]

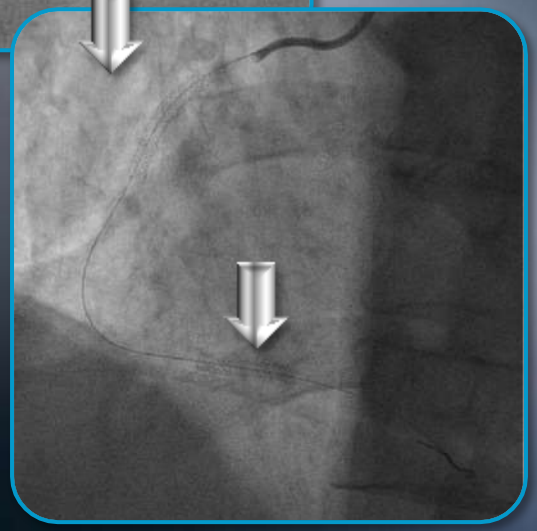
Proximal end of the Promus PREMIER™ Stent is 2.4x stronger than the PROMUS Element™ Stent and 1.4x stronger than the Xience V™ Stent[1]

1. Bench testing performed by Boston Scientific Corporation. Data on file at Boston Scientific.

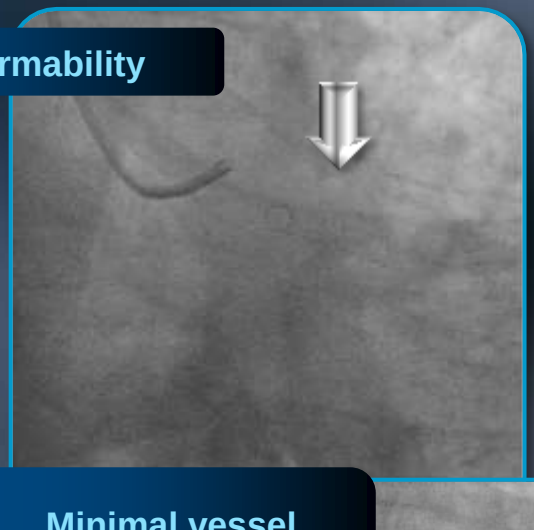
Customized Architecture with the most visible alloy and exceptional conformability



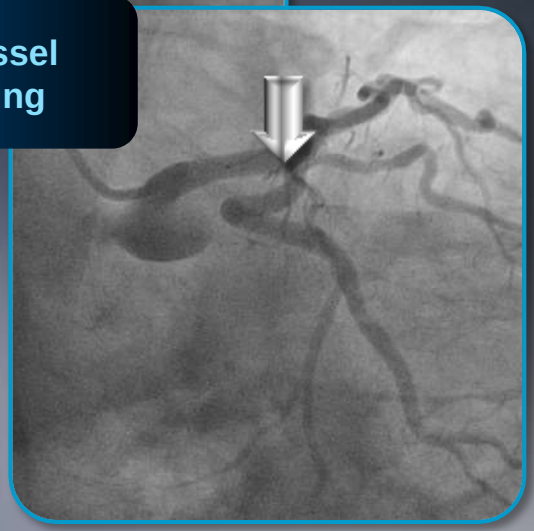
Radiopacity



Conformability



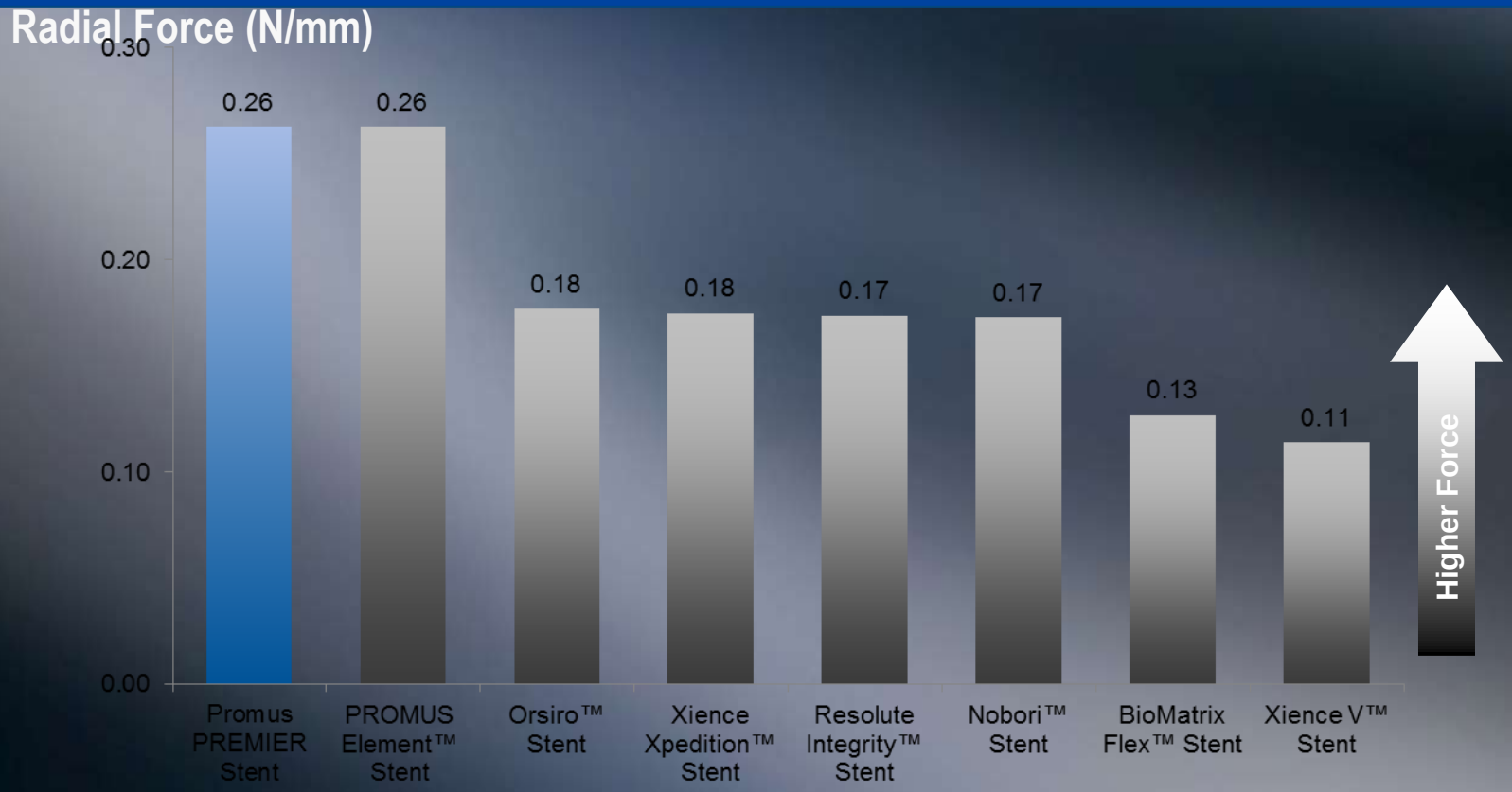
Minimal vessel straightening



1. Images courtesy of John Ormiston, MD., Mercy Hospital Aukland, New Zealand. Results from case studies are not predictive of results in other cases. Results in other cases may vary.
2. Bench testing performed by Boston Scientific Corporation. Data on file at Boston Scientific.

Unmatched Radial Strength

Promus PREMIER™ Stent has up to 136% Higher Radial Strength than Xience stents[1]

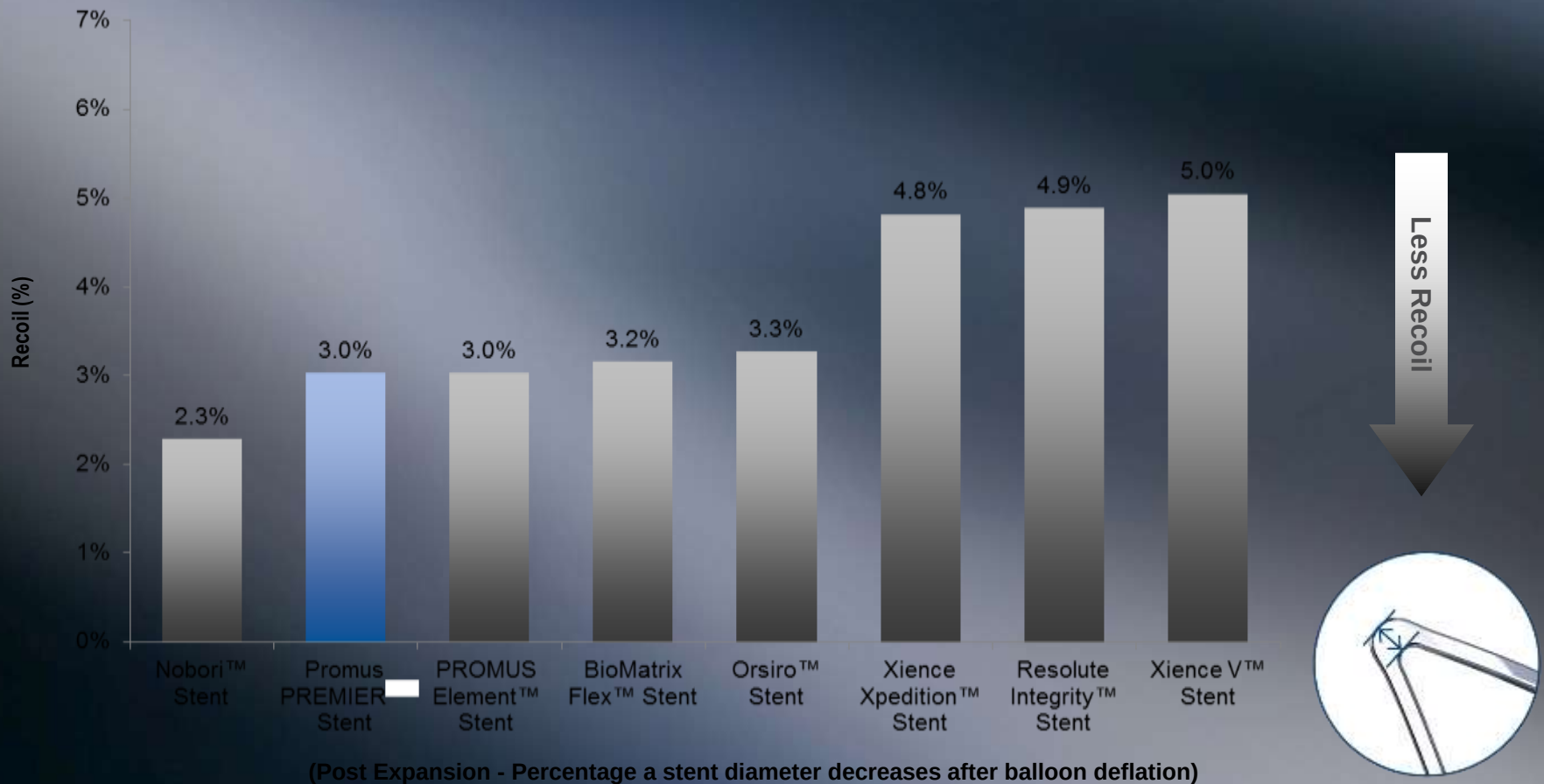


(Amount of radial force required to reduce the diameter of a deployed stent by 15%)

1. Bench testing performed by Boston Scientific Corporation. Data on file at Boston Scientific. All stents 2.50 mm; Promus PREMIER Stent n = 15, PROMUS Element Stent n = 15, Orsiro Stent n = 3, Xience Xpedition Stent n = 3, Resolute Integrity Stent n = 3, Nobori Stent n = 3, BioMatrix Flex Stent n = 3, Xience V Stent n = 10. Bench test results may not necessarily be indicative of clinical performance.

Exceptionally Low Recoil

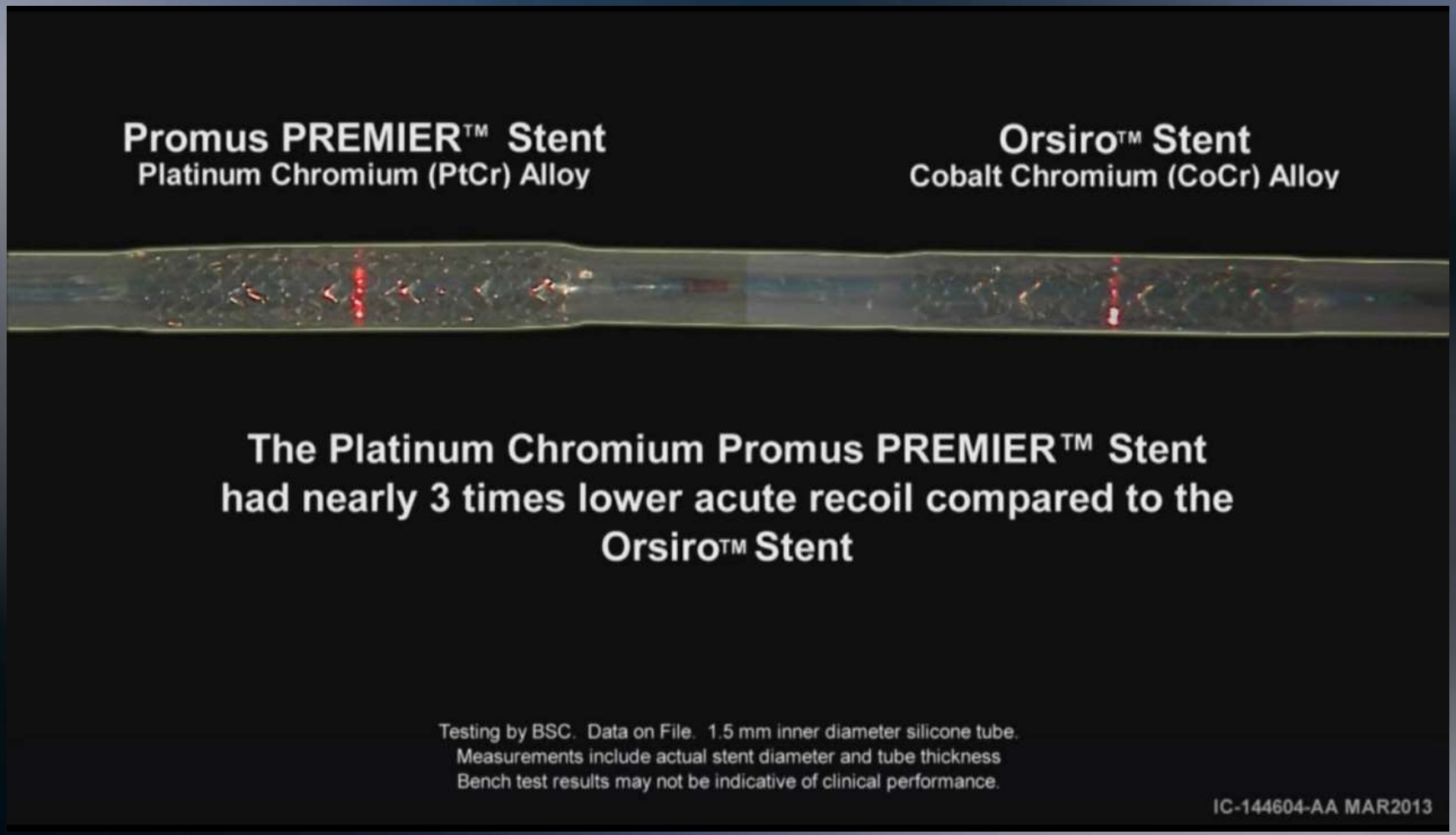
Promus PREMIER™ Stent has up to 40% Less Recoil than Xience Stents tested[1]



