How To Deal With Calcified Lesion:
Expert's Concept & Technique

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Speaker's name: .....

☐ **I have the following** potential conflicts of interest to report:

- ☐ Consulting
- ☐ Employment in industry
- ☐ Stockholder of a healthcare company
- ☐ Other(s)

☐ **I do not have any potential conflict of interest**

Speaker's name: Teguh Santoso

V **I do not have any potential conflict of interest**

Why Is Calcification Considered As Non Favorable Condition For PCI[1]

Higher risk of ***post-stenting complications***, such as dissections, vessel perforations[2-4]

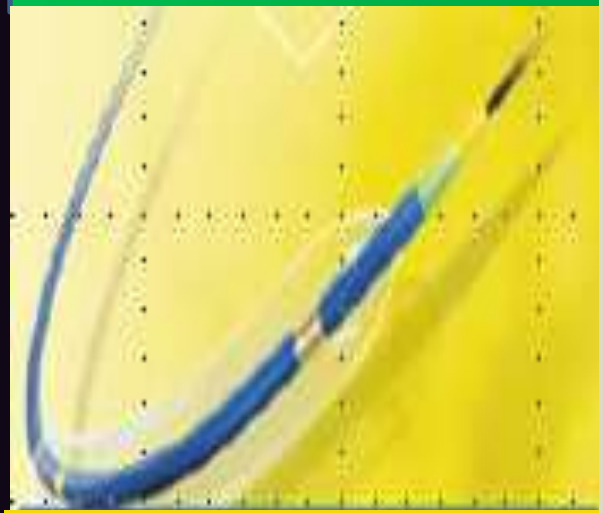
Higher risk of stent thrombosis & restenosis because of ***incomplete stent apposition***[2-4]

Special ***challenges for DES / BRS implantation***[5]:

1. More difficult to deliver to the lesion site
2. Vigorous manipulation of DES can result in disruption of polymer coating & reduced effectiveness
3. Suboptimal deployment
4. Impaired local delivery of the drug through calcified lesion

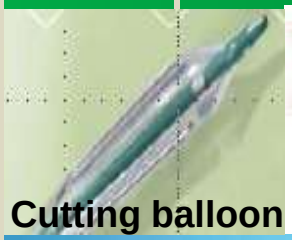
1. Park SJ, et al. Circ Cardiovasc Intervent 2009;2:59-68 ; 2.Fujii K, et al JACC 2005;45:995–998, 3. Berenguer A, et al. Am Heart J 2005;150:536–542, 4. Migliorini A, et al. Am J Cardiol 2005;96:1110–1112.; 5. Rathore S, et al. Cathet Cardiovasc Interv 2010;75:919–927

Soft plaque			Resistant plaque	
All comer lesions	ISRS	Ostial, bifurcation	Fibrotic lesions	***Calcified lesions***
Optimize stent deployment	Avoid slippage	Avoid plaque shift	Change lesion compliance	



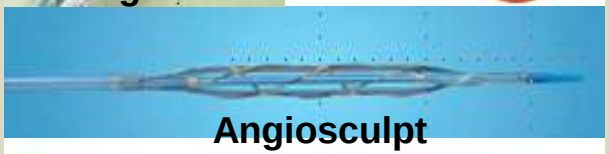
Compliant/NC balloon

Conventional pre-dilatation

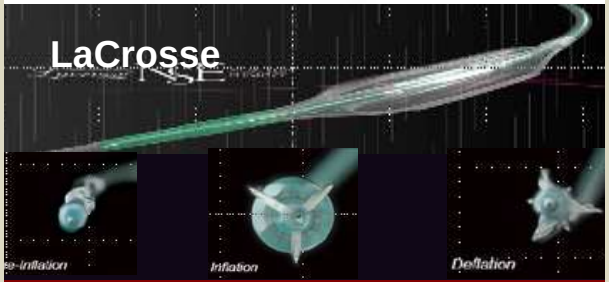


Cutting balloon

Scoreflex



Angiosculpt



Plaque scoring

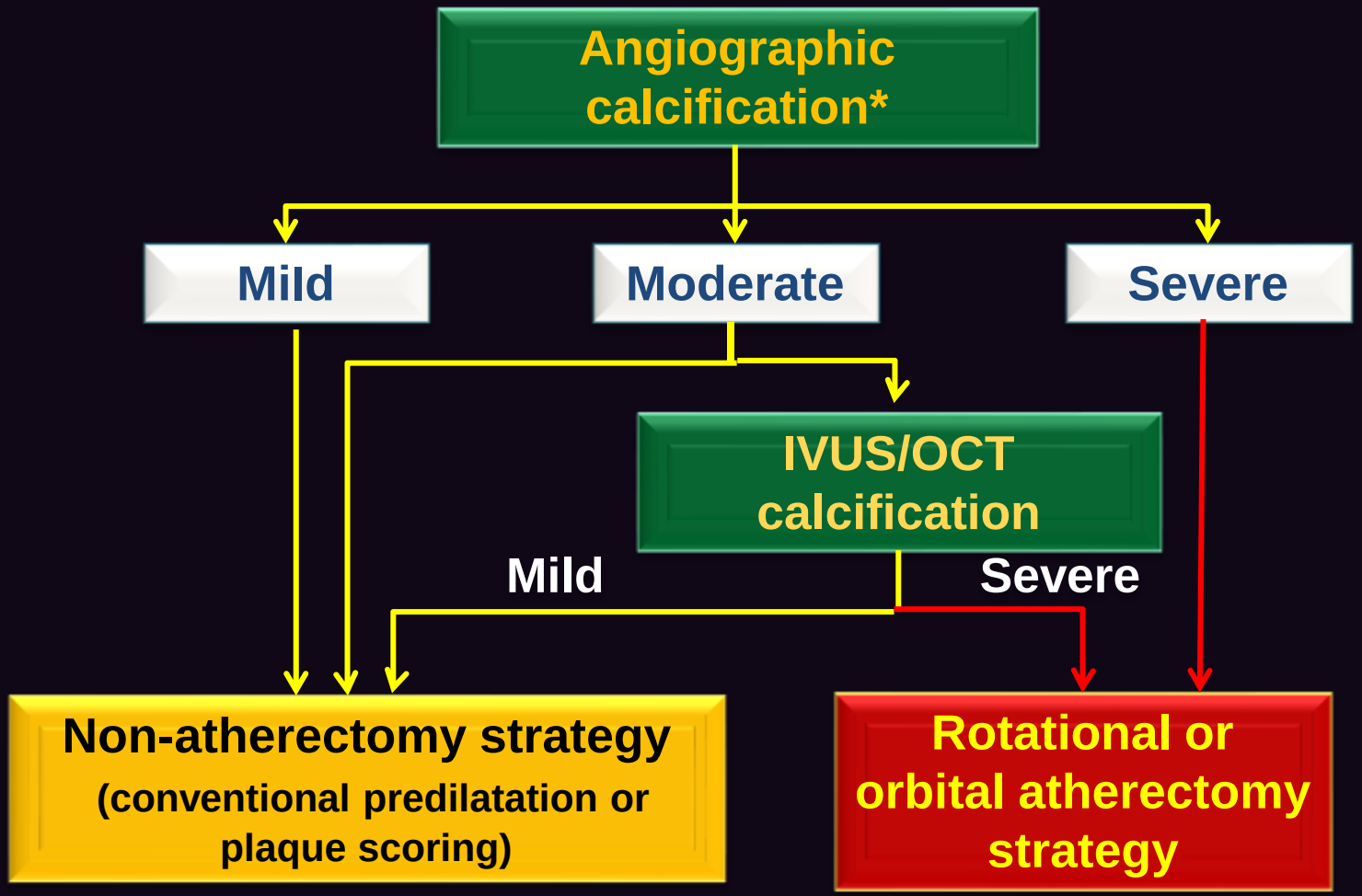
Rotablator

Orbital atherectomy

Excimer laser atherectomy

Plaque modification /debulking

Algorithm for Management of Calcified Lesions



If degree of calcification is intermediate or indeterminate by angiography, ***IVUS or OCT*** may be useful for reclassification.
However, it is important to have ***low threshold for rotablation for BRS implantation***

* Mild-moderate: densities noted only during the cardiac dycle; Severe: radioopacities visible without cacdiac motion before contrast injection surrounding the complete lumen of the coronary artery

Plaque Scoring For Calcified Lesion

When ?

- *Mild or moderate* calcification

- *Severe calcification*, as adjunctive treatment after rotablation/orbital atherectomy

How ?