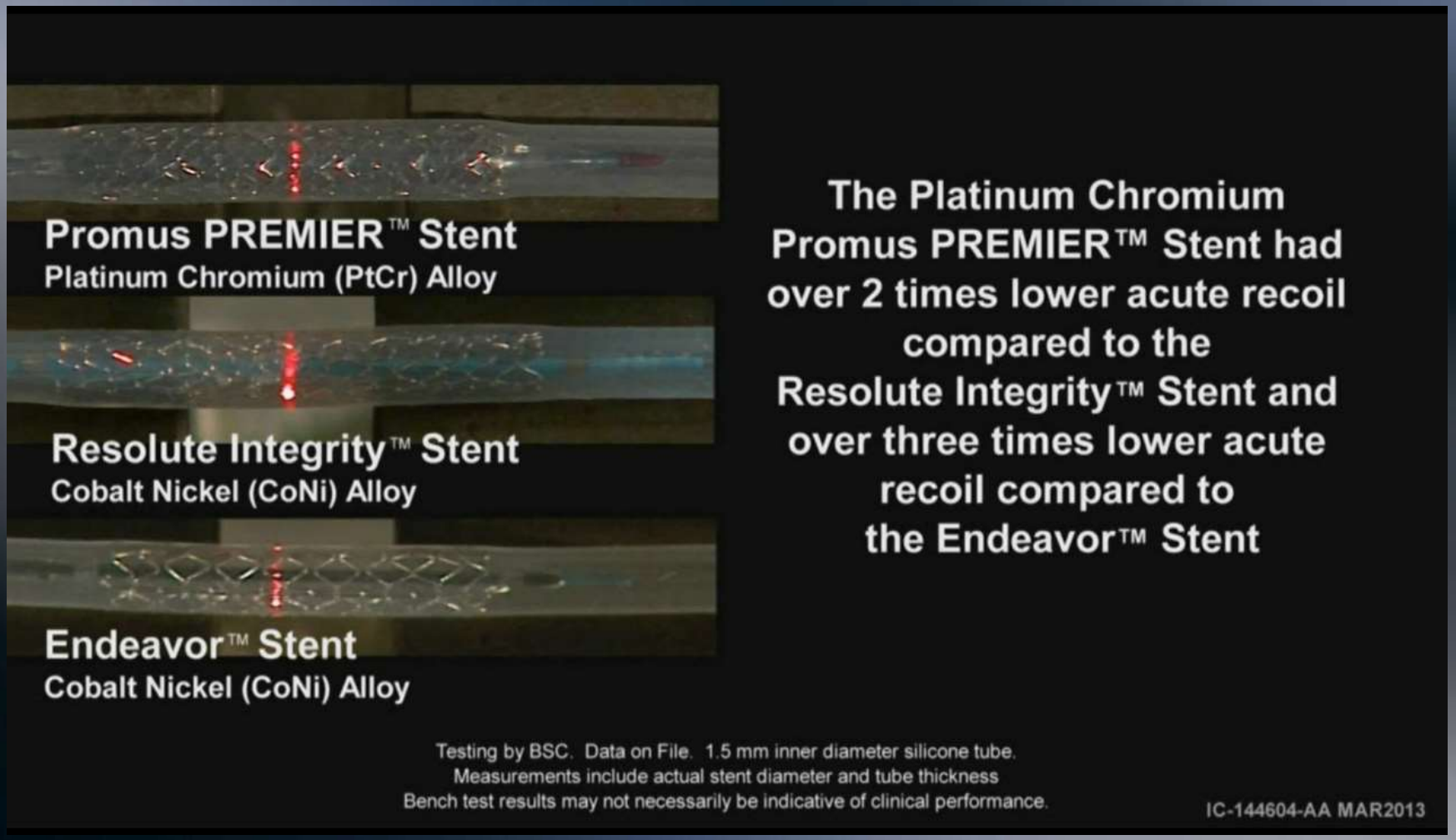
(Post Expansion - Percentage a stent diameter decreases after balloon deflation)

1. Bench testing performed by Boston Scientific Corporation. Data on file at Boston Scientific. All stents 2.50 mm; Promus PREMIER Stent n = 15, PROMUS Element Stent n = 15, Orsiro Stent n = 3, Xience V Stent n = 10, Resolute Integrity Stent n = 3, Nobori Stent n = 3, BioMatrix Flex Stent n = 3.
Bench test results may not necessarily be indicative of clinical performance.

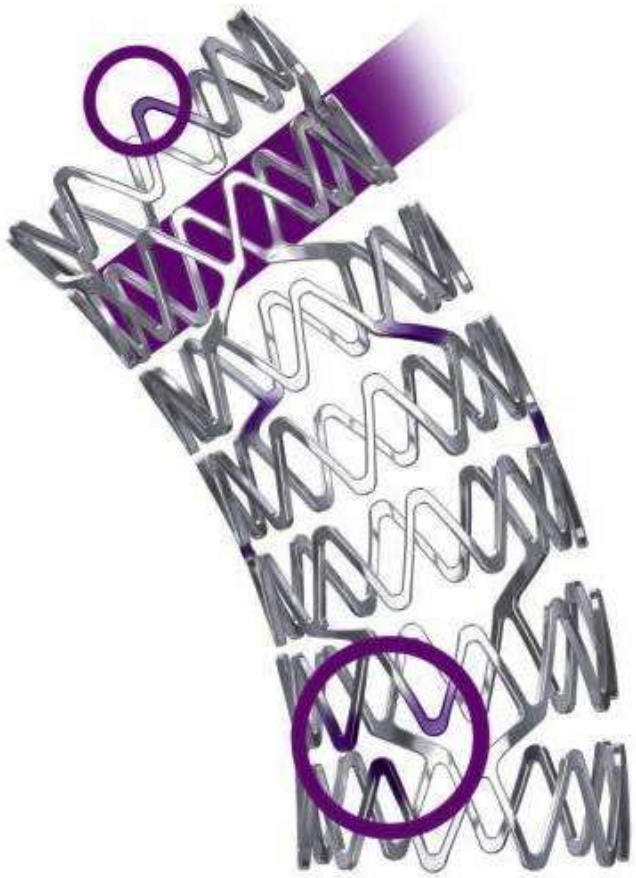
Exceptionally Low Acute Lumen Loss



Exceptionally Low Acute Lumen Loss

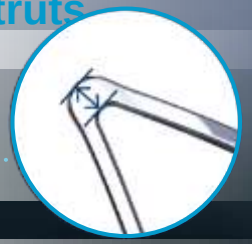


Stent Design Summary
Platform Matters



Strong radiopaque alloys facilitate **thinner struts**

Strong alloys and wider connectors provide **fracture resistance**[1]



Short, and increased segments per length improve **conformability** and minimize gaps on a bend[1]

Number of connectors critical for maximum **flexibility**, conformance to the vessel and fracture resistance

Extensive, deliverable size model matrix and **expansion capability** facilitates complex PCI

All images are for illustrative purposes only. Data on file at Boston Scientific.

Randomized Comparison of PtCr-EES vs CoCr-ZES in All-Comers Receiving PCI

: The HOST-ASSURE Randomized Trial

Hyo-Soo Kim, MD/PhD

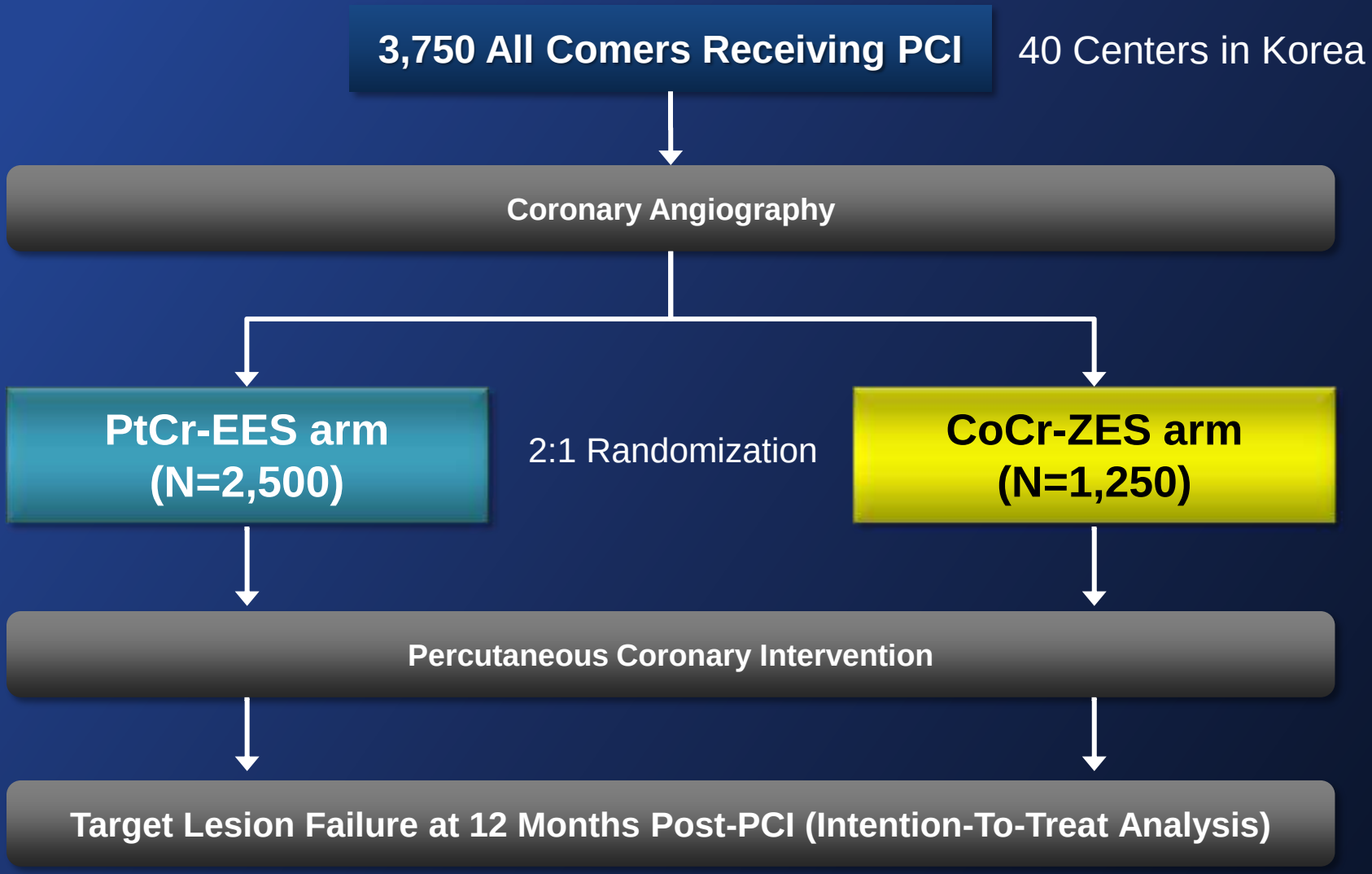
Kyung-Woo Park, Si-Hyuck Kang, Kwang-Soo Cha,
Byoung-Eun Park, Jay-Young Rhew, Hui-Kyung Jeon, In-Ho Chae
On Behalf of The HOST-ASSURE Trial Investigators

Seoul National University Hospital, Seoul, Korea

Study Design

Prospective, single-blinded, randomized multi-center trial

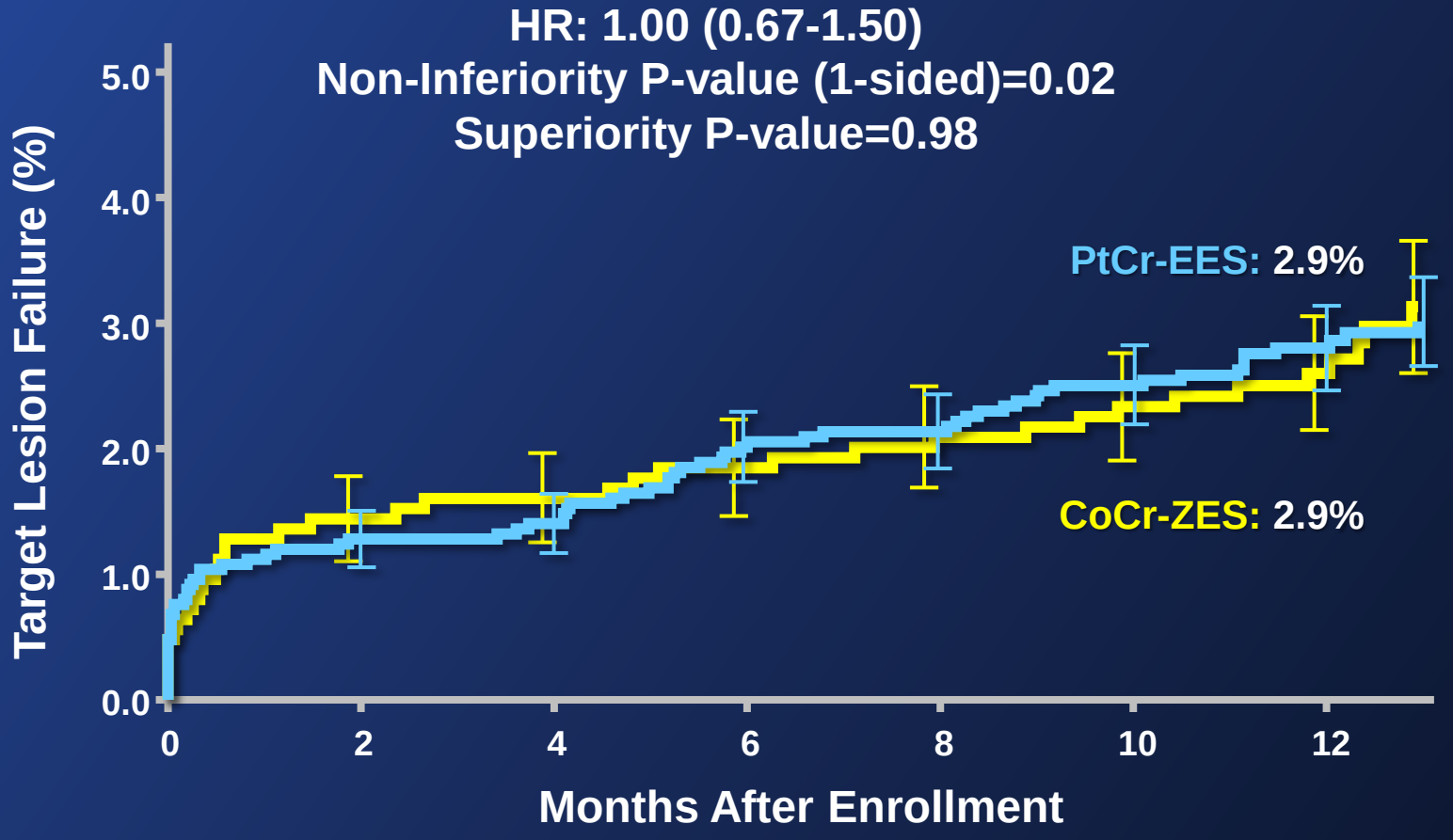
HOST ASSURE



Target Lesion Failure

Composite of C-death, TV-related MI, ischemia-driven TLR

HOST ASSURE

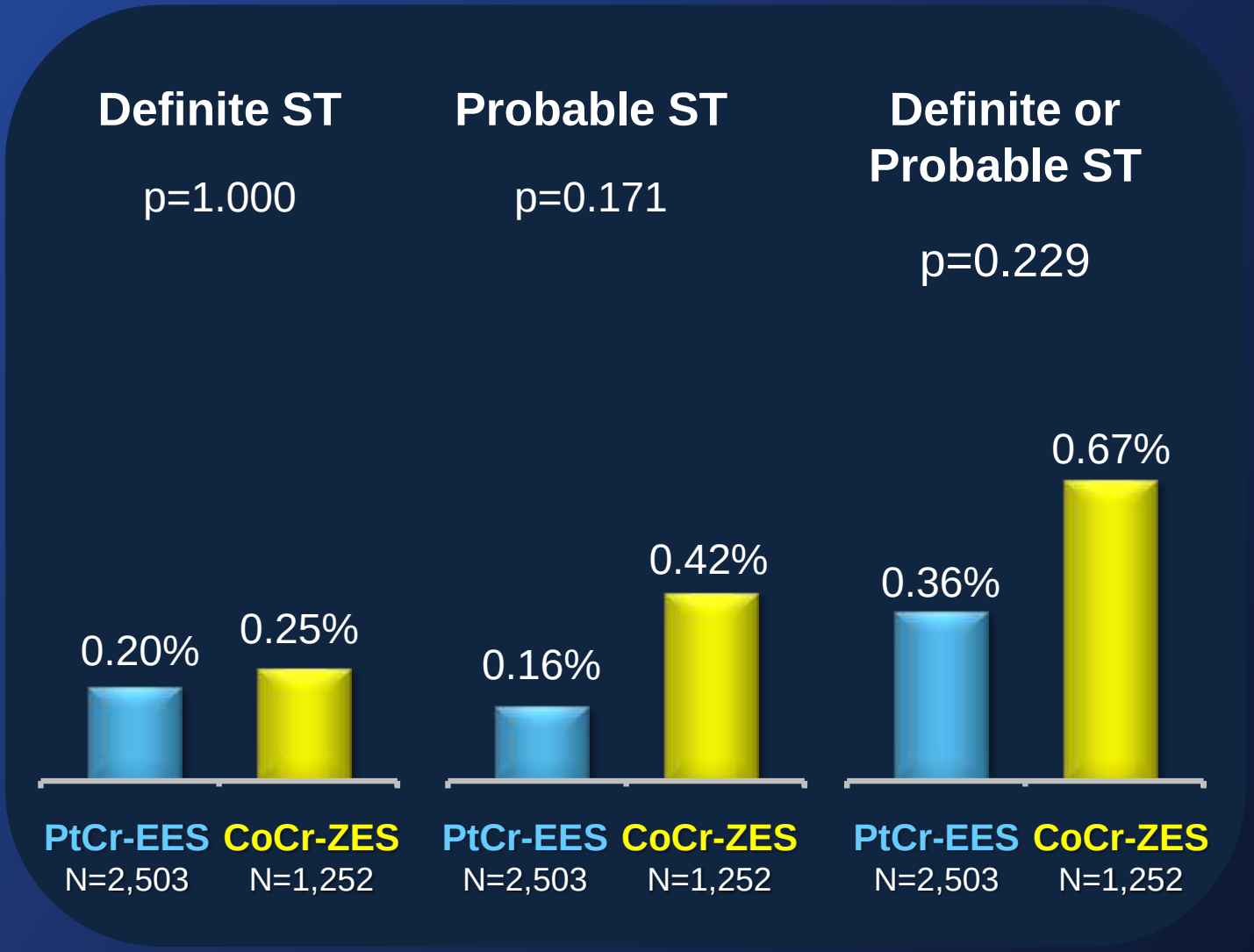


Patient Number At Risk

PtCr-EES	2,503	2,446	2,426	2,408	2,401	2,376	1,887
CoCr-ZES	1,252	1,222	1,213	1,209	1,205	1,198	952

Stent Thrombosis

HOST ASSURE



The PLATINUM Trial Study Design:

1530 patients with 1 or 2 *de novo* native coronary artery target lesions

RVD ≥2.5 to ≤4.25; Lesion length ≤24 mm

Peri-proc: ASA ≥300 mg, clopidogrel ≥300 mg load unless on chronic Rx

Randomized 1:1

Stratified by diabetes, intention to treat 1 vs. 2 target lesions, & study site

XIENCE V CoCr everolimus-eluting stent

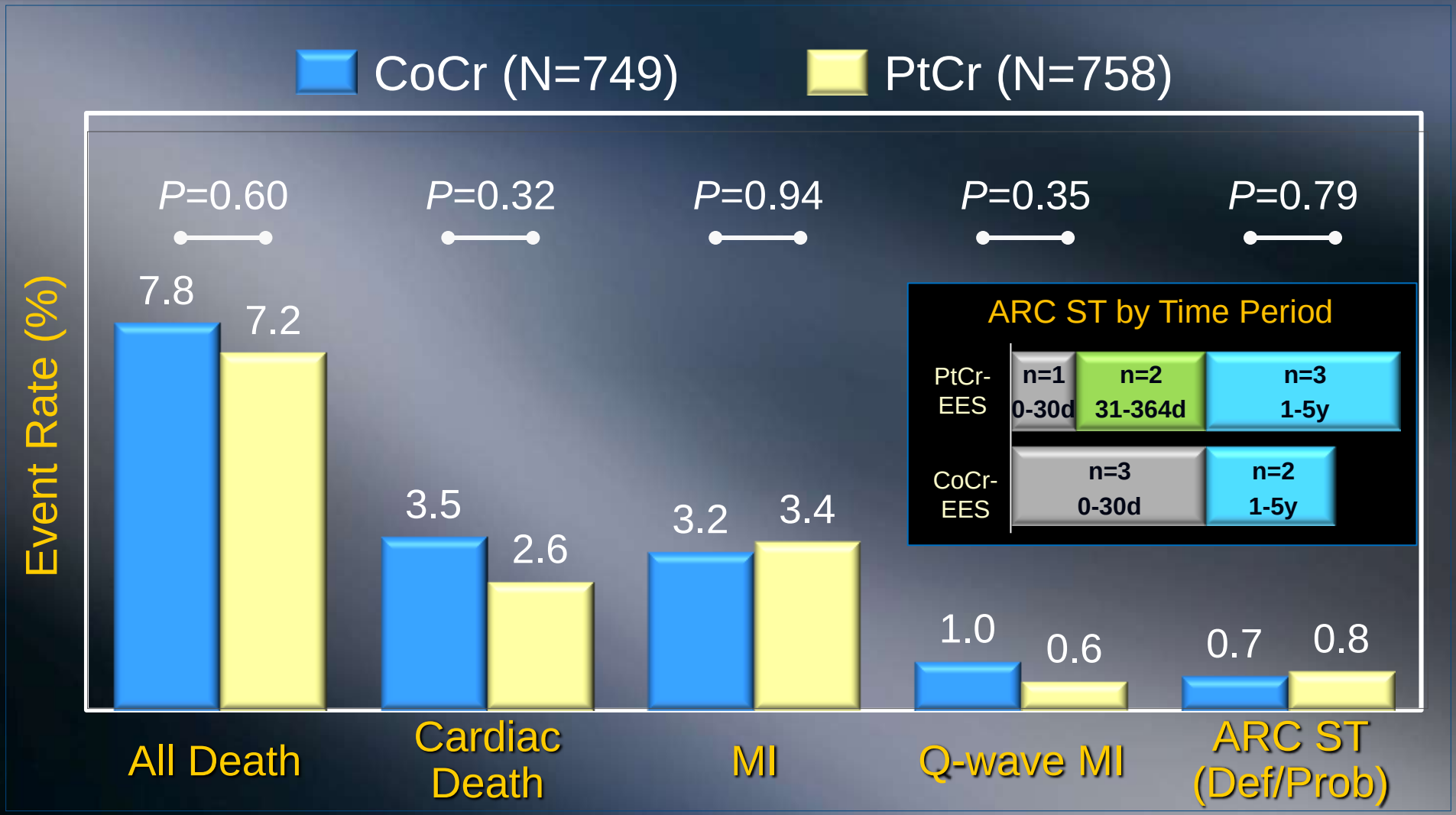
PROMUS Element PtCr everolimus-eluting stent

ASA indefinitely, thienopyridine ≥6 mos (≥12 mos if not high risk for bleeding)

Clinical f/u only: 1, 6, 12, 18 months then yearly for 2-5 years

Stone, et al. Presented as poster at ACC 2015.

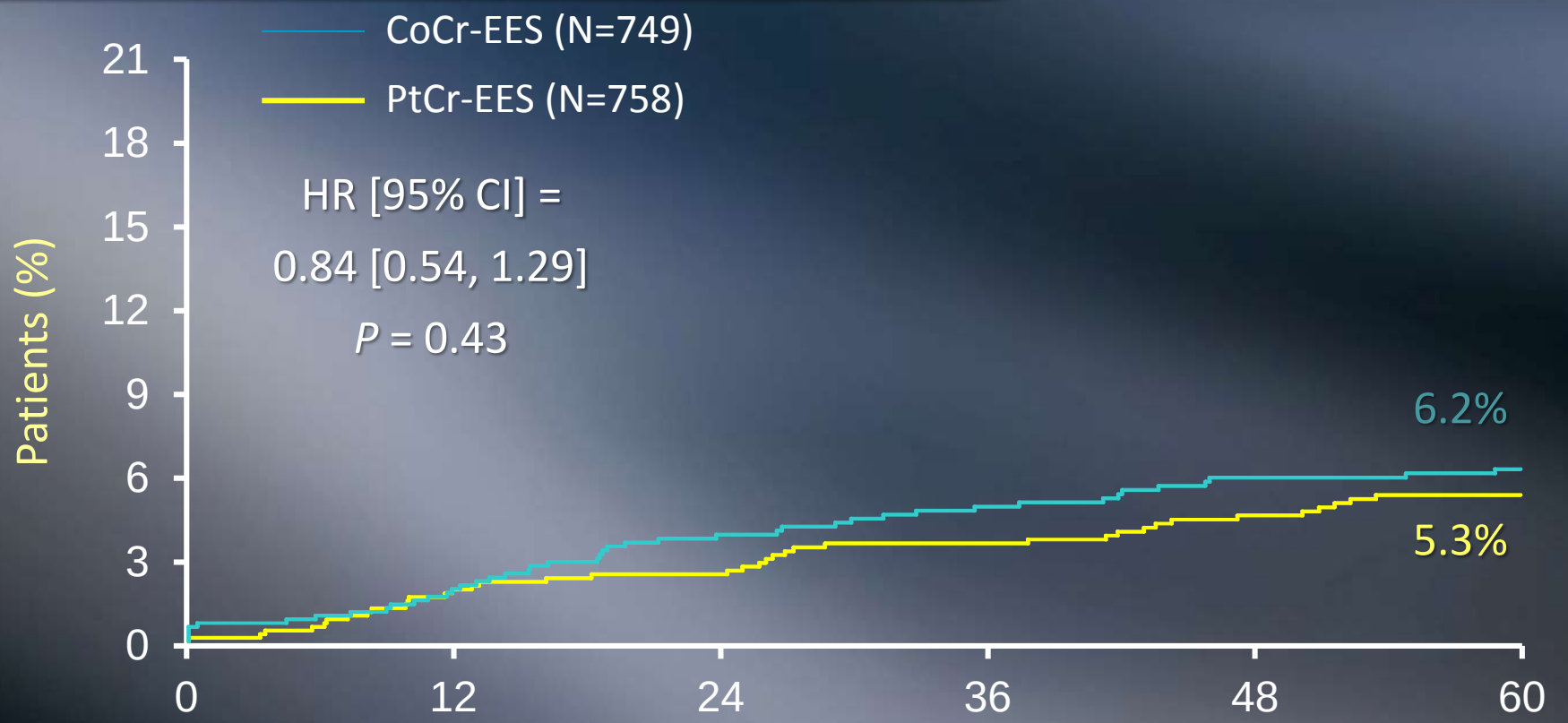
Safety Measures at 5 Years



Time to event rates

Stone, et al. Presented as poster at ACC 2015.

Ischemia-Driven TLR
5-Year Follow-up



No. at risk

CoCr-EES	749	724	687	663	639	447
PtCr-EES	758	739	710	696	669	464

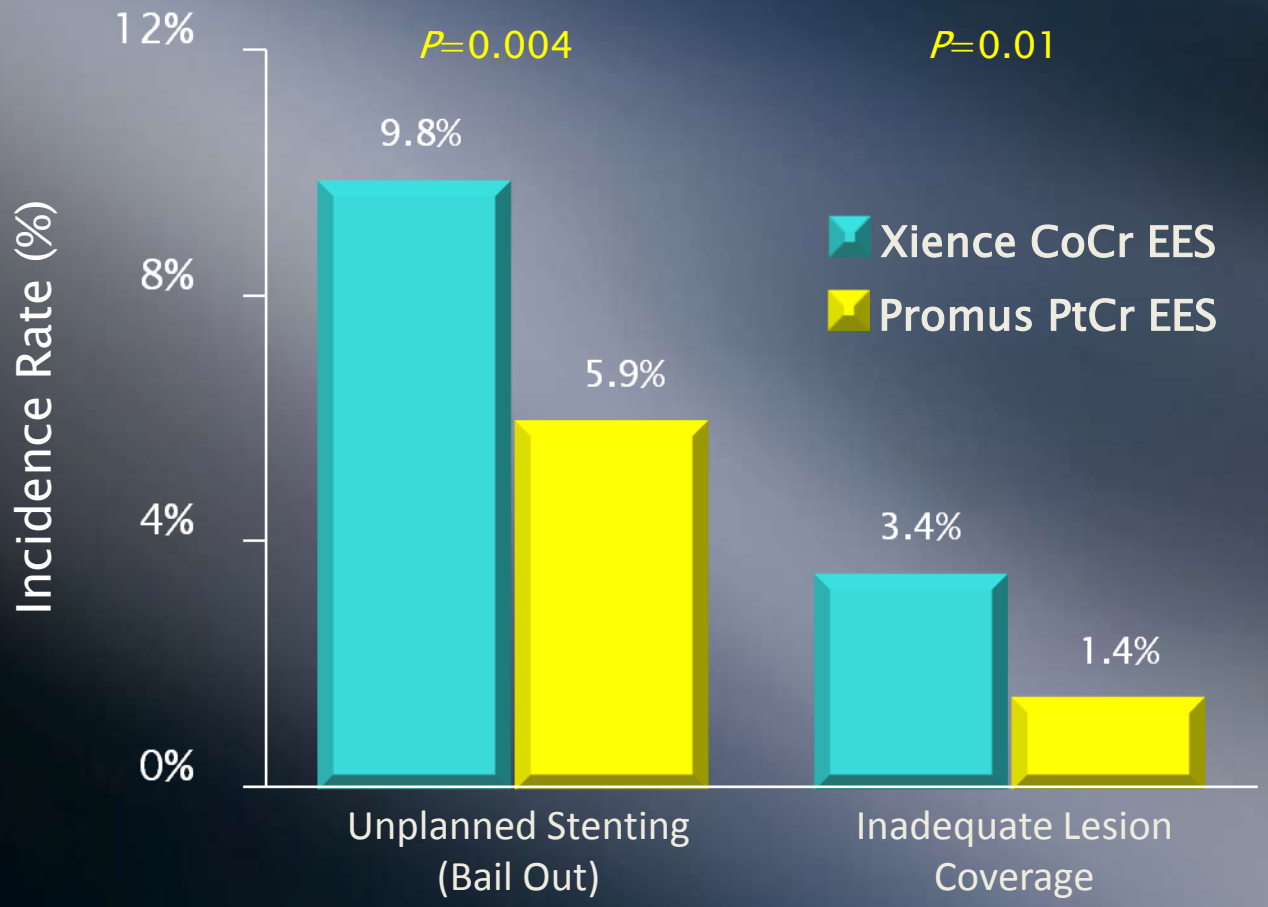
PLATINUM Clinical Trial Program evaluated the PROMUS Element™ Stent (Promus PtCr EES).

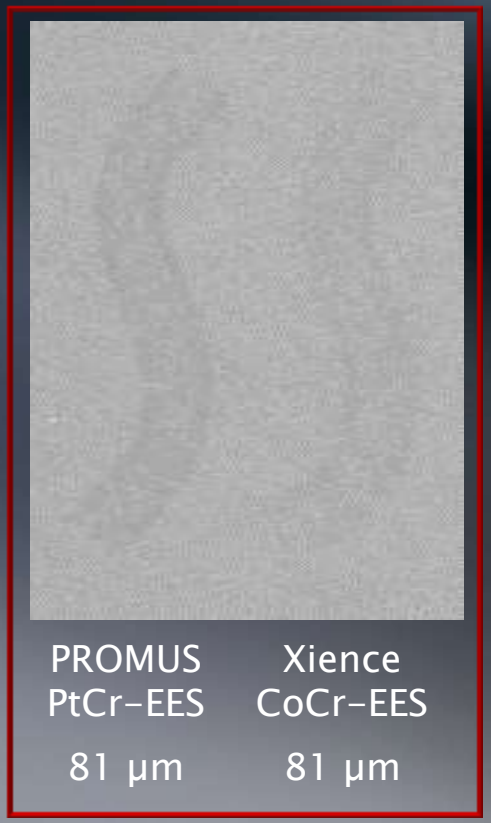
Stone, et al. Presented as poster at ACC 2015.

PtCr (vs. CoCr) Platform May Impact Clinical Outcomes:

Bailout and Inadequate Lesion Coverage

PLATINUM Workhorse Trial





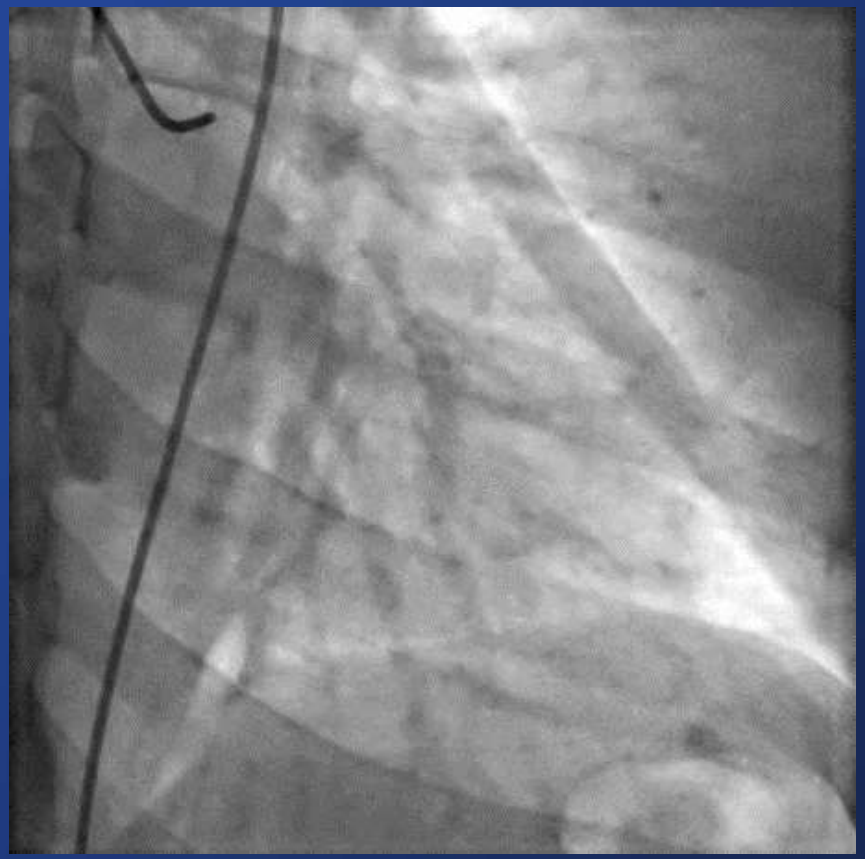
Stone et al. JACC. 2011;57:1700-1708

PLATINUM Clinical Trial Program evaluated the PROMUS Element™ Stent (Promus PtCr EES).