Balloon diameter selection

- Balloon to artery ratio < 1.1 (vessel ≥ 3.0 mm)
- Balloon to artery ratio 1.0 (vessel < 3.0 mm)

- If using IVUS, measure media to media & maintain 1:1 balloon to artery ratio

- Slow inflation

Balloon length selection

- *Shorter length* easier to deliver, esp. in tortuous anatomy

- *Re-inflation* along *length of lesion* acceptable

Plaque Scoring For Calcified Lesion

Advantages

- *Precise* dilatation
- Scores plaque by *severing the elastic/fibrotic continuity* of the vessel wall (including calcified area)
- Dilatation at *lower pressures* with less recoil vs. POBA
- Lumen gain through *plaque compression* instead of vessel wall expansion
- *Better vessel preparation* reduces stent malapposition
- *Lower residual % diameter stenosis* (vs. POBA + stent)
- *No slippage* on deployment
- Minimal *plaque shift*
- Less acute *complication* vs. POBA

Rotational Atherectomy: *Indications*

More For Plaque Modification / Lesion Preparation

- To change lesion compliance
- To help minimize vessel trauma
- To increase MLD
- To reduce plaque burden &/or minimize plaque shift
- To facilitate stent delivery & deployment

- Moderate to severe calcification:
  - Easier advancement of balloons/stents
  - Better strut symmetry/apposition
- Calcified, ostial lesions (RCA, LM)

Contraindications of Rotational Atherectomy

Labeled contraindications:

- *Last remaining vessel* with compromised LV function
- *Saphenous vein grafts*
- Angiographic evidence of *thrombus* pre-treatment
- Angiographic evidence of *significant dissection* at treatment site
- *Occlusions* not passable with guide wire

Relative contraindications*:

- Severe unprotected *LM or 3VD*
- Severe *LV dysfunction*
- Lesion length *> 25 mm*
- Lesion angulation *> 45^0*
- Unavailability of CABG

Tomey, MI, et al. J Am Coll Cardiol Intv 2014;7:345–53

Preprocedural Preparation For RA

- *Hydration*
- *Appropriate BP*
- Assess:
  - LV regional & global function
  - Status of other vessels / collaterals
- *Avoid GP IIb/IIIa inhibitors* in complex tortuous/angulated lesions
- *Temporary pacemaker* not always necessary, but may sometimes be advisable:
  - Large right dominant RCA
  - RCA is the most of the remaining circulation
  - LCX lesion that provides collaterals to RCA

Guide Catheter Selection For RA

- Coaxial, good support (*coaxial position* is more important than good GC support):
  AL is good for LCX, as it can be manipulated to "telescope" into the LCX
- GC with *rounded curves* better (easier to get the burr)
  For *LCA, EBU better than JL*
- *Side holes* may increase perfusion & promote particle clearance:
  But *usually not needed*
- Beware of "*fish-mouthing*" of soft tip GC:
  As it can *hinder advancement* of large burrs
- If only small burr is needed, use of smaller GC is better:
  As it can *intubate the ostium* (less debulking of the ostium)

Guide Wire Selection & Manipulation

- 4 types (A, C, Extra Support, Rotawire Floppy) – all substandard to PCI GWs
- *Avoid inadvertent kinking (difficult advancement, & if inside the coronary artery – may induce perforation)*
- *Interrogate GW bias*
- *No double wiring*
- In *very complex* cases, use conventional PCI GW & exchange via a *microcatheter* (save time & contrast)
- Placed the *distal tip distal to the lesion*
- *Don't* place the distal tip in a *small branch* (any of its rotation once the burr is activated can result in GW fracture)
- In *tortuous RCA or serpentine LAD*, the GW may induce "*pseudolesions".*

  DD/: *new thrombus, occult lesions, dissections* (pull the GW until the flexible tip is in the pseudolesion or change to a soft PTCA GW)

Burr Selection For RA

- Burr-artery ratio ≈ 0.6 – 0.85
- Uncertain → smaller is always safer

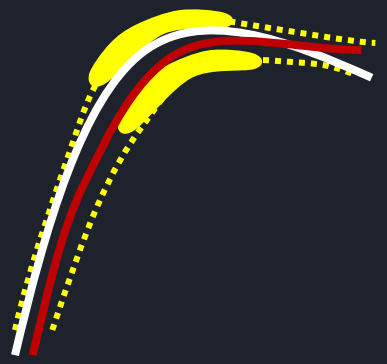
Burr size (mm)	1.25	1.5	1.75	2.00	2.15	2.25	2.38	2.50
Minimum ID (inch)	.053	.063	.073	.083	.089	.093	.098	.102
Guide size (F)	6F	6F	7F	8F	8F	9F	9F	10F

When To Choose Undersize Burr

- *Excessive plaque burden :* (long, heavy calcification, CTO)
- Lesion *proximal tortuosity*
- *Angulated segments of > 60^0* (i.e.: higher risk of perforation)
- Vessels with *pseudolesions*
- Severe *GW bias* in the proximal segment

Burr Advancement

- Platform speed *140.000-190.000* rpm
- Be gentle, excessive pressure on the lesion produces friction & heat
- *No decelerations > 5000 rpm* (otherwise: poor flow & CPK rise may ensue)
- Run time usually *< 30 seconds*
- Too much pressure & uncontrolled jump forward of the may result in:
  - burr stalling,
  - thermal damage,
  - generation of large particle
  - spiral dissection



Rotawire ***Floppy*** tends to go to greater curvature side

Rotawire ***Extrasupport*** tends to go to lesser curvature side

Flow & Hemodynamics During RA

- When ablating a lesion, *flow should not be totally obstructed for more than a few seconds* – retract burr until complete clearance of contrast occurs
  - To insure that particulates created by the ablation can be cleared in small increments
- *Vasospasm or attenuated distal flow* are warning signs of *slow/no-flow phenomenon*
  - Use *flush solution* (nitrates, verapamil)(*through the driveshaft or IC) or liberal use of *IC nitrates*
- *Low BP* secondary to *transient bradycardia* may indirectly related to hypovolemia
  - Give *SA, pressor infusion*

*** 0.9% NS 1000 cc, heparin 10,000 U, verapamil 10 mg = 10 mcg/mL, nitroglycerin 5 mg = 5 mcg/mL**

Complications Of Rotational Atherectomy

Complications common to PCI:

1. MI
2. Stroke
3. Urgent CABG
4. Vascular access complications
5. Death

Angiographic complications:

1. Dissection
2. Perforation
3. Short term closure
4. Side branch loss
5. Slow flow / no reflow phenomenon
6. Vasospasm
7. Burr entrapment (burr stall)

Tomey, MI, et al. J Am Coll Cardiol Intv 2014;7:345–53

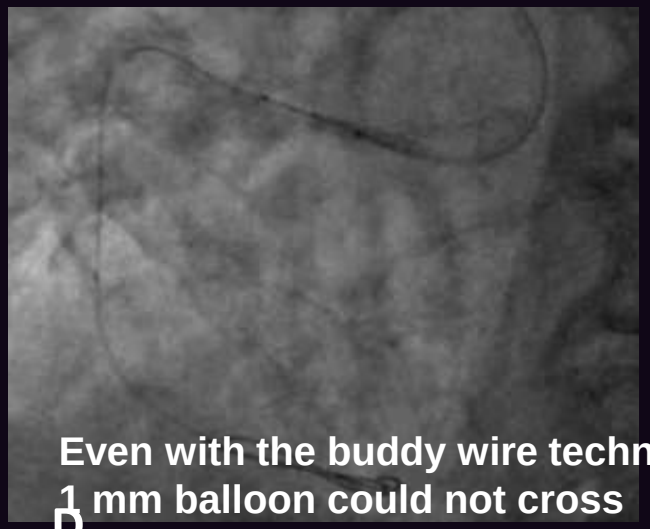
Case 1: Heavily Calcified Ostial & Angulated Prox. RCA

Relative Contraindication

A

Heavily calcified ostial & prox. RCA stenosis

B



Even with the buddy wire technique, 1 mm balloon could not cross

C

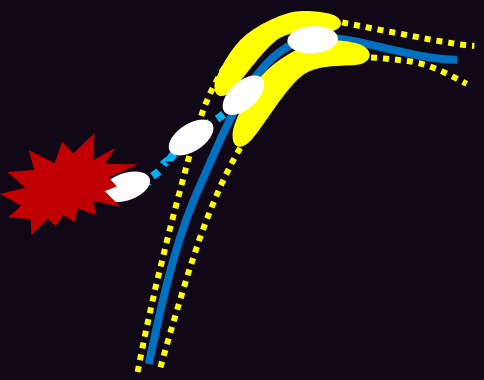
RA of the ostium & halfway RA for the prox.RCA

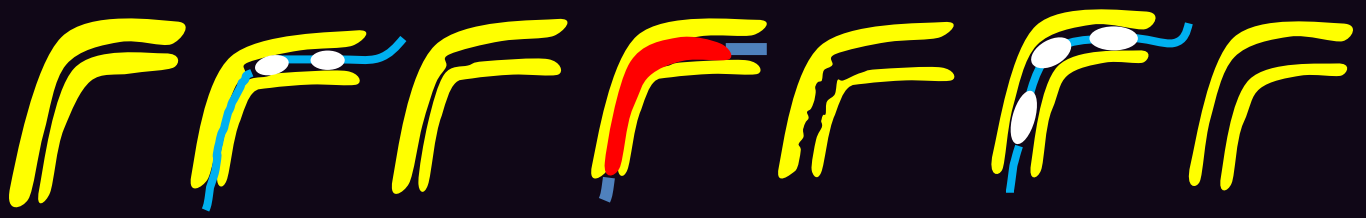
D

Balloon dilatation

Note: (1). *Co-axiality* of AL GC (prevent GW dissection & aortic perforation); (2). GC is *not intubated;* (3). *Very slow burr* advancement with slow pecking motion; (4) *Halfway RA* for the acutely angulated prox. RCA

Halfway Rotational Atherectomy





Half way RA, small burr

Balloon dilatation

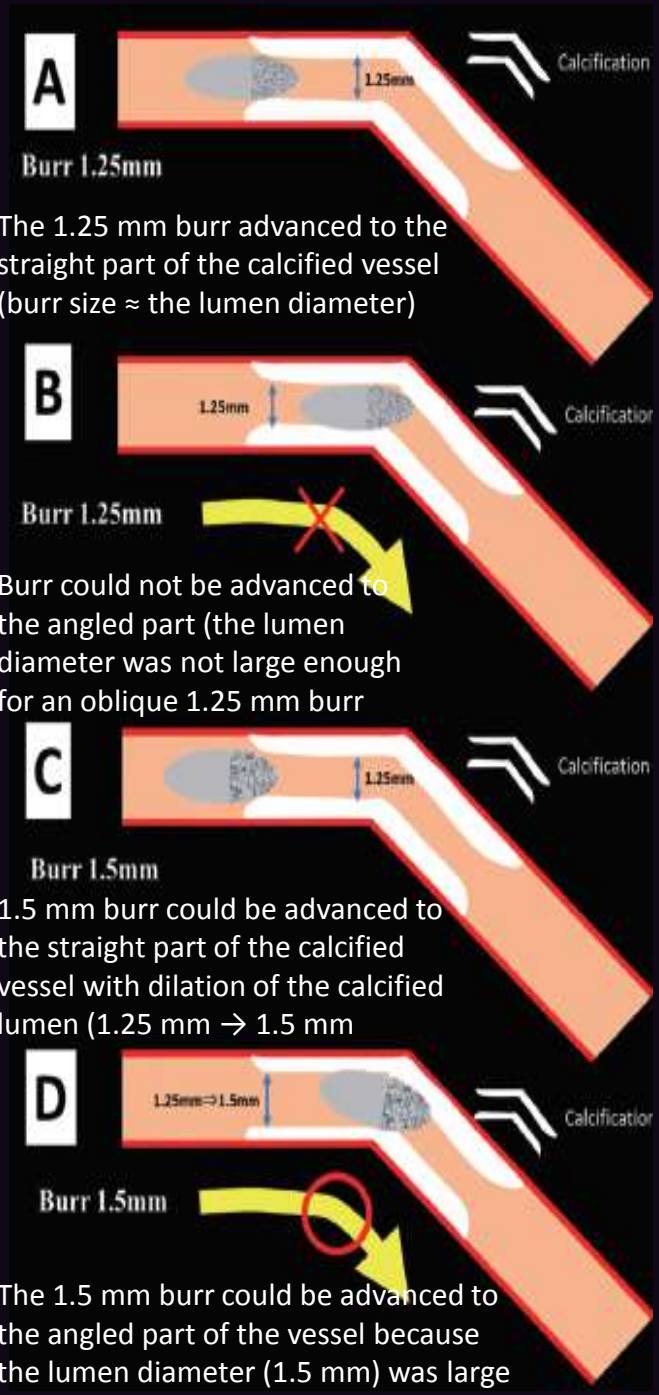
RA with bigger burr

Angulated lesion is prone for
perforation & burr entrapment

	Halfway rotational atherectomy	Conventional Rotational atherectomy	Comments
Advantages	Low risk of vessel perforation or burr entrapment	Lesion can be more easily dilated with a balloon, if the burr advances beyond the angle.	The manufacturer does not recommend RA for angulated lesion of $\geq 45^0$
Disadvantages	No guarantee that the lesion beyond the angle could be dilated with a balloon	Higher risk of vessel perforation and burr entrapment	Switch from halfway RA to conventional RA is easy, because there would be no severe complications following halfway RA

Sakakura K, et al. Int Heart J 2016; 57: 376-379

When a Burr Can Not Penetrate the Calcified Lesion, *Increasing Burr Size* as Well as Decreasing Burr Size Can Be a Solution in Rotational Atherectomy

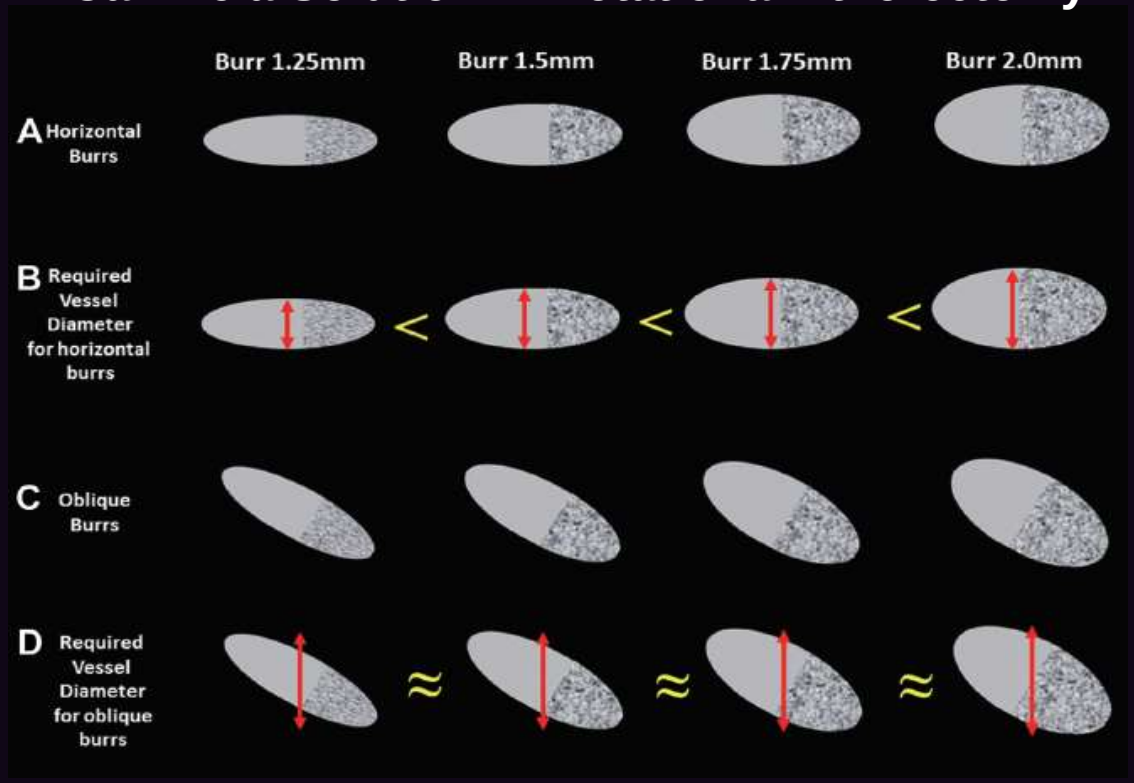


The 1.25 mm burr advanced to the straight part of the calcified vessel (burr size ≈ the lumen diameter)

Burr could not be advanced to the angled part (the lumen diameter was not large enough for an oblique 1.25 mm burr

1.5 mm burr could be advanced to the straight part of the calcified vessel with dilation of the calcified lumen (1.25 mm → 1.5 mm

The 1.5 mm burr could be advanced to the angled part of the vessel because the lumen diameter (1.5 mm) was large enough for an oblique 1.5 mm burr



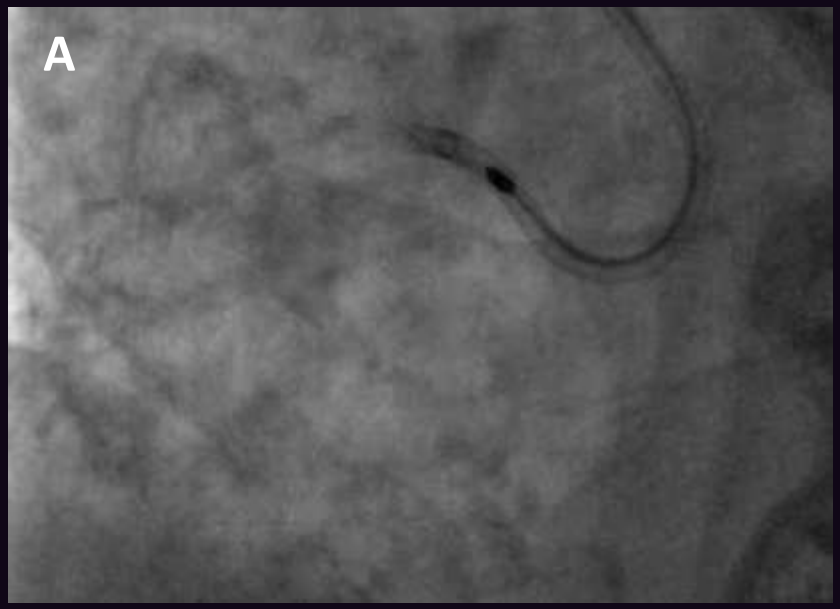
When a burr cannot penetrate the lesion, ***downsizing*** of the burr is generally recommended.

Changing the GW from rotawire floppy to rotawire extra-support (or from extra-support to floppy) is another option. Because the sizes of the long axes are the same between the burrs, the ***required vessel diameters in oblique burrs are similar between the burrs***

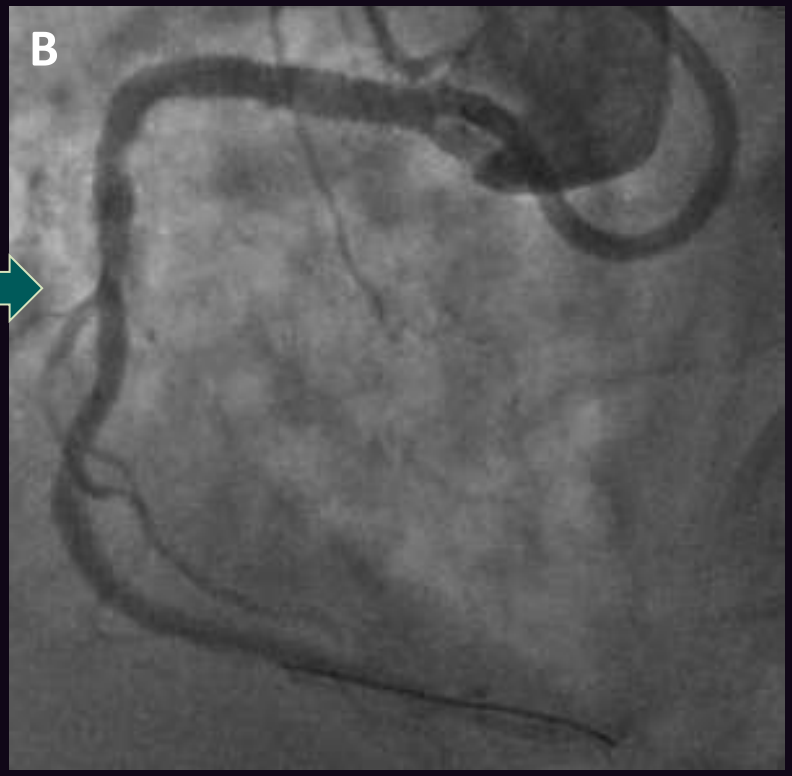
Sakakura K, et al. Int Heart J 2017; 58: 1-4