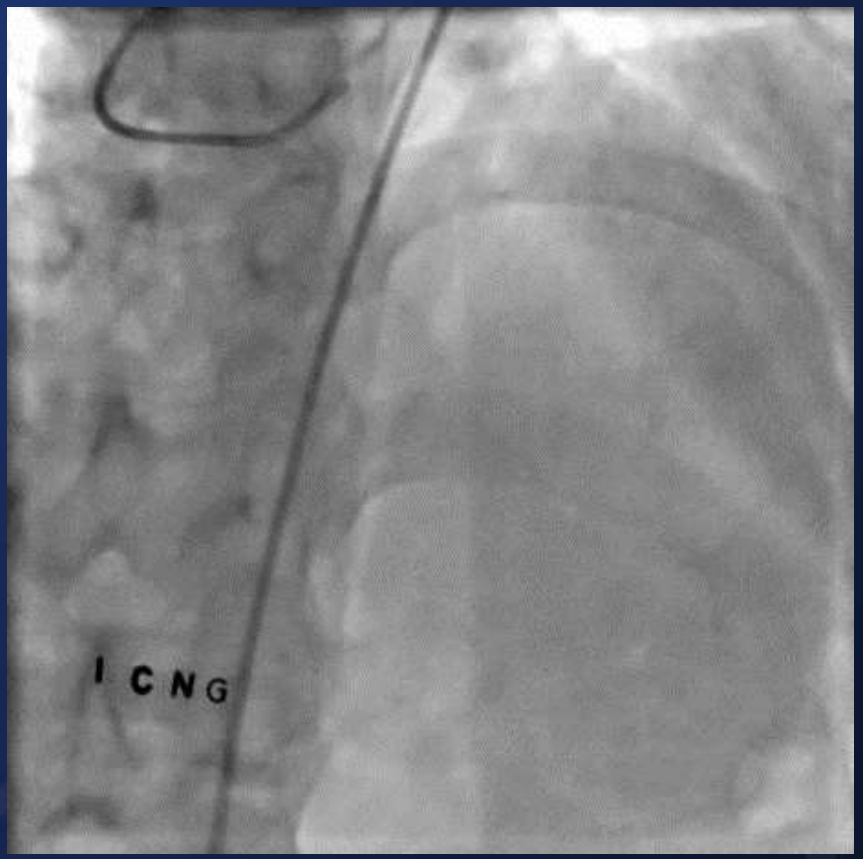
Multi-Stent Technique at LM bifurcation

- Promus Element DES -

RAO Caudal



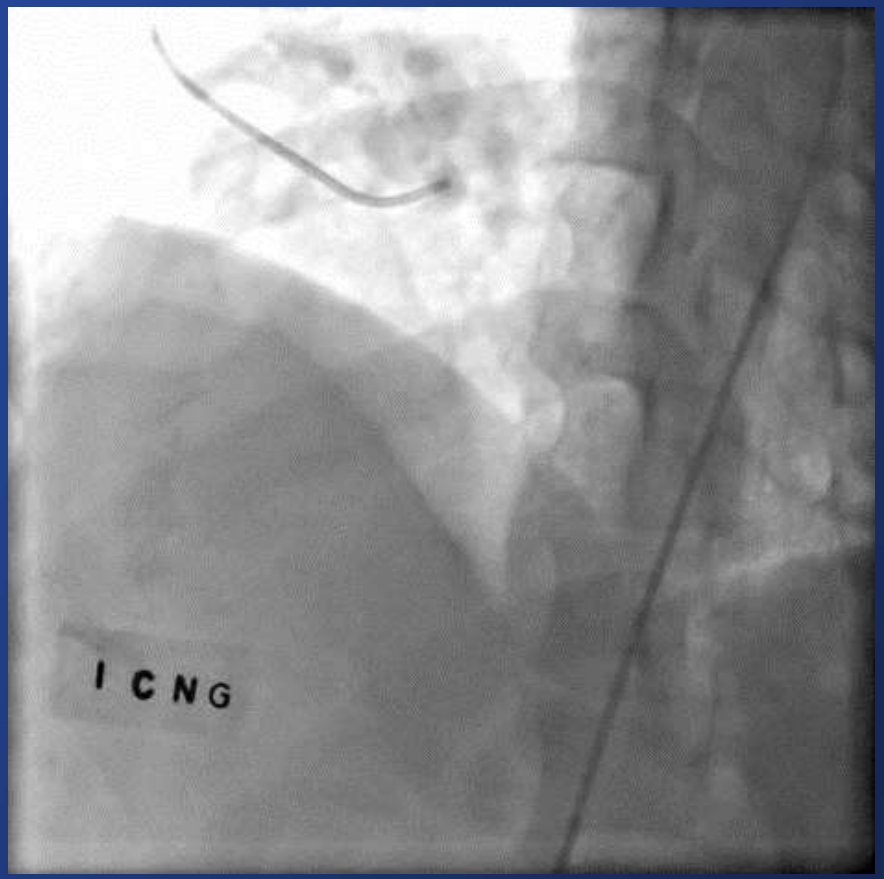
AP Cranial



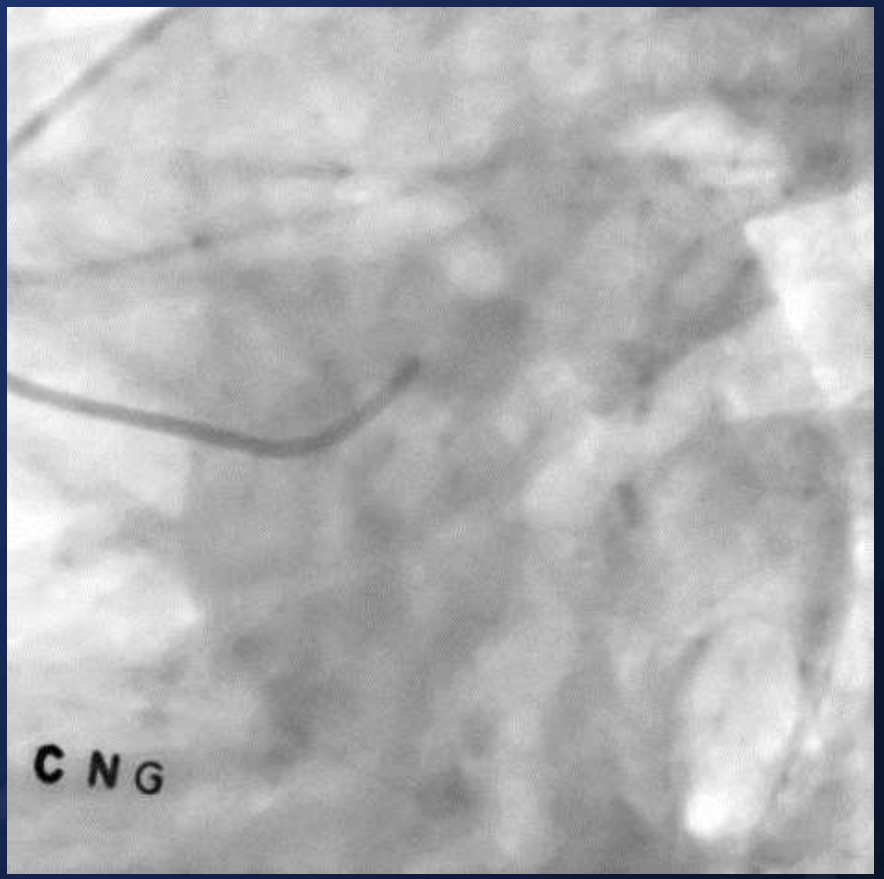
Multi-Stent Technique at LM bifurcation

- Promus Element DES -

LAO Cranial

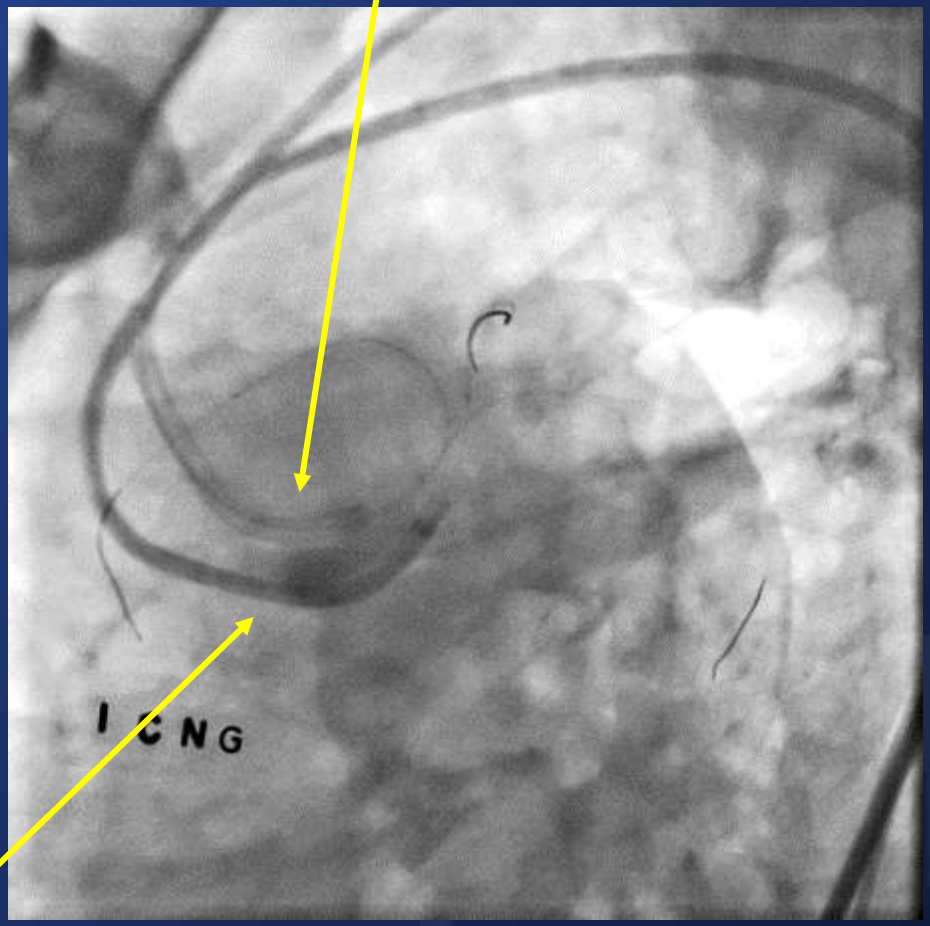


LAO Caudal



Two guiding catheter engagement to LCA

JL4, 8FR via right femoral artery to LAD & LCX

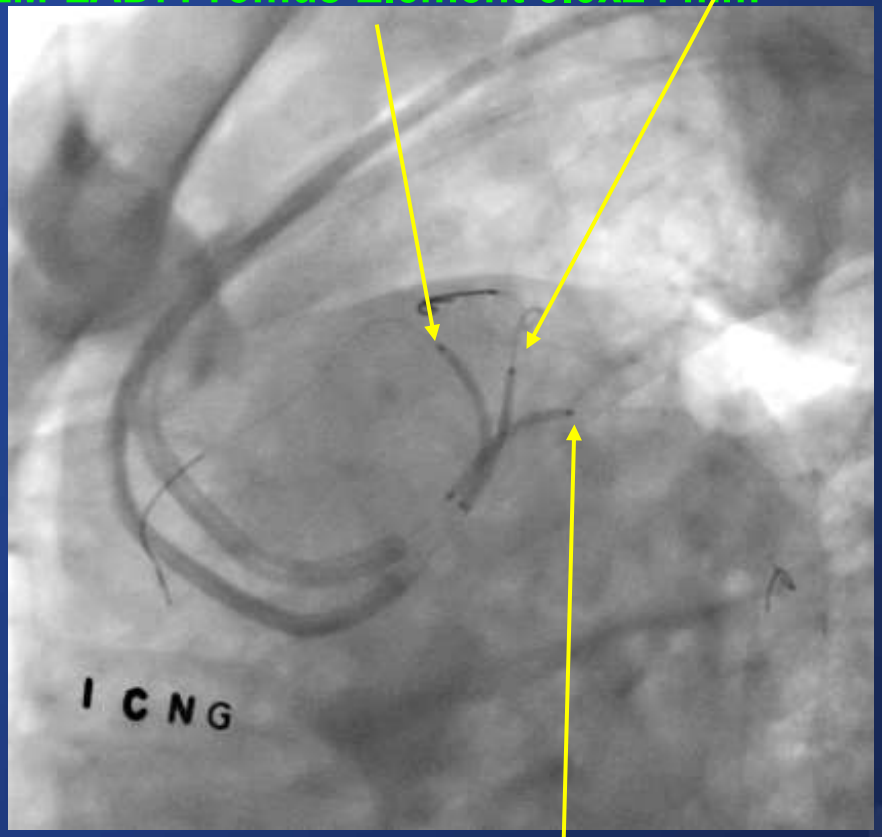


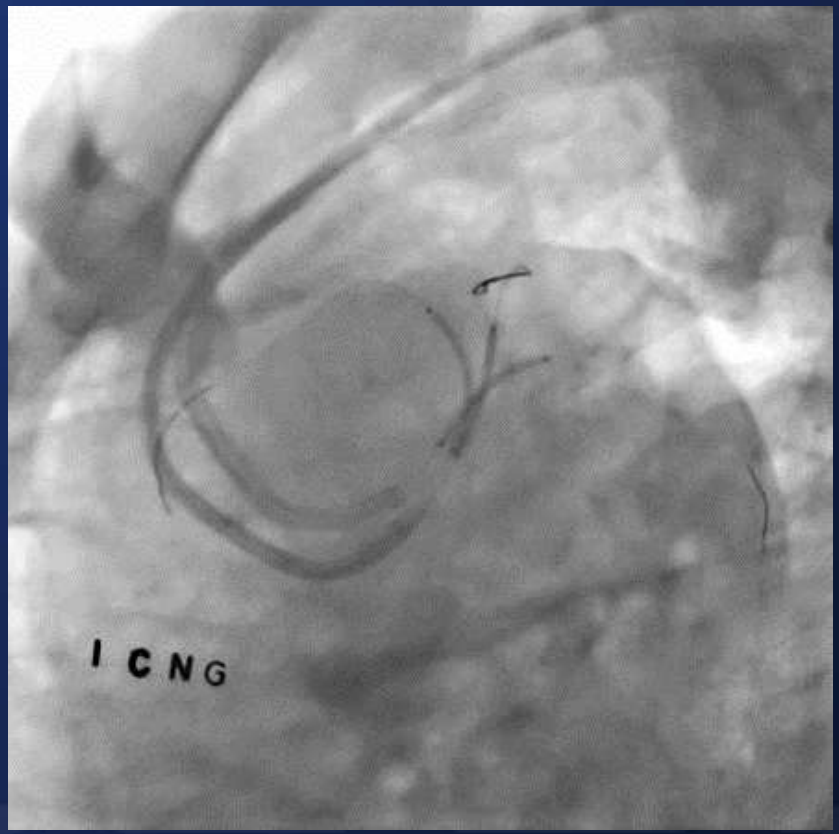
JL4, 7FR via left femoral artery to R.I.