Case 1: Heavily Calcified Ostial & Angulated Prox. RCA

Relative Contraindication



Although 1.25 mm burr could not penetrate, *1.5 mm & 1.75 mm burrs could pass* the angulated calcified lesion

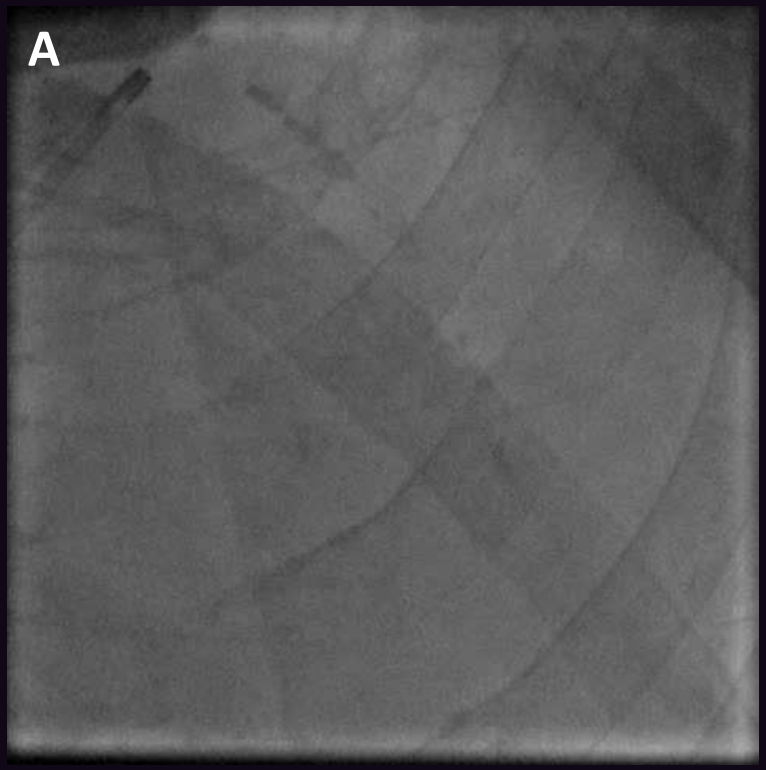


Excellent final result after predilatation & implantation of 2 overlapping DES

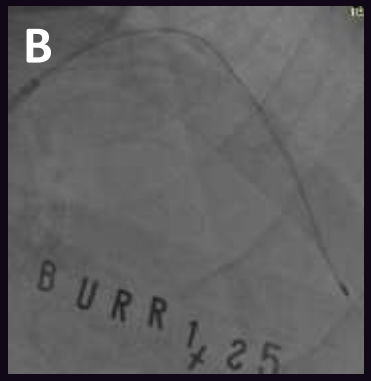
Note: (5) Bigger burrs (1.5 mm & 1.75 mm) burrs could pass the lesion; (6). *Increasing the burr size a*s well as decreasing the burr size can be an option when the burr cannot penetrate the lesion.

Case 2: Severely Calc. Long LAD Stenosis With EF 35%

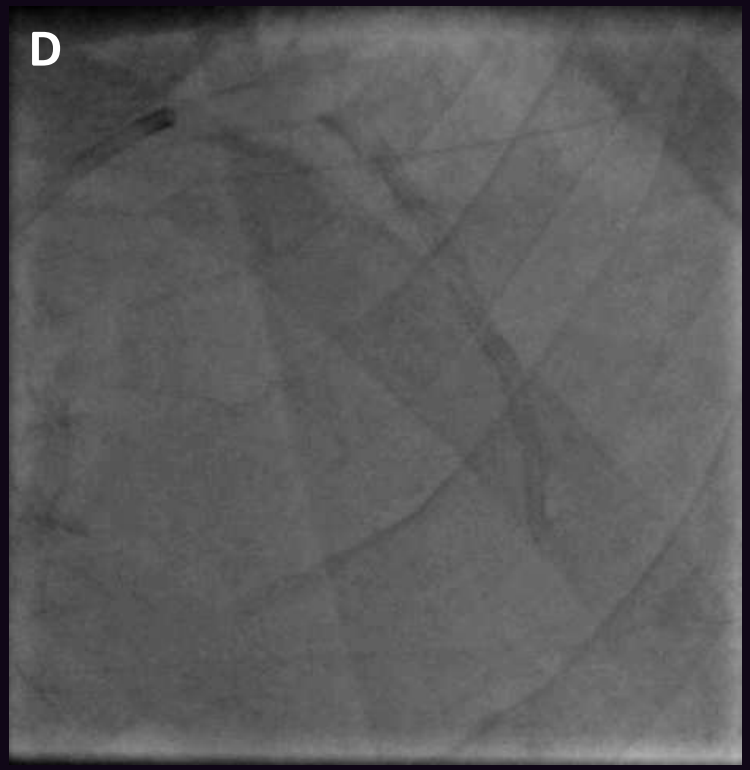
Relative Contraindication



Heavily calcified long LAD stenosis



Rotablation
(#1.25, #1.50, #1.75)



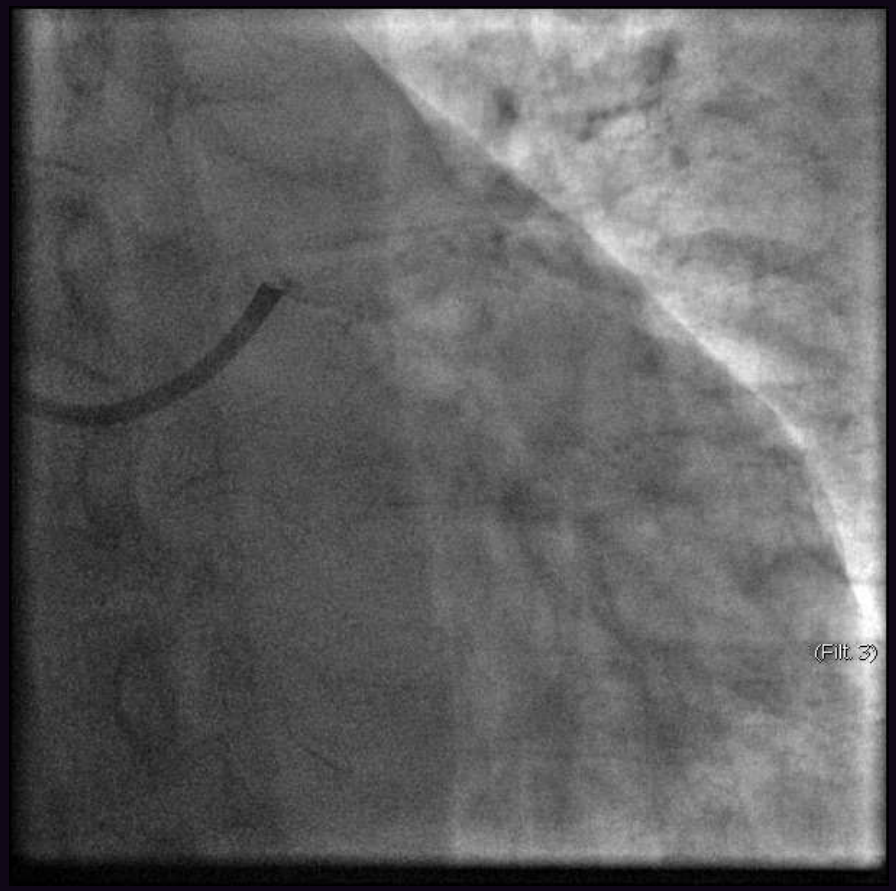
Excellent result after implantation of 3 overlaping DES

Note: (1). *Step wise rotablation* (#1.25 – #1.50 – #1.75); (2) *Short ablation runs* of 15-20 s; (3). *IC vasodilation, liberal use of flush solution;* (4). *Take time* between runs; (4). *Vasopressors (rarely IABP) if needed*