Triple Kissing DES Implantation to Trifurcation

LM-RI: Promus Element: 3.0x20 mm

LM-LAD: Promus Element 3.5x24 mm



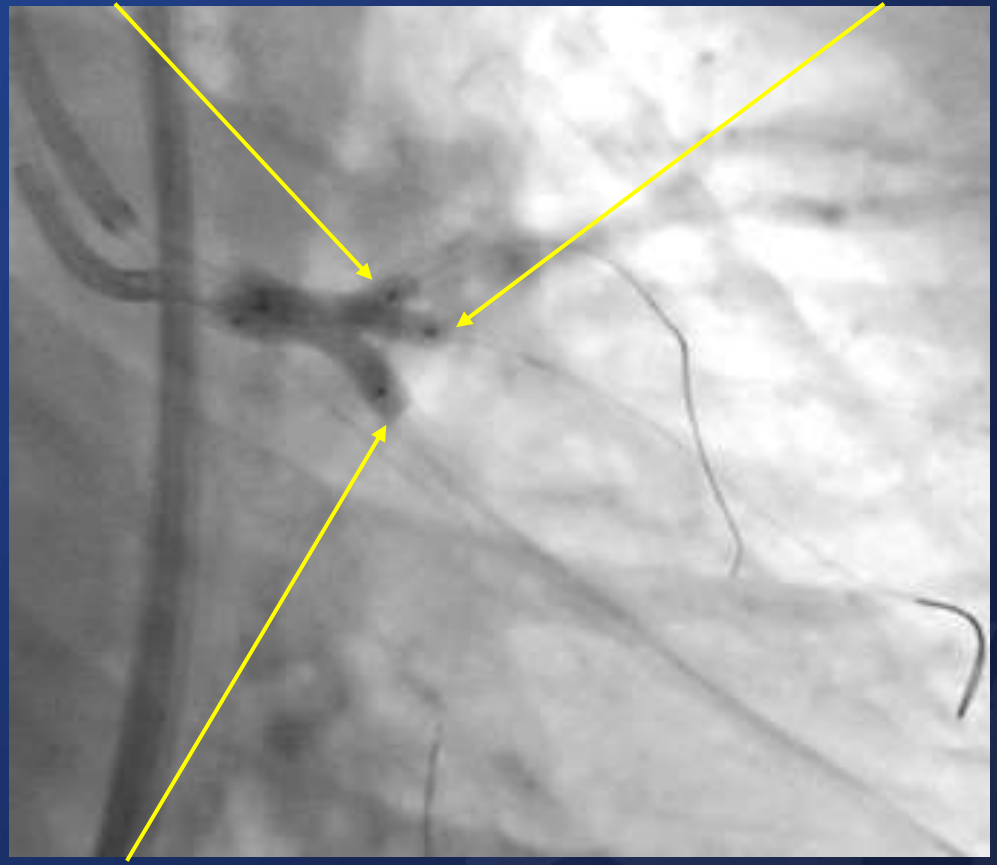


LM-LCX:Promus Element
3.5x20 mm

Adjunctive Triple Kissing Ballooning

LM-LAD: MEO-CROSS 3.5x15 mm (3.5 mm)

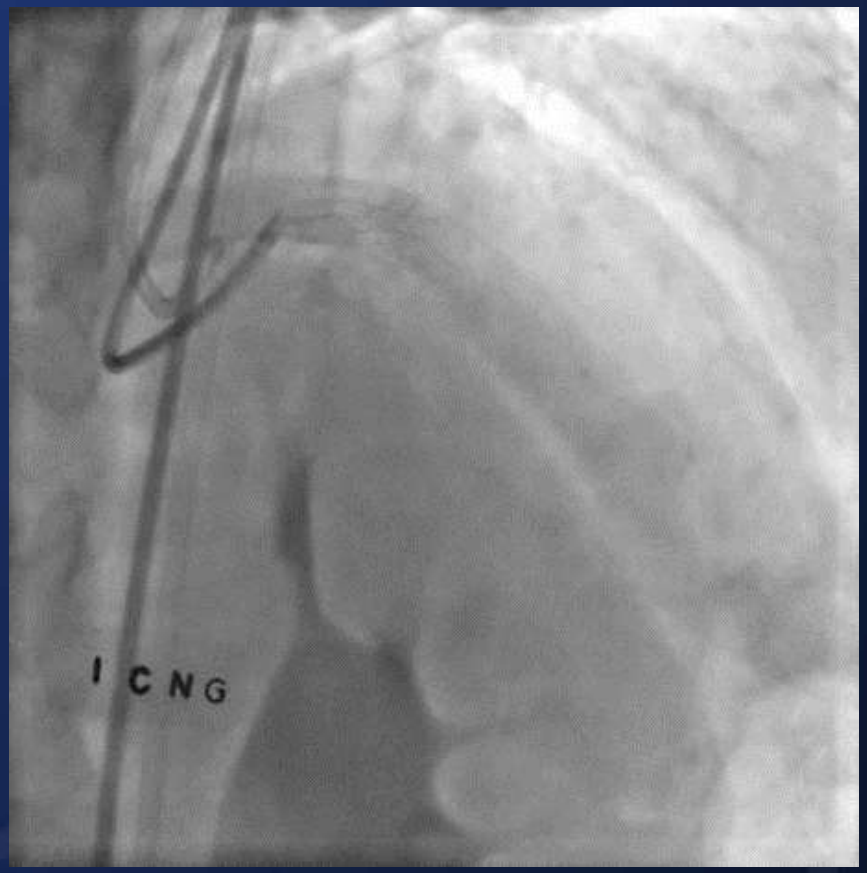
LM-RI: TREK 3.0x15mm (3.5 mm)



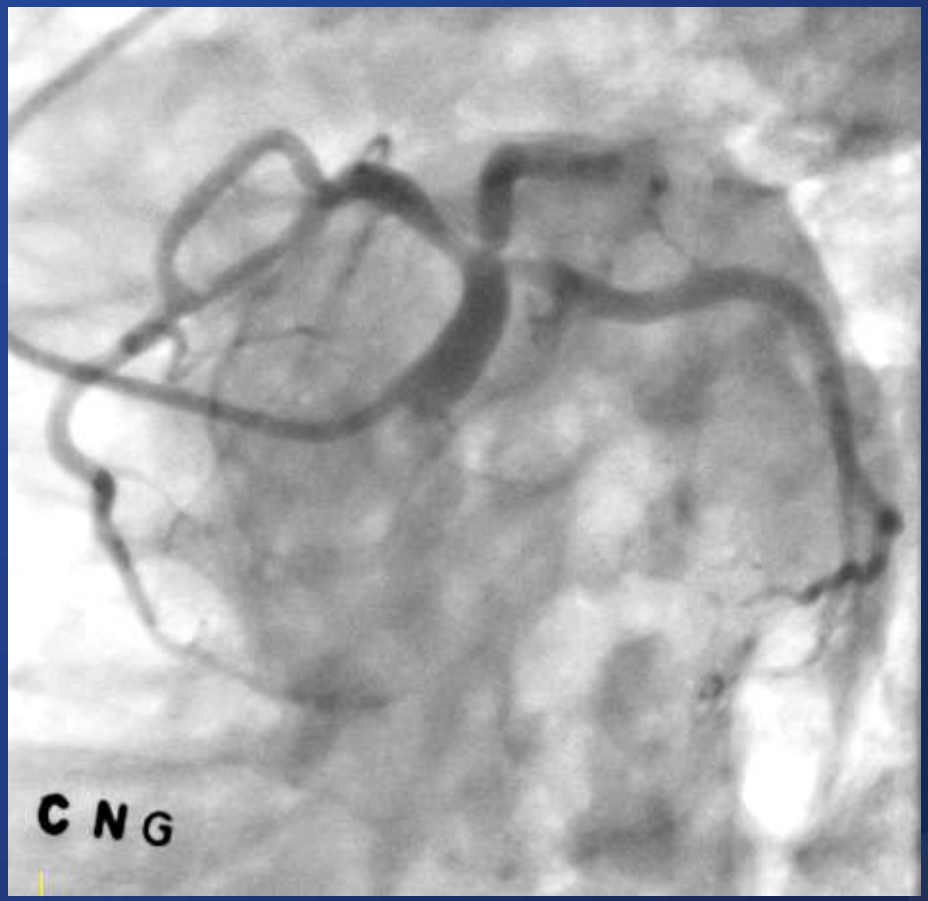
LM-LCX: Sequent 3.5x15mm (3.5 mm)

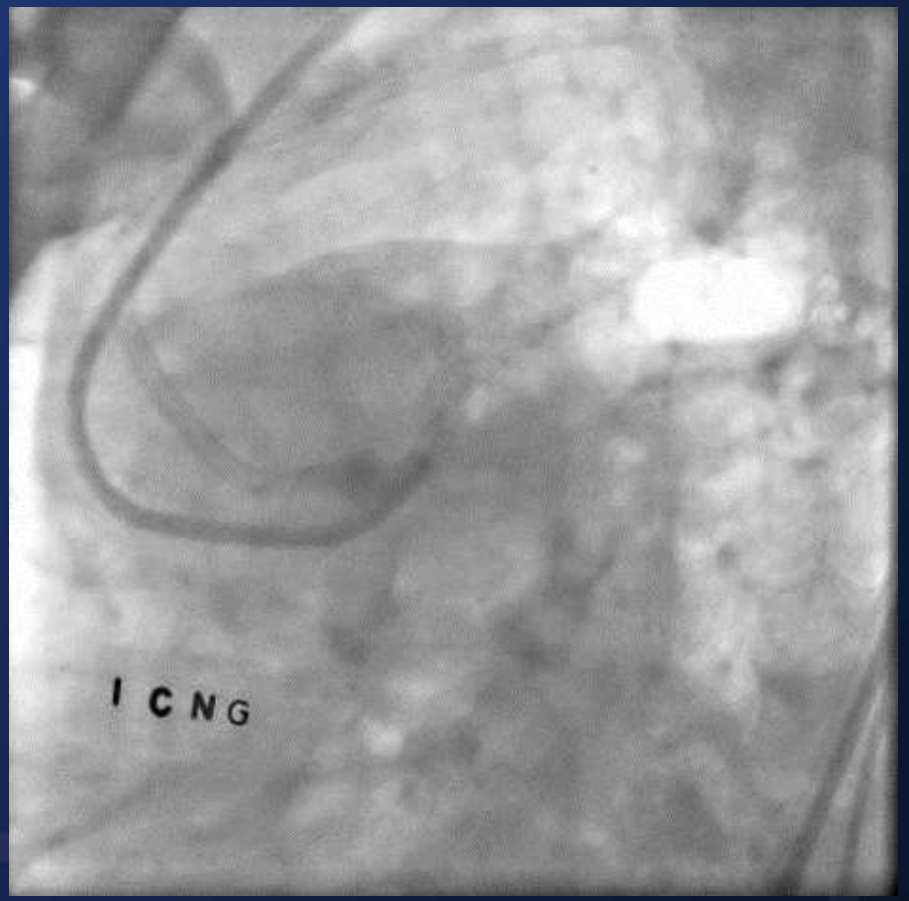
Multi-Stent Technique at LM bifurcation

- New DES -



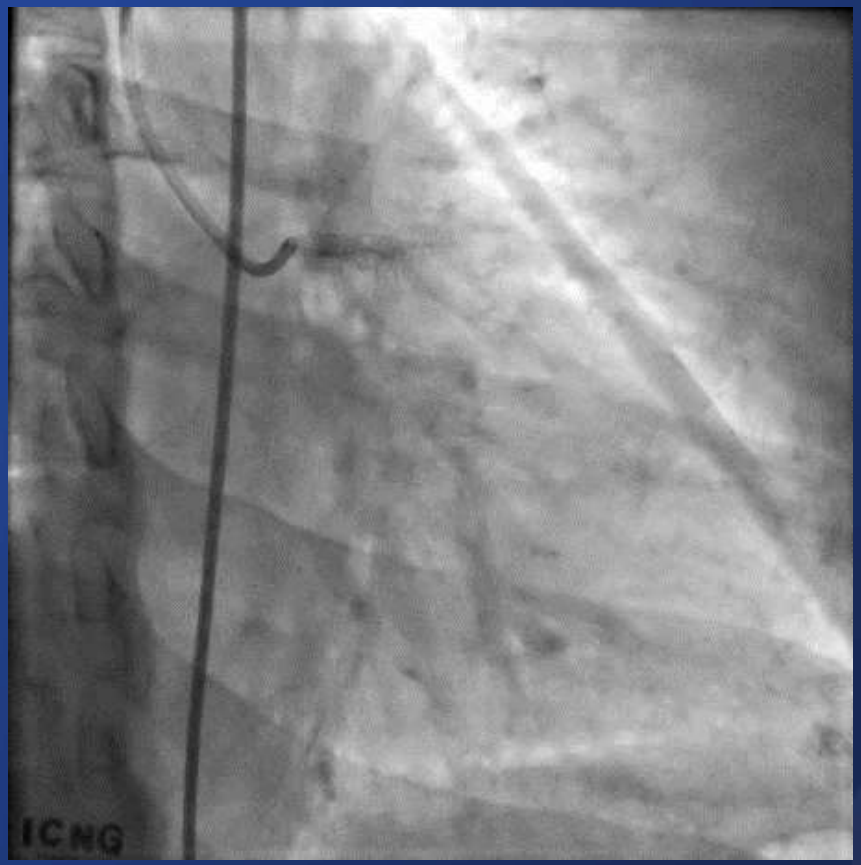
Final Angiography (LAD Caudal)