Case 3: Calcified, Complex LM Bifurcation

Relative Contraindication

Rsl, male, 63 yrs, UAP, Medina 1,1,1, SYNTAX Score 35, EuroScore 5

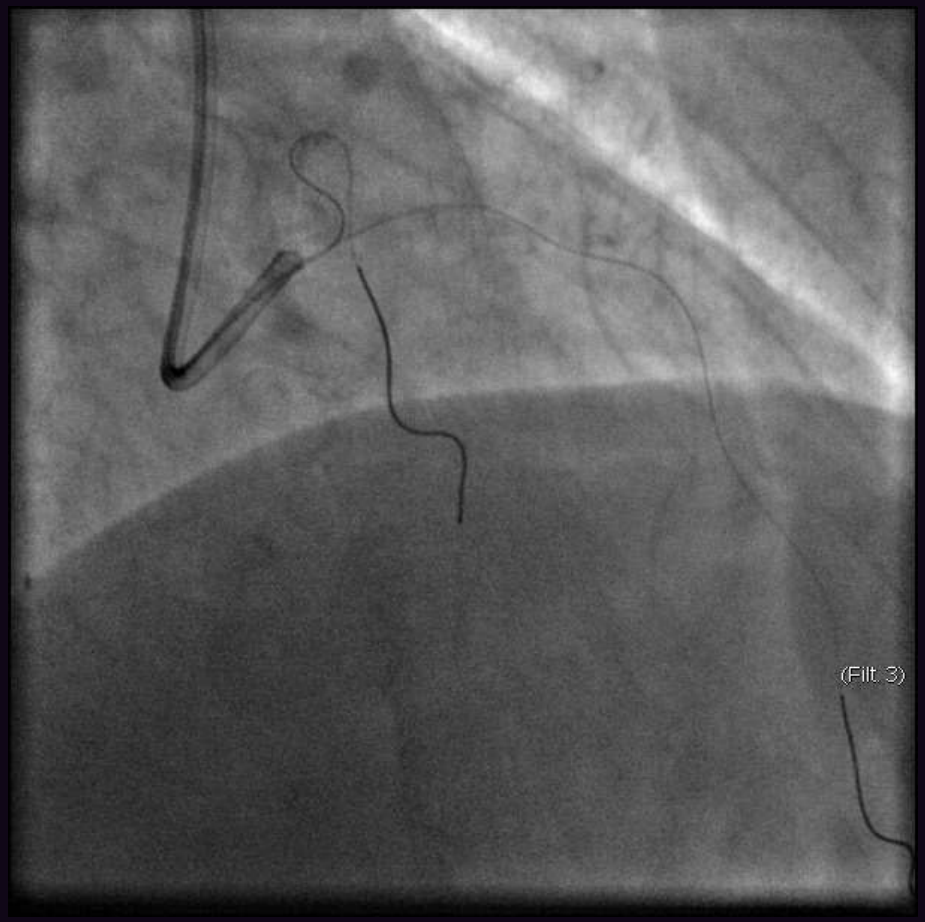


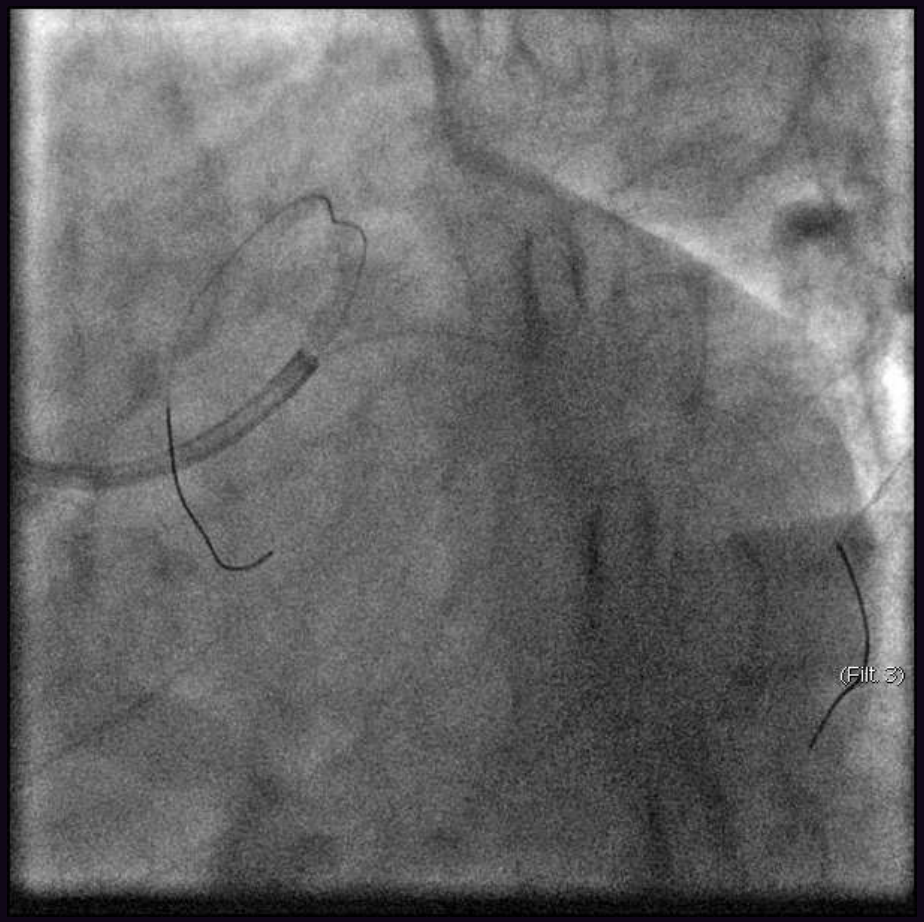
Note: heavy calcification in the LM/LADpm/LCXp

Case 3: Calcified, Complex LM Bifurcation

Relative Contraindication

Rsl, male, 63 yrs, UAP, Medina 1,1,1, SYNTAX Score 35, EuroScore 5





Note: heavy calcification in the LM/LADpm/LCXp

Case 3: Calcified, Complex LM Bifurcation

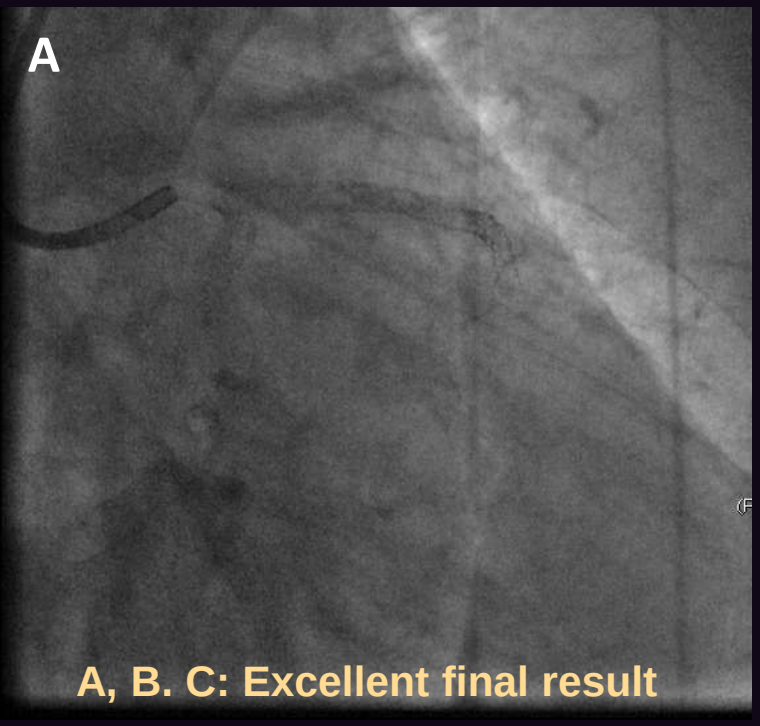
As balloons & Tornus could not cross, ***rotablation was performed (1.25-1.75 mm).*** Followed by **high pressure balloon** dilatation

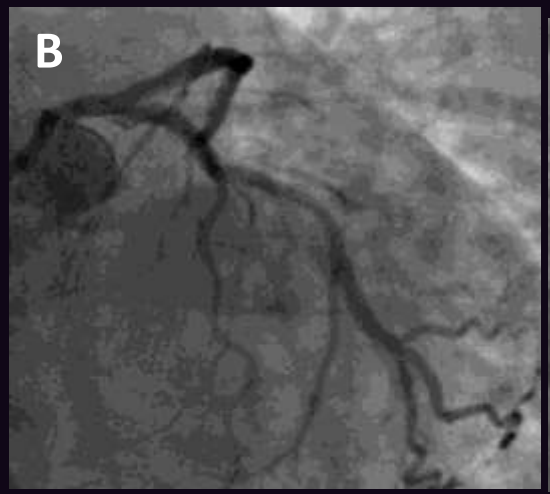
After implantation of 2 overlapping DES in the LADpm, another DES was implanted in the LM-LCX.

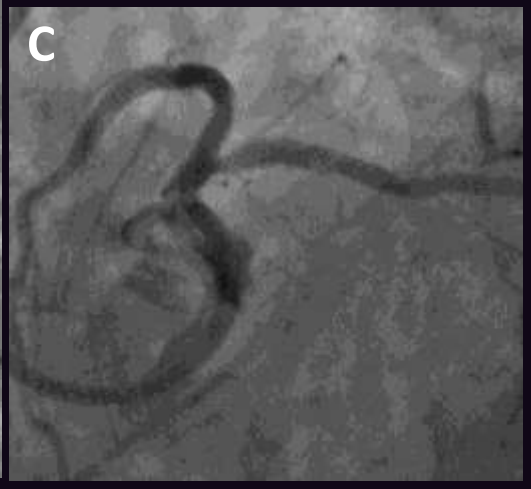
DK crush technique: After kissing balloon dilatation (KBD)(LM-LAD & LM-LCX), another DES was implanted (LMos-LADp, overlapping with previously implanted stent), followed by final KBD & POT in the LM shaft/os

Note: (1). ***Co-axiality important*** (LAD/LCX); (2). For ***angulated LCX, start with small burr (1.25 mm),*** esp. when there is ***GW bias; (3).*** May need ***larger burr, if lesion preparation is still suboptimal*** with 1.75 mm burr (LM is a big vessel)

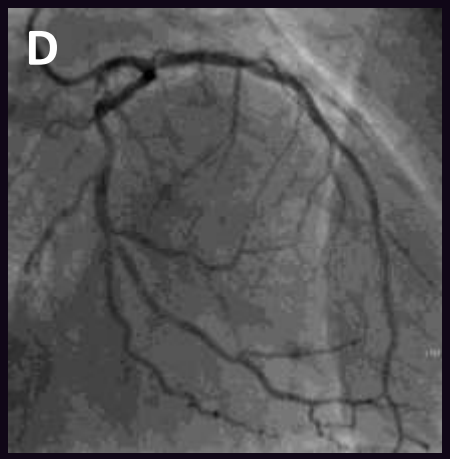
Case 3: Calcified, Complex LM Bifurcation