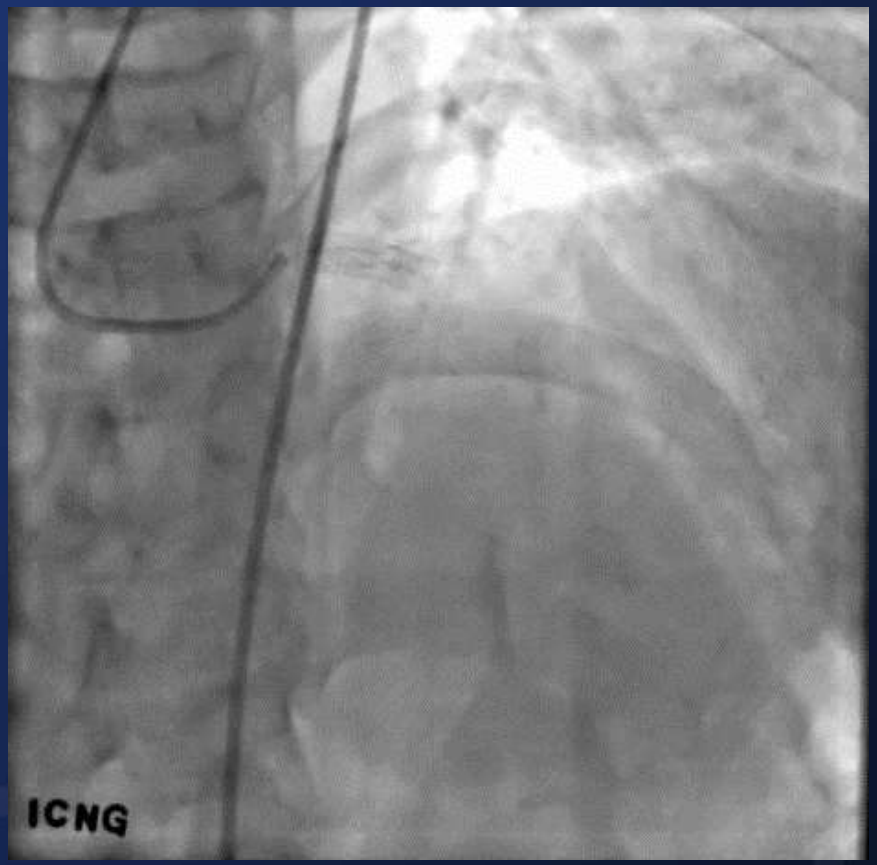


26M Follow-Up CAG

RAO Caudal

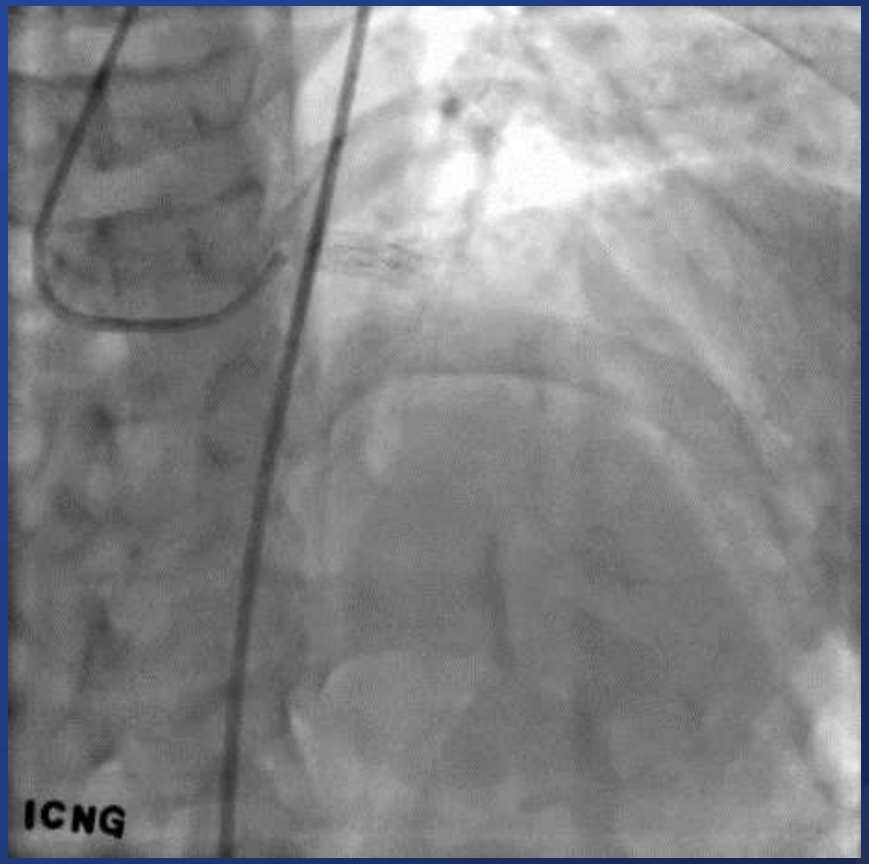


AP Cranial



26M Follow-Up CAG

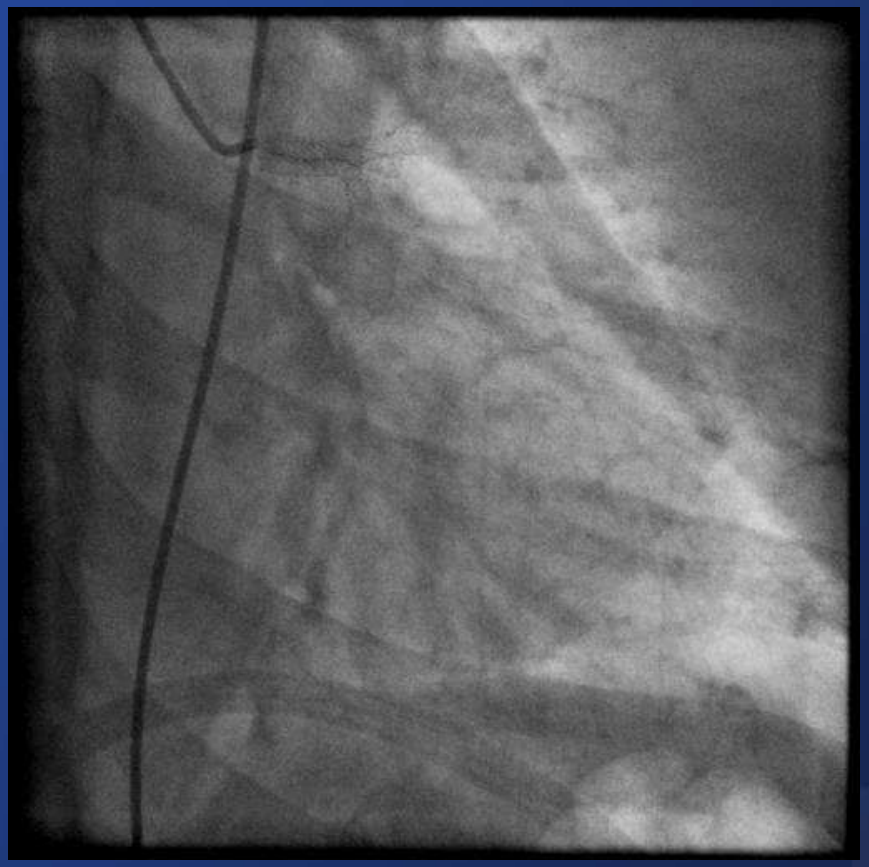
LAO Cranial



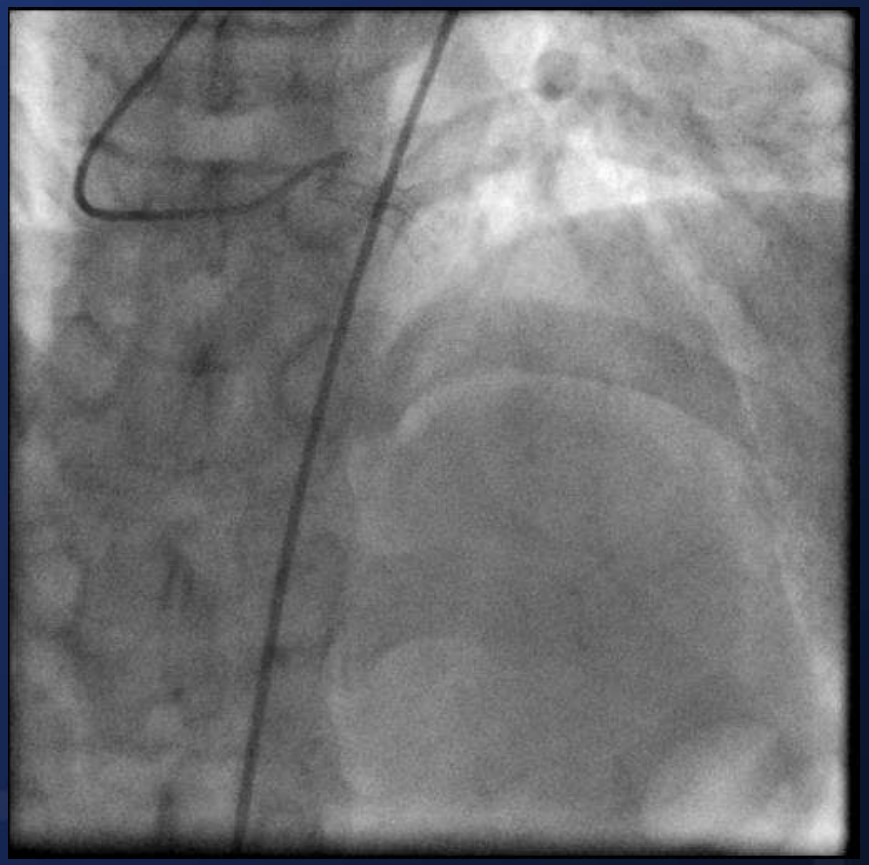
LAO Caudal

38M Follow-Up CAG

RAO Caudal

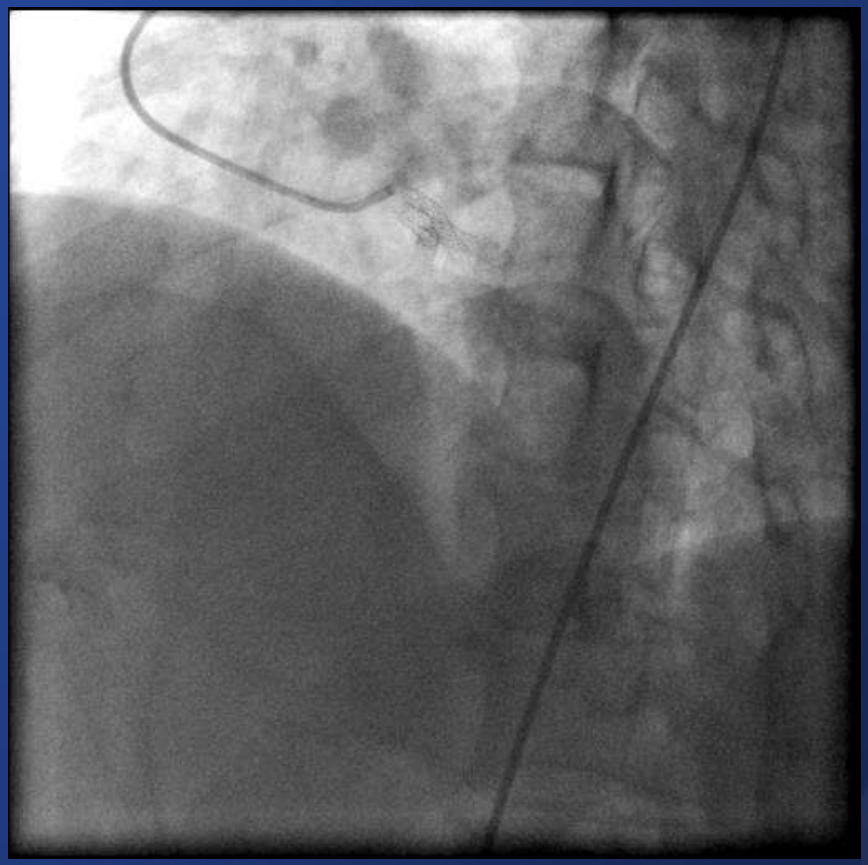


AP Cranial

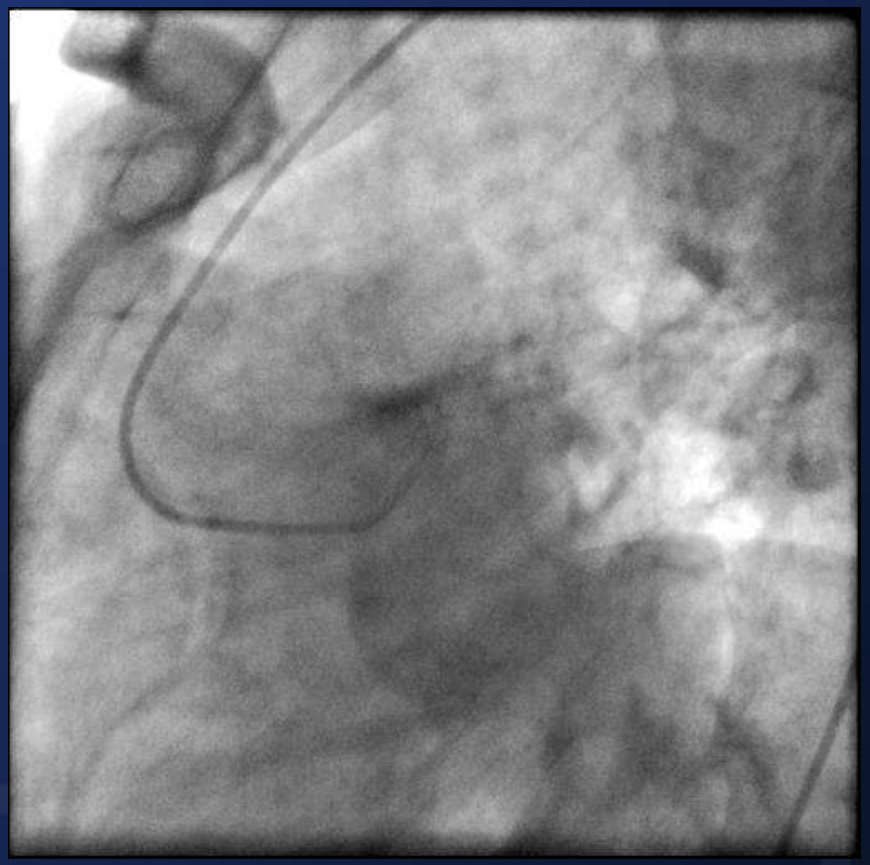


38M Follow-Up CAG

LAO Cranial

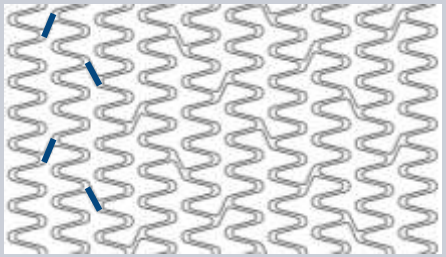
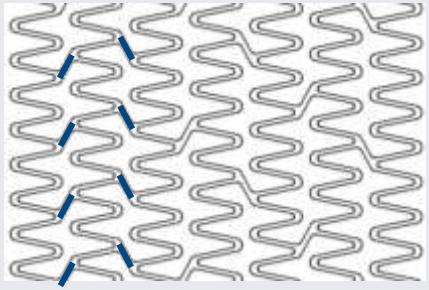
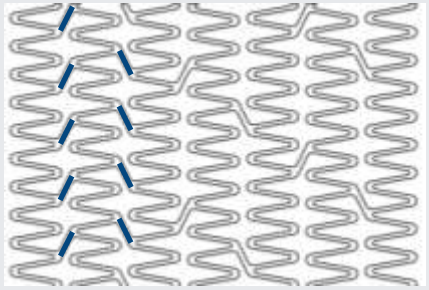


LAO Caudal



Promus PREMIER™ Stent

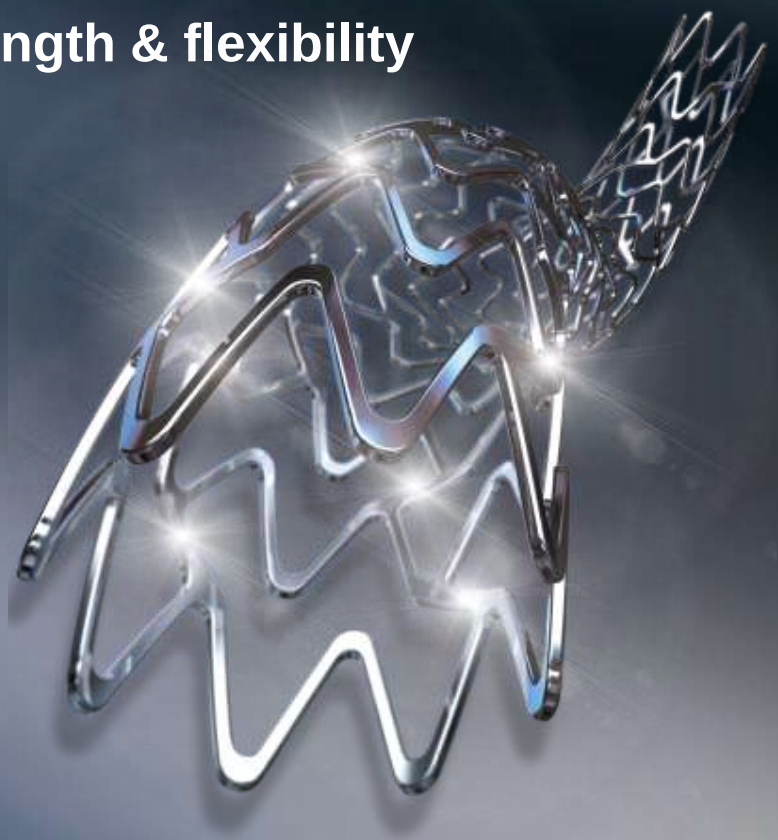
Customized Stent Architecture – 4 Unique Models

Stent Model	# of Peaks	# of Connectors	Proximal End ↓	Distal End ↓
Small Vessel (2.25 mm)	8	2 throughout		
Small Workhorse (2.50-2.75 mm)	8	4 on proximal end; 2 throughout stent body		
Workhorse (3.00-3.50 mm)	8	4 on proximal end; 2 throughout stent body		
Large Vessel (4.00 mm)	10	5 on proximal end; 2 throughout stent body		

Promus PREMIER™ Stent System

Customized for Premier Outcomes

- **Customized stent architecture for strength & flexibility**
- **Outstanding clinical outcomes[1]**
- **Unmatched deliverability[2]**



1. See Directions for Use for clinical outcomes data – PLATINUM Clinical Trial Program.
2. Deliverability bench testing performed by Boston Scientific Corporation on 2.50 mm stents (n = 3). Data on file at Boston Scientific.