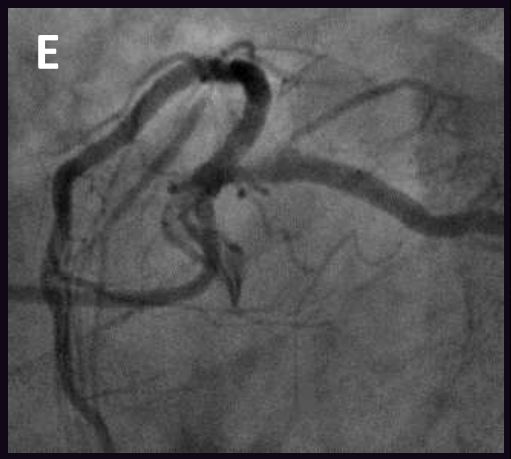


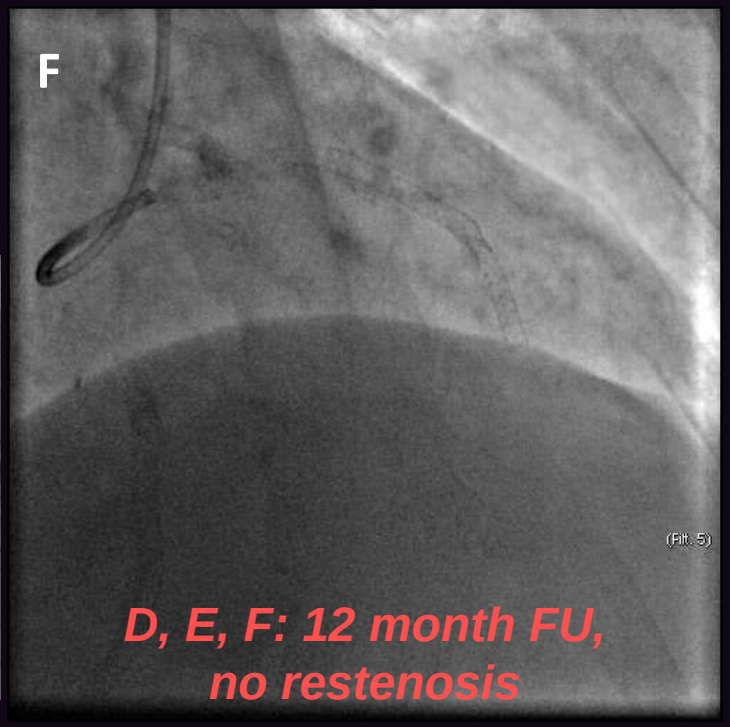




A, B. C: Excellent final result

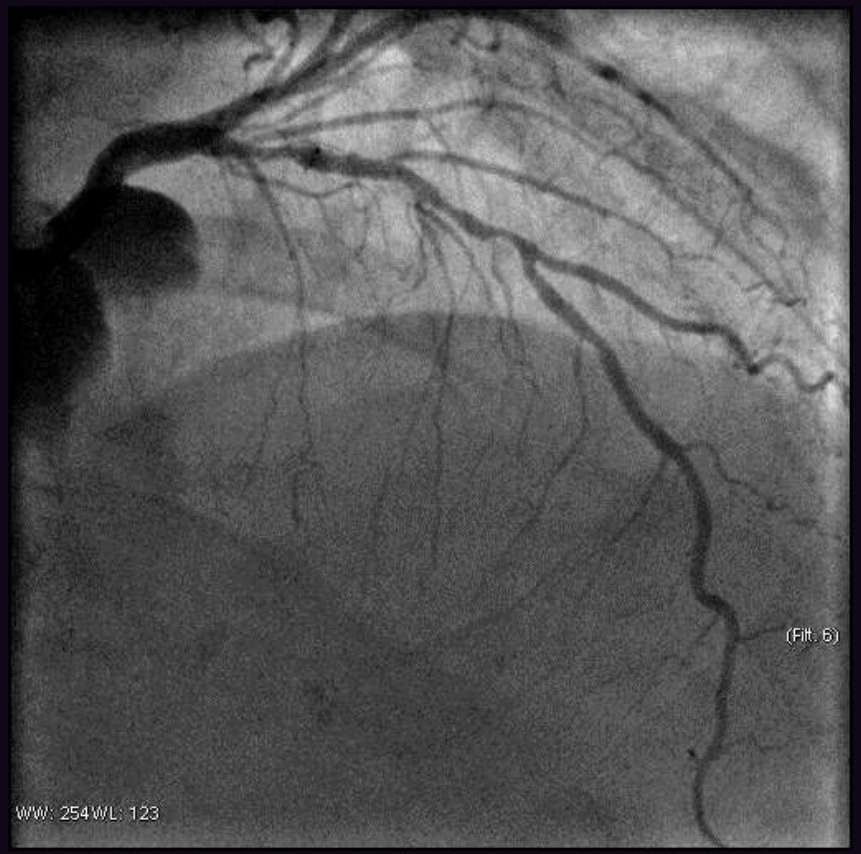






D, E, F: 12 month FU, no restenosis

Case 4: BVS For Calcified LAD

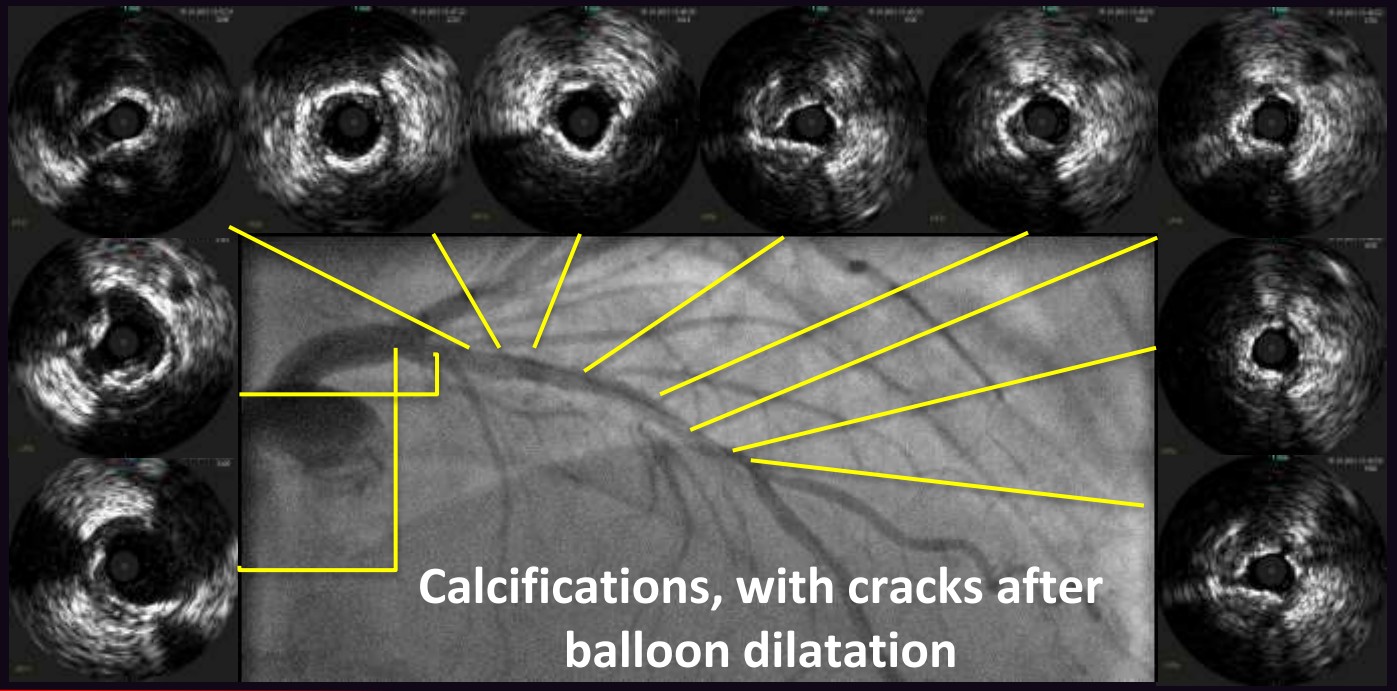


Diffuse, calcified, 70-80% stenosis of the LADp-m

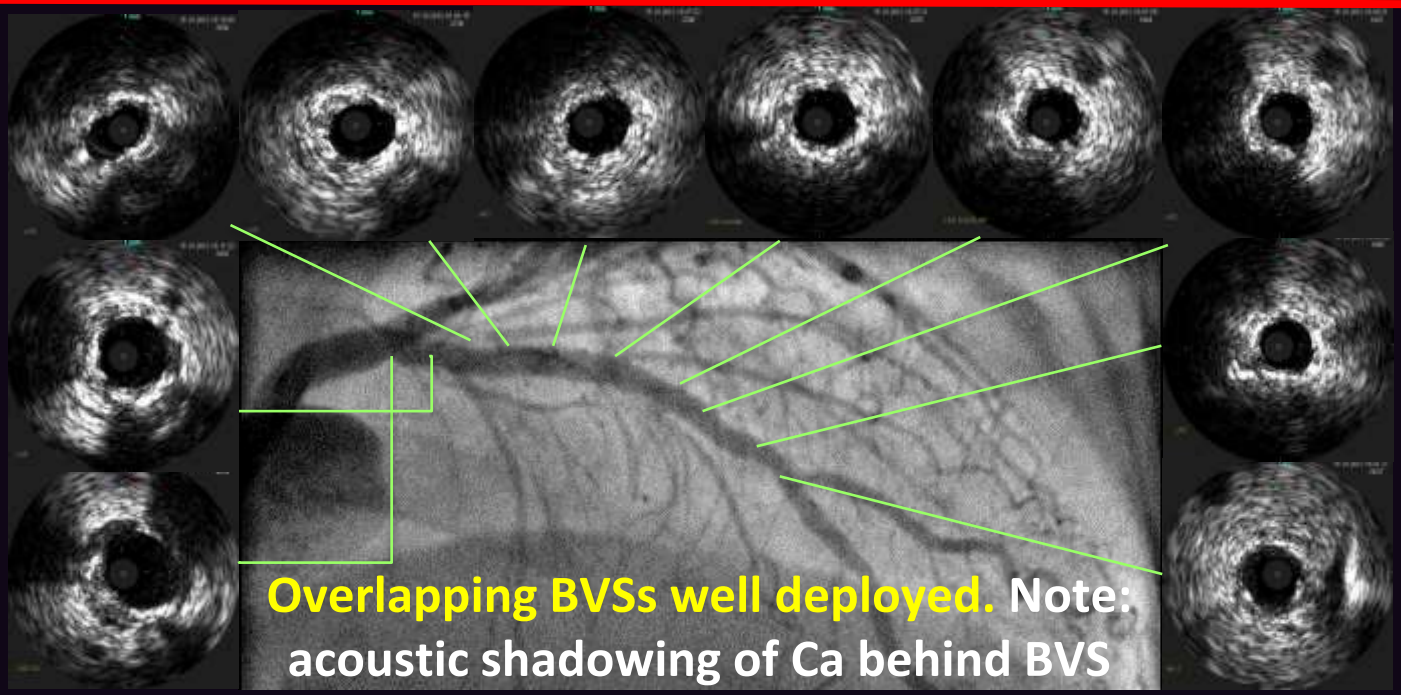
Excellent angiographic result after **rotablation,** followed by **high pressure dilatation** & implantation of **2 overlapping BVS** (2.5x28 mm & 3.0x18 mm)