Why Does Stent Platform Matter to Perform a Good PCI

HS (Hyo-Soo) Kim, MD/PhD/FAHA

Cardiovascular Center,
Seoul National University Hospital,
Seoul, Korea

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Why Does Stent Platform Matter to Perform a Good PCI

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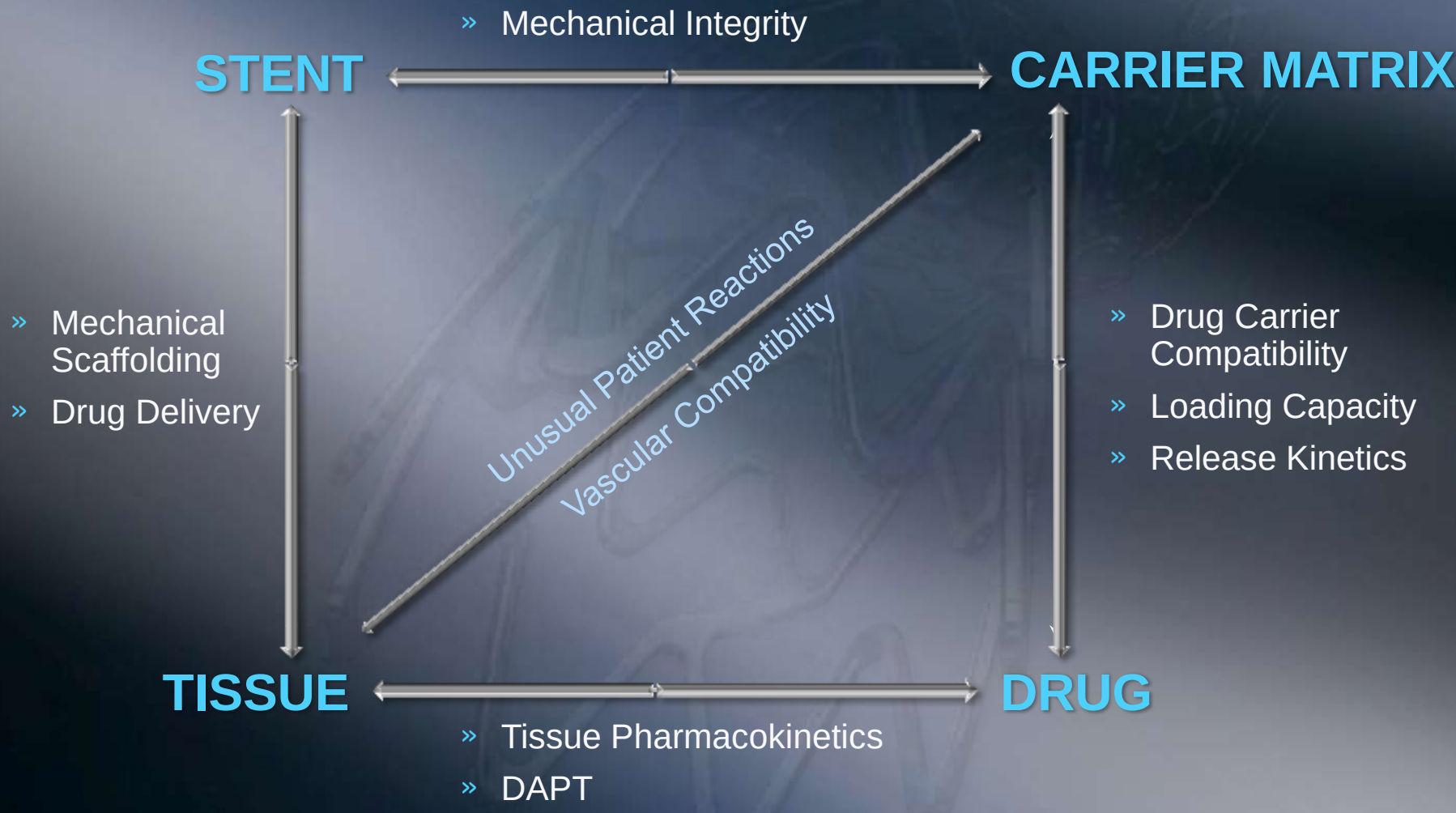
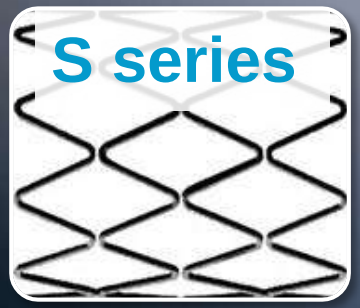
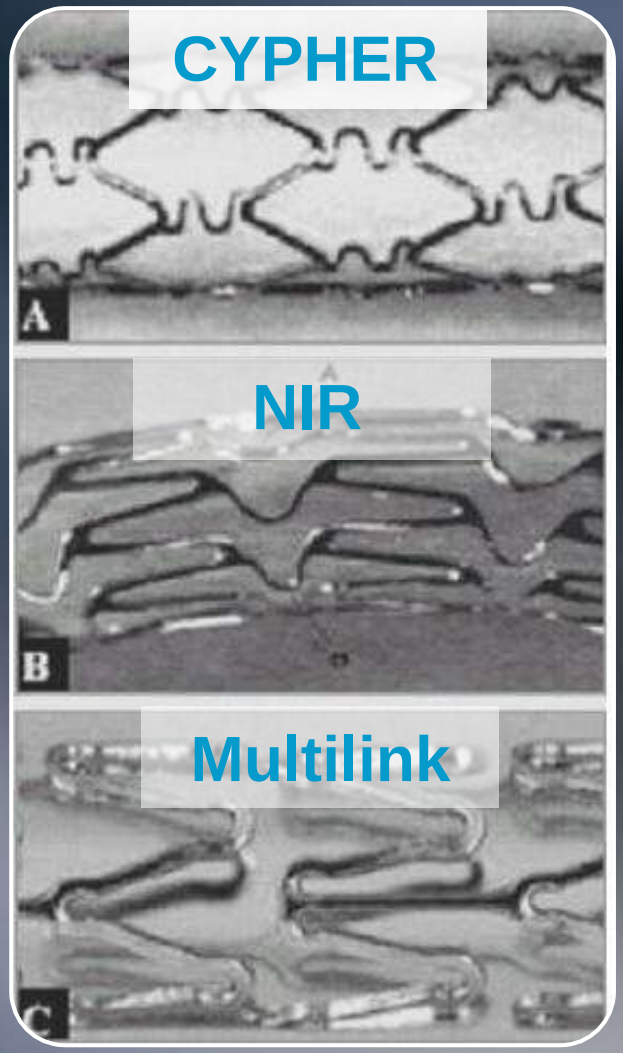
Seoul National University Hospital,
Seoul, Korea

Drug-Eluting Stent Interactions



Some early memories…





Stent and Delivery System Design

A Balancing Act

Key design variables to consider…

Clinical Requirements
- Safety
- Efficacy

Procedural Requirements
- Deliverability
- Radial Strength
- Conformability
- Low Embolization
- Fracture Resistance
- Low Vessel Trauma
- Deflation Time
- Lesion Access
- Size Matrix
- Crossability
- Axial Strength

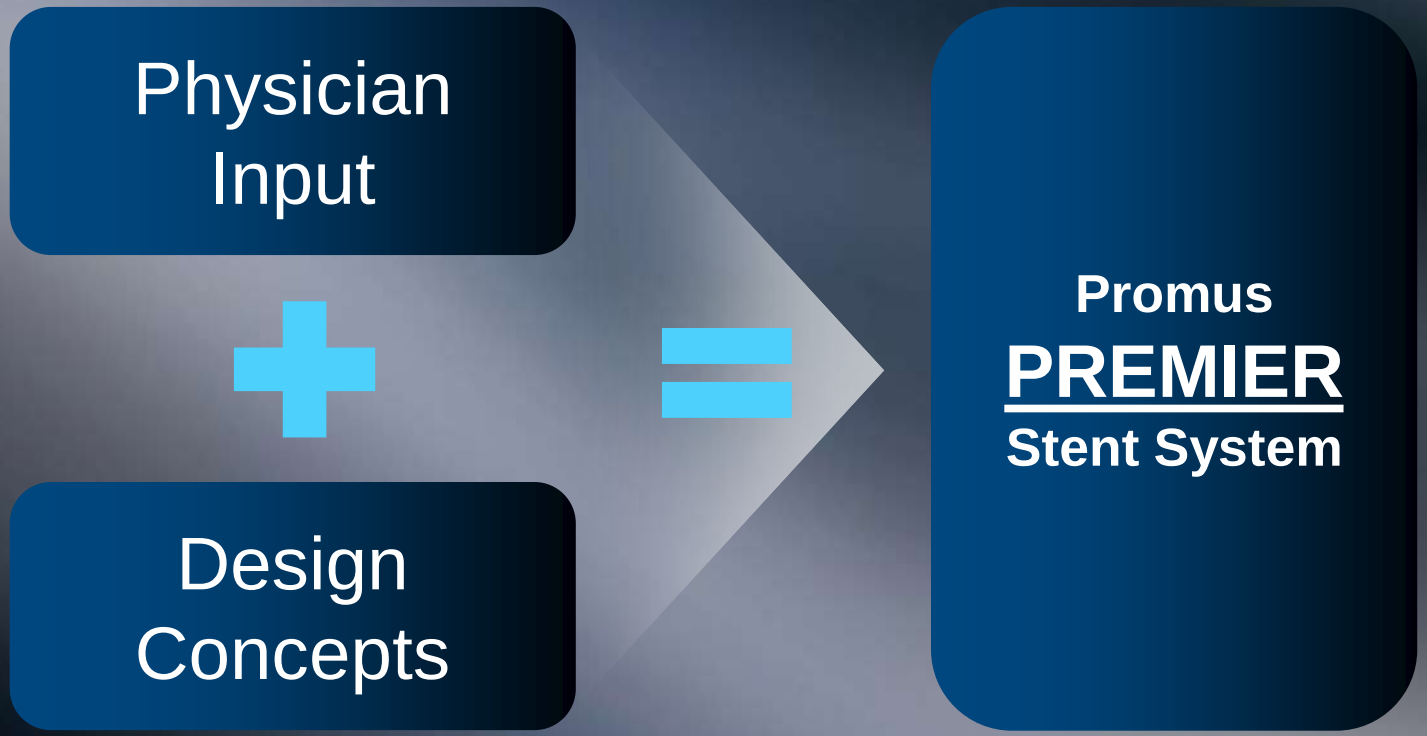
Stent Design Options
- Material
- Geometry
- Strut Thickness
- Number of Connectors
- Manufacturability

System Design Options
- Material Type
  - Shaft and Balloon
- Thicknesses
  - Shaft and Balloon
- Balloon Compliance
- Balloon Overhang and Cone Angle
- Tip and Crossing Profile
- Manufacturability

Promus PREMIER™ Stent System

Design Innovation

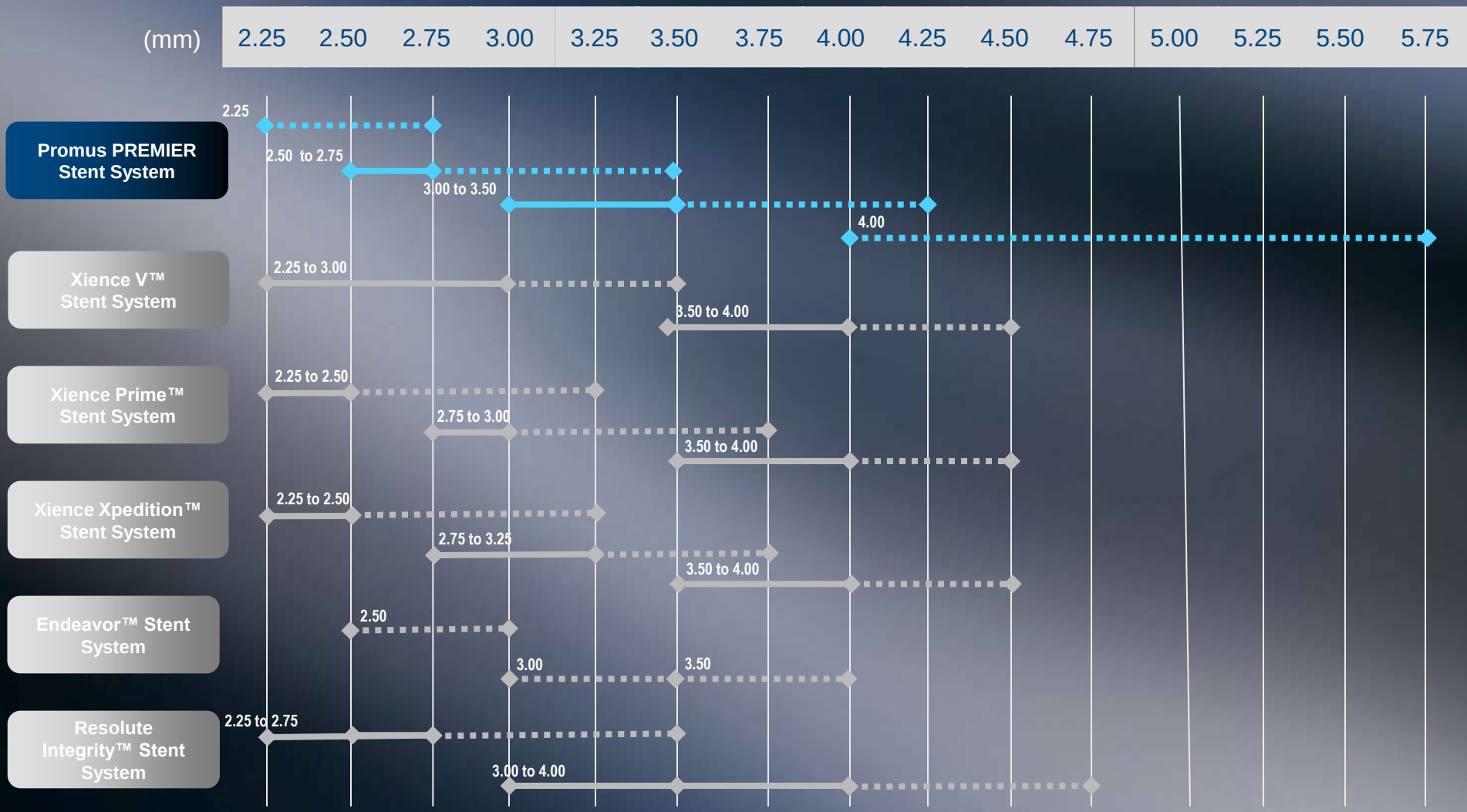
Boston Scientific's Commitment to Innovation



The next advance in stent technology

Labeled Post-Dilatation Limits

Labeled Nominal:
Labeled Post Dil Limit:

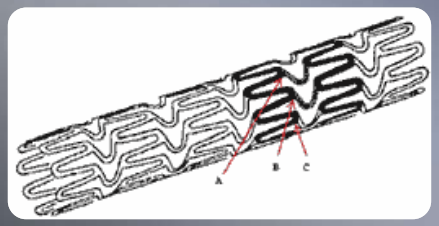


Promus PREMIER Stent System, Xience V Stent System, Xience Prime Stent System, Xience Xpedition Stent System, Endeavor Stent System and Resolute Integrity Stent System Directions for Use.

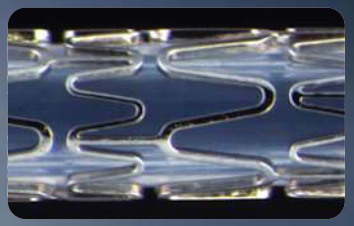
This material is not intended for use in the US or Japan. Please see glossary.

Evolution of Stent Design

NIR™ Stent



Express™ Stent

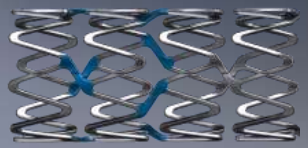


Liberté™ Stent

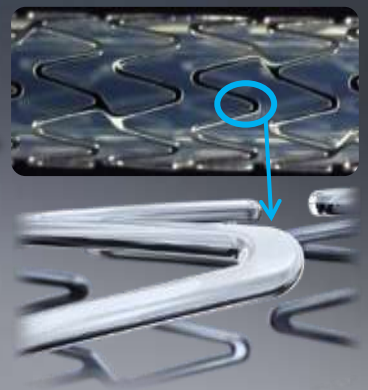
PROMUS™ CoCr Stent

Element™ PtCr Stent

PREMIER™ PtCr Stent



SYNERGY™ Bioabsorbable Polymer PtCr Stent



Specialty, Longer, Smaller, Ostial, Bifurcation, Absorbable scaffolds etc

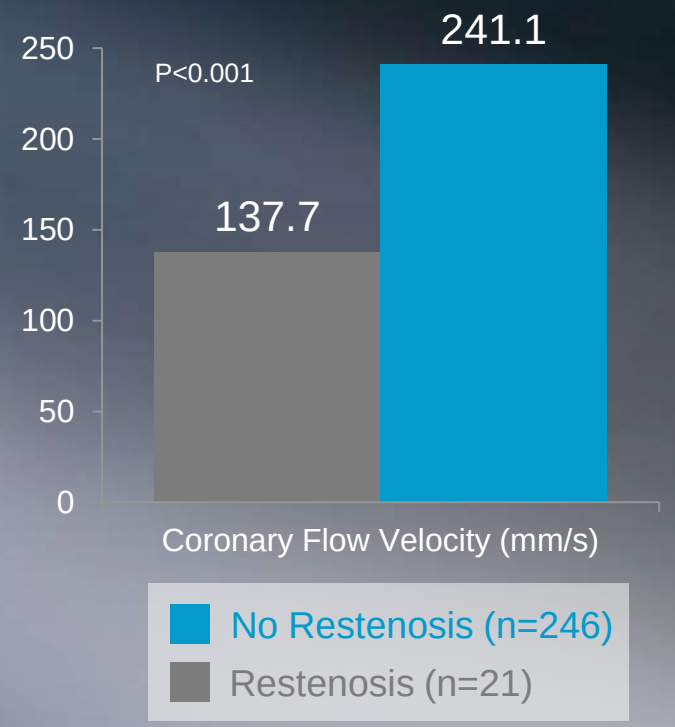
Edge Effects and Restenosis

Stent Edge Effects = More Turbulent Blood Flow

More Turbulent Blood Flow = Lower Flow Velocity

Lower Flow Velocity Leads to Higher Restenosis

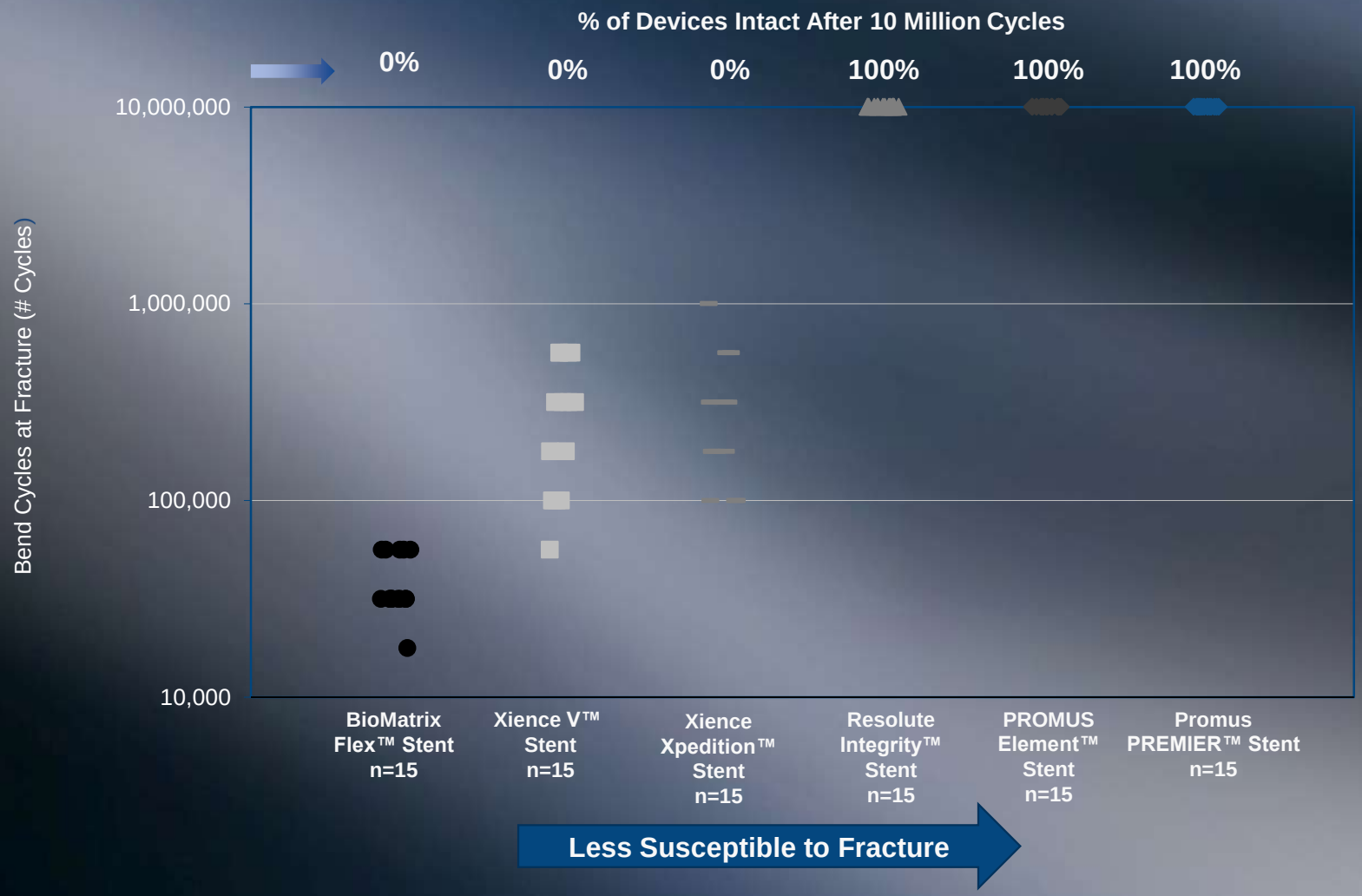
Changes in shear stress and flow velocity associated with restenosis



Hikita et al. Scandinav; Cardiovasc Jour 2009;43:298-303

Bend Fatigue Bench Test[1]

Increased Fracture Resistance



1. Presented by John Ormiston, MD., CRT 2013 Bench test results not necessarily indicative of clinical performance.

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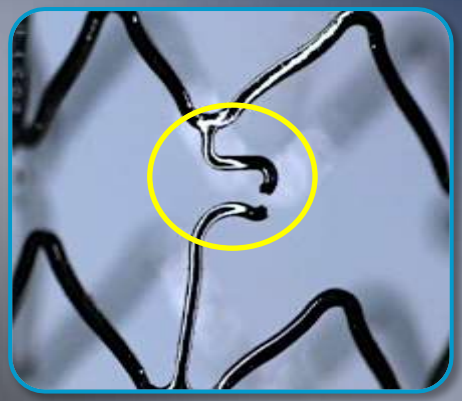
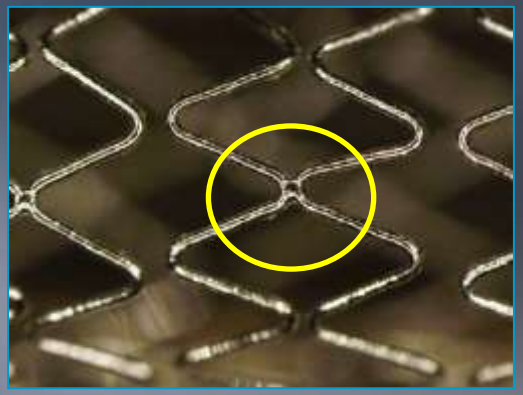
Stent Architecture
Fracture resistance



- BSCs PtCr two-connector designs give maximum flexibility
- 50% wider connectors provide fracture resistance
- No welded connectors or wire limitations



Wider peaks focus strain to **minimize recoil and fracture**

All images are for illustrative purposes only. Data on file at Boston Scientific

New Ormiston Bend Fatigue Bench Test[1]

Increased Fracture Resistance

1 Presented by John Ormiston, MD., CRT 2013

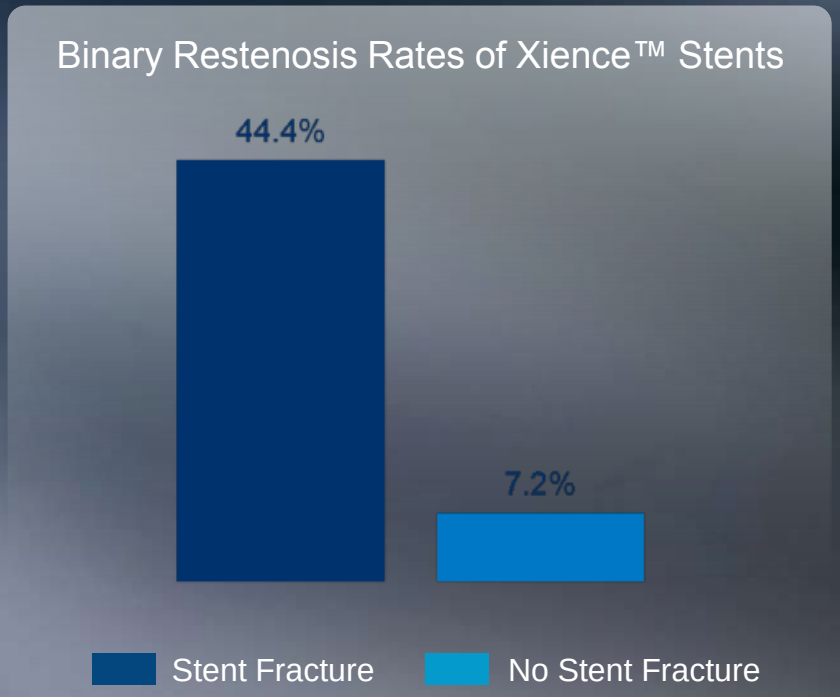
This material is not intended for use in the US or Japan. Please see glossary.

Additional Fracture Data

Izawa,Y et al, ACC 2013

Xience™ Stent Fracture Data

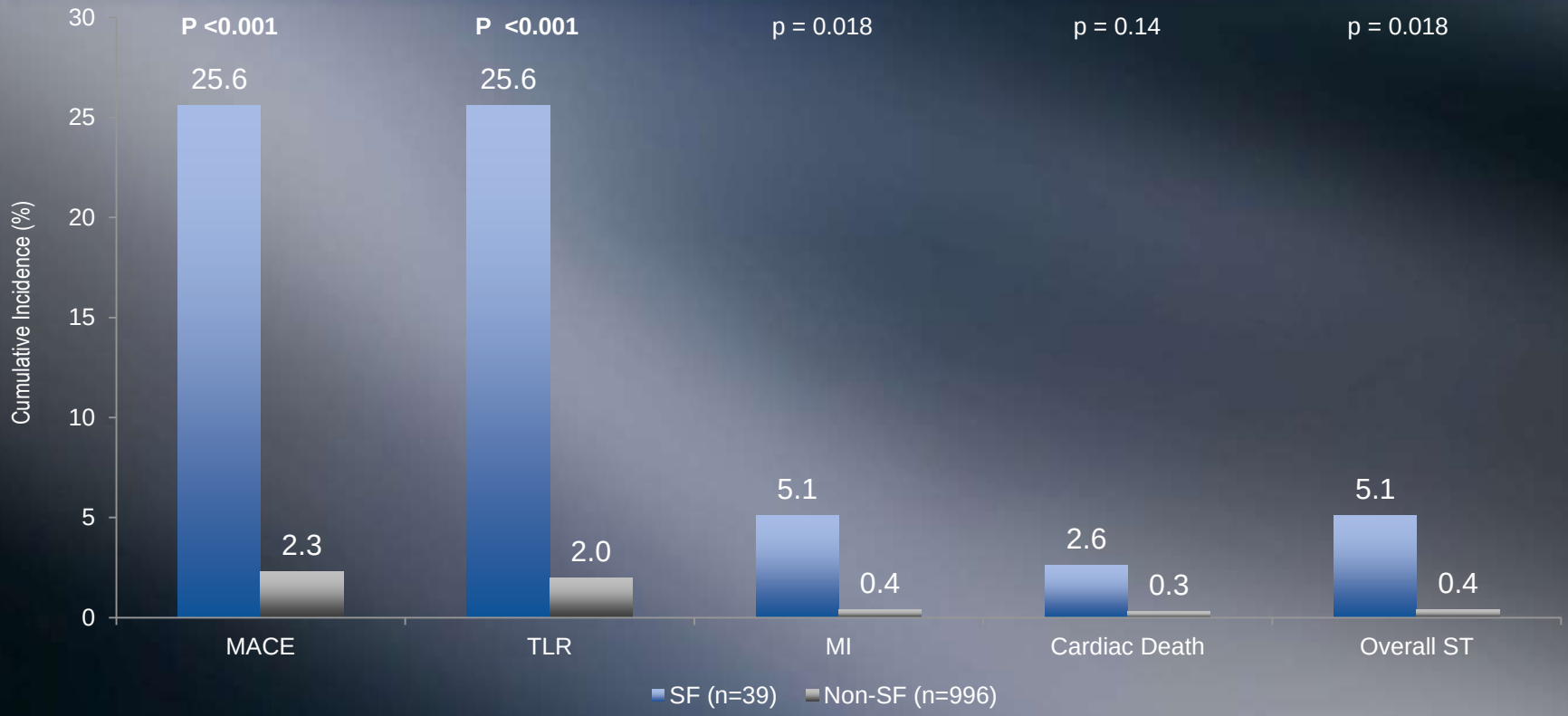
- 2% fracture rate
  ~45 of 2269 lesions had fracture
- Xience Stent Fracture led to a 6-fold increase in binary restenosis when compared to non-fractured Xience Stent*



*Presented by Izawa, Y at ACC 2013.

Xience V™ Stent Fracture
Led to Higher Event Rates

39 Total incidences of **Xience V Stent Fracture (SF) = 2.9%** of total lesions evaluated



Xience V Stent - Major Adverse Cardiac Events within 9-months of Implant

*Presented by Shoichi Kuramitsu, MD; ESC 2012.

Importance of Strength and Conformability in Right Coronary Arteries

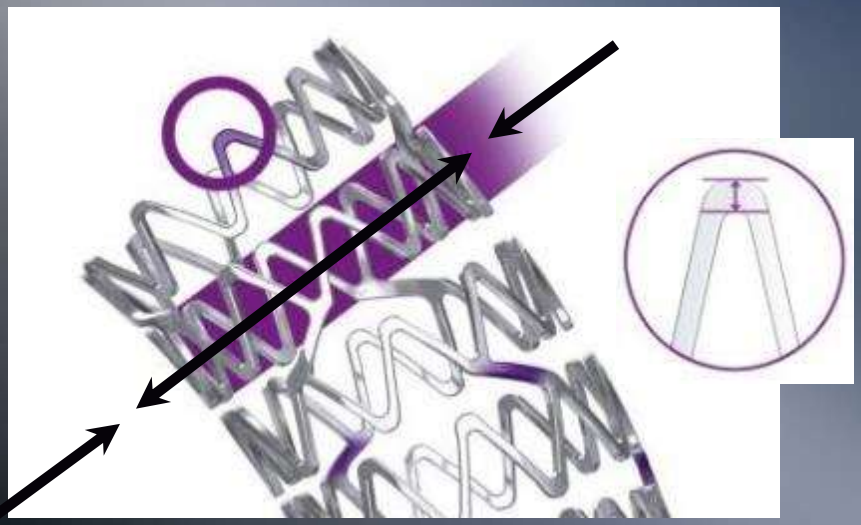
Right Coronary Arteries

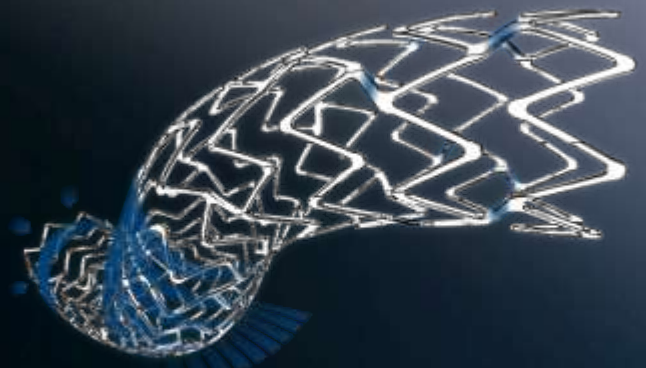
- Represent ~35% of lesions*
- Have lesions in angulated segments 62% of the time**
- Location of 67% of fractures+

*Dehmer, et al, JACC 2012;60:2017-31
**Katritsis, et al. J Int Card 2008;21:140–150
+Kuramitsu, et al. CCI Vol. 5, No. 5 October 2012

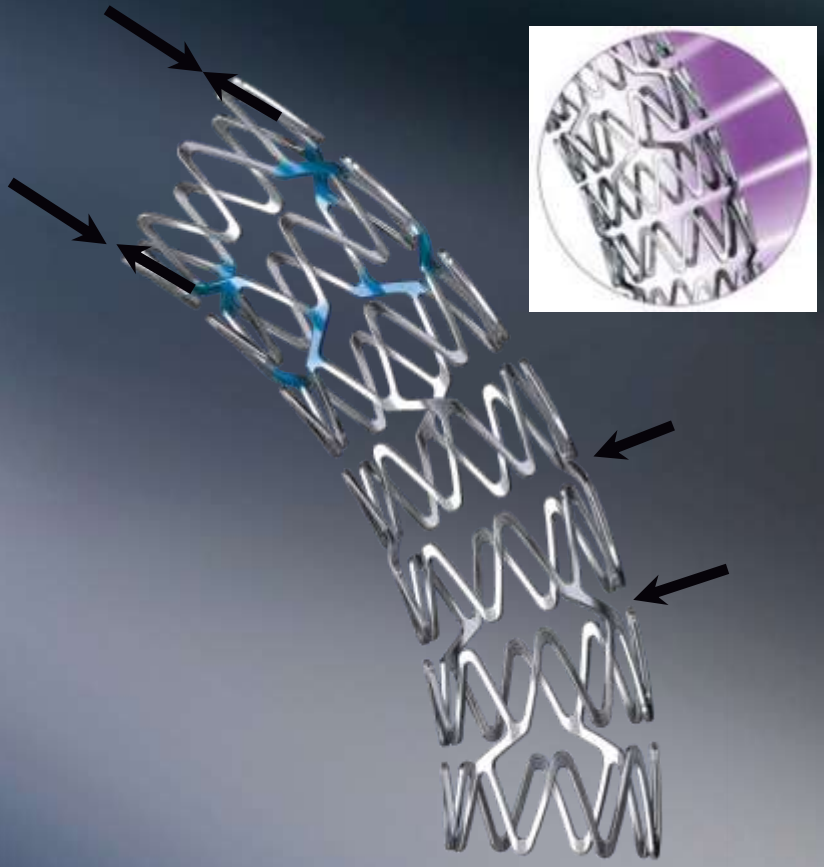
Key areas of stent design

Segment design drives
- Radial strength
- Recoil
- Expansion uniformity





Connector number & design drives
- Axial strength
- Conformability
- Fatigue resistance



Exceptionally Low Acute Lumen Loss