Note: (1). ***Low threshold for rotablation / appropriate predilatation with NC balloon*** to reach full balloon expansion with a 1:1 B-to-A ratio & almost ***no residual stenosis; (2). IVUS or OCT*** **recommended;** (3) high pressure post-dilatation

IVUS after lesion preparation: ***BVS sizing is done with help of IVUS***

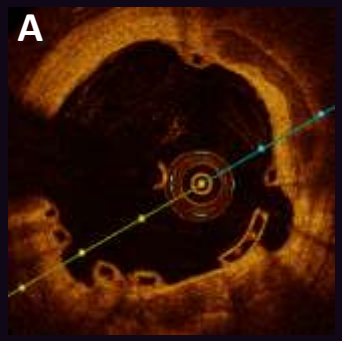


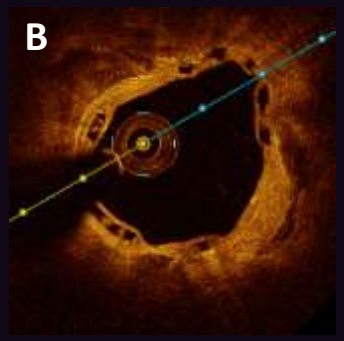
IVUS after BVS implantation: ***Excellent result***

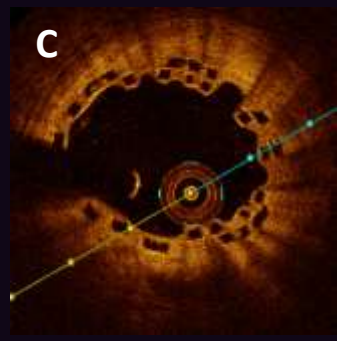


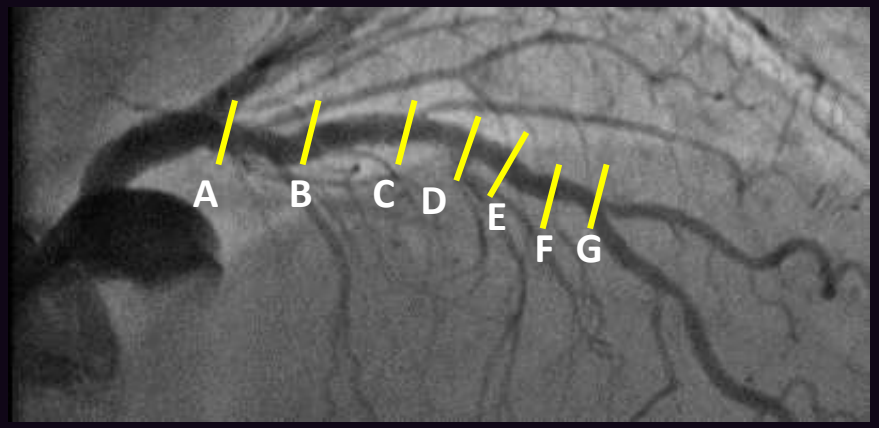
Case 4: BVS For Calcified LAD

10 month follow up

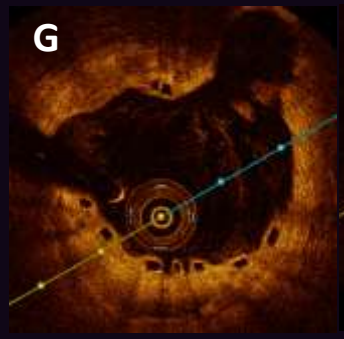


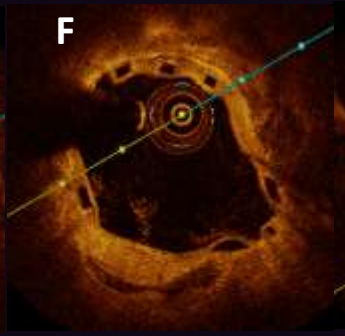


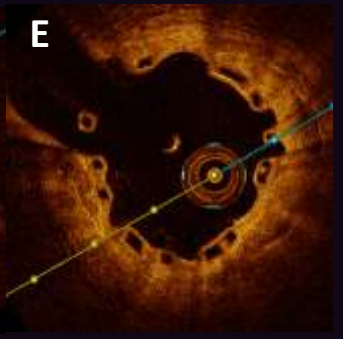


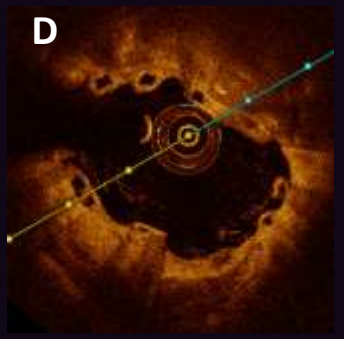


No restenosis









Treatment Of Calcified Lesions: PCI Guidelines

Device	ACCF/AHA/SCAI 2011	ESC/EAPCI 2014
Cutting balloon angioplasty	• Might be considered to avoid slippage induced coronary artery trauma during PCI for in-stent restenosis or ostial lesions in side branches. (**Class IIb-C**) • Should not be performed routinely during PCI. (**Class III-A**)	May be useful in highly calcified, rigid ostial lesions.
Rotational atherectomy	• Reasonable for fibrotic or ***heavily calcified lesions*** that might not be crossed by a balloon catheter or adequately dilated before stent implantation. (**Class IIa-C**) • Should not be performed routinely for de novo lesions or in-stent restenosis. (**Class III-A**)	Might technically be required in cases of ***tight & calcified lesions***, to allow subsequent passage of balloons & stents.

Levine GN et al. JACC 2011;58:e44-122; Windecker S et al. EHJ 2014;35:3541-619

Orbital Atherectomy

Device Features
- Simple device setup
- Microsecond feedback to changes in loading
- 135cm usable length

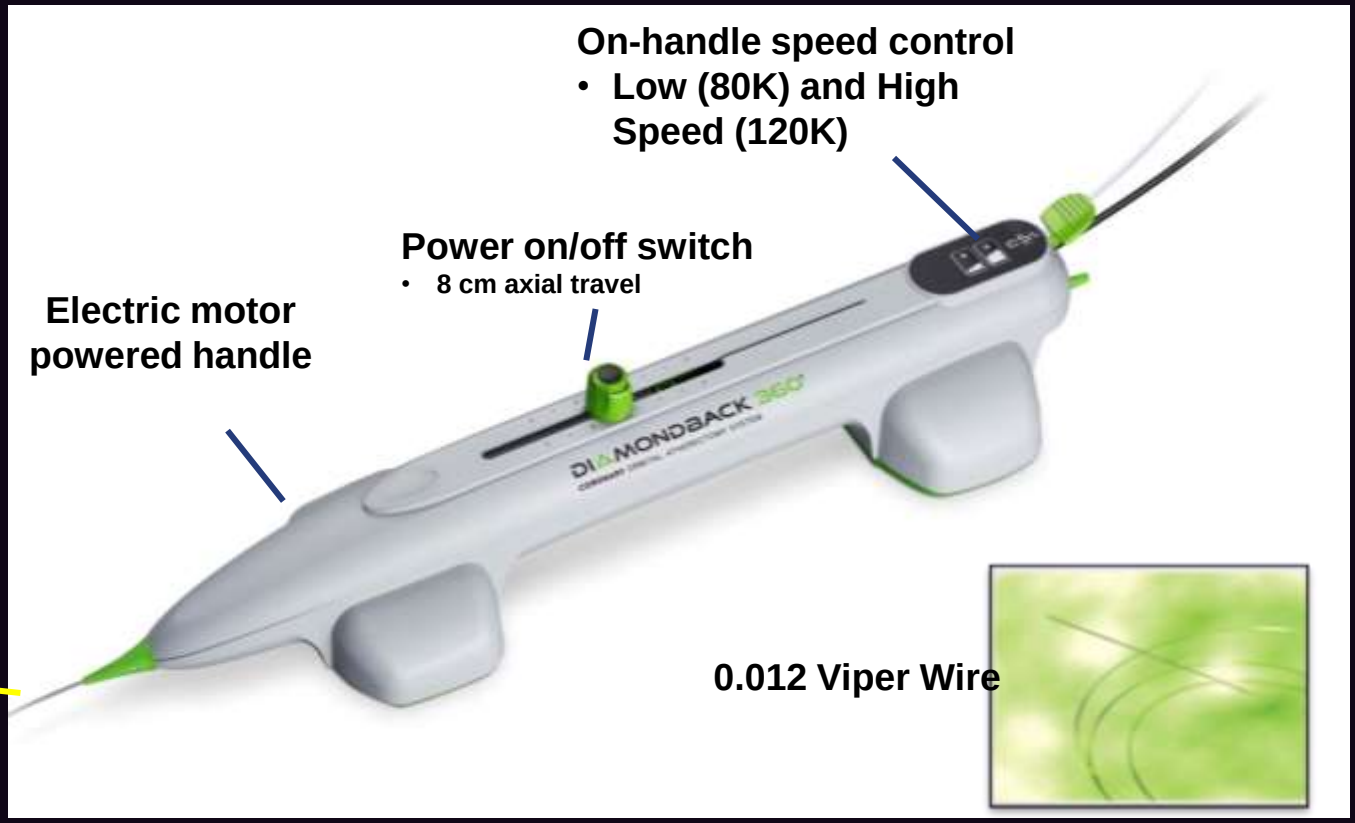
Eccentrically mounted diamond-coated crown

6Fr Guide Compatible Saline Sheath

On-handle speed control
- Low (80K) and High Speed (120K)

Power on/off switch
- 8 cm axial travel

Electric motor powered handle



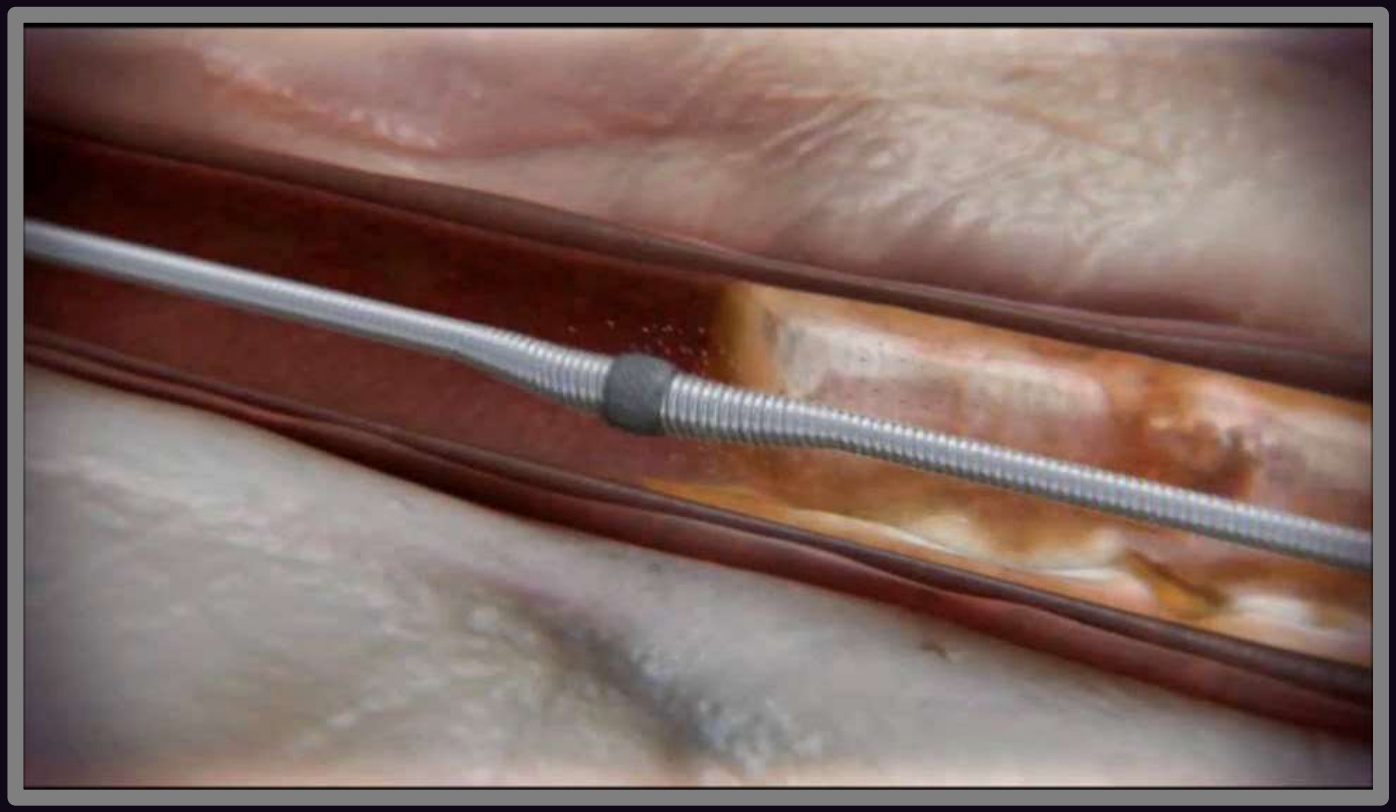
0.012 Viper Wire

Saline Infusion Pump
- Mounts directly on to an IV pole
- Provides power
- Delivers fluid
- Includes saline sensor

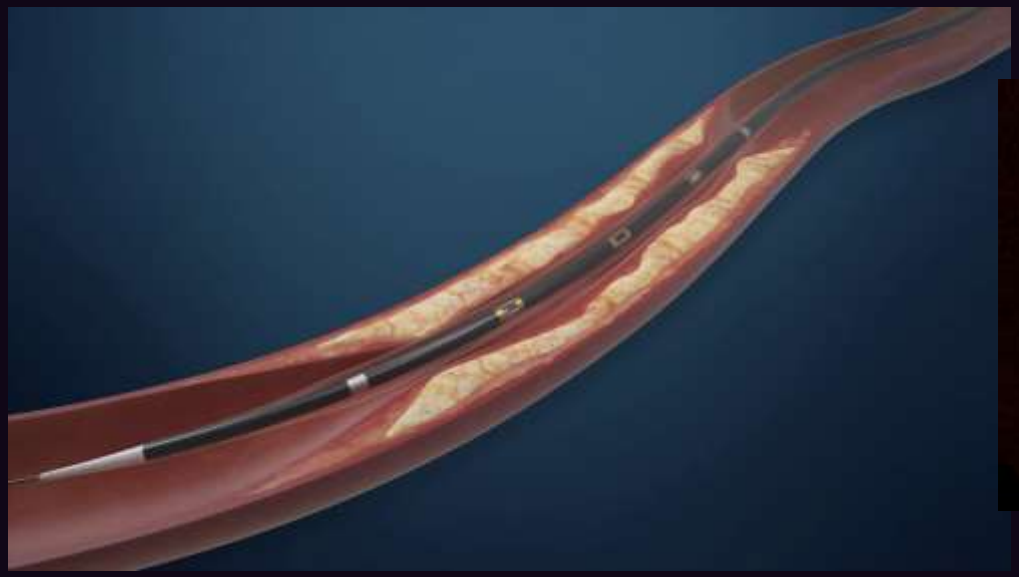
ViperSlide® Lubricant
- ViperSlide reduces friction during operation
- 20ml ViperSlide per liter of saline

Orbital Atherectomy:
Mechanism

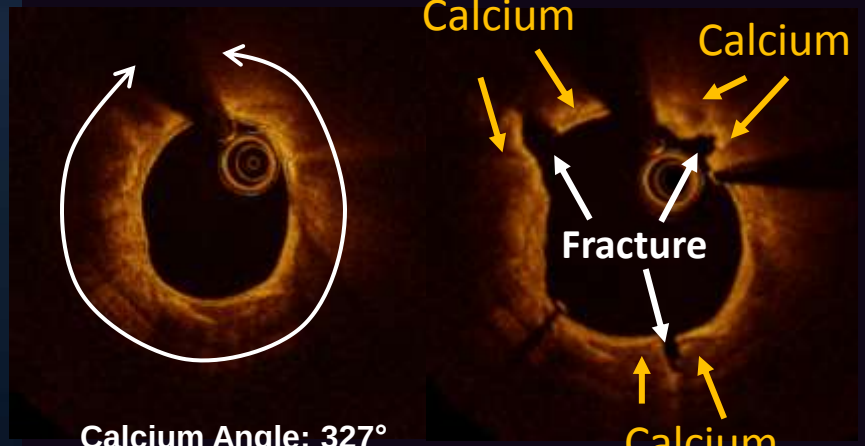
Differential Sanding & Centrifugal Force



What Next ? Lithoplasty - Disrupt CAD



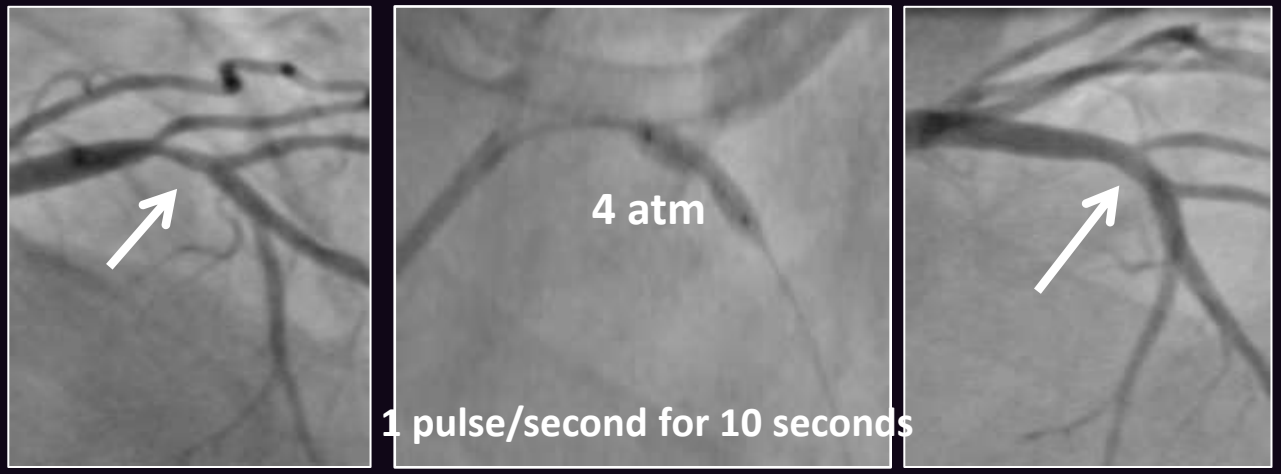
Circumferential Calcium Fracture



Baseline

Lithoplasty

Final



Brinton T, Ali Z, Hill J et al. TCT 2016. Disrupt CAD

Thank You