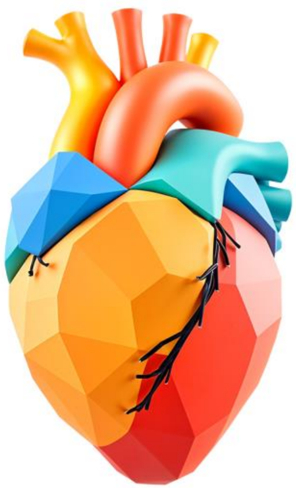
Critical Cardiovascular Care

دانشگاه علوم پزشکی و خدمات
بهداشتی درمانی تهران

مرکز قلب تهران



12th Annual Tehran Heart Center Congress

7th CRITICAL CARDIOVASCULAR CARE

دوازدهمین کنگره سالیانه مرکز قلب تهران

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2025

۲۵ و ۲۶ بهمن ماه ۱۴۰۳

13 & 14 February
Tehran Heart Center
Tehran, Iran

Calcified Lesion

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Interventional Cardiologist
Assistant Professor of Rajaei Heart Institute

- From the perspective of the coronary interventionalist, coronary calcification remains one of the most challenging lesion subsets
- often found in patients with complex multivessel disease, chronic total occlusion, long lesions, and bifurcations
- Challenges with calcified lesion
  - limits the ability to deliver
  - limits the ability to adequately deploy
  - suboptimal result
  - increasing the risk of restenosis or stent thrombosis
  - increases the risk of acute procedural complications such as stent loss and coronary perforation
- severe calcified coronary disease is an independent predictor of a worse prognosis following PCI

Diagnosis of coronary calcification

CORONARY COMPUTERISED TOMOGRAPHY ANGIOGRAPHY (CCTA)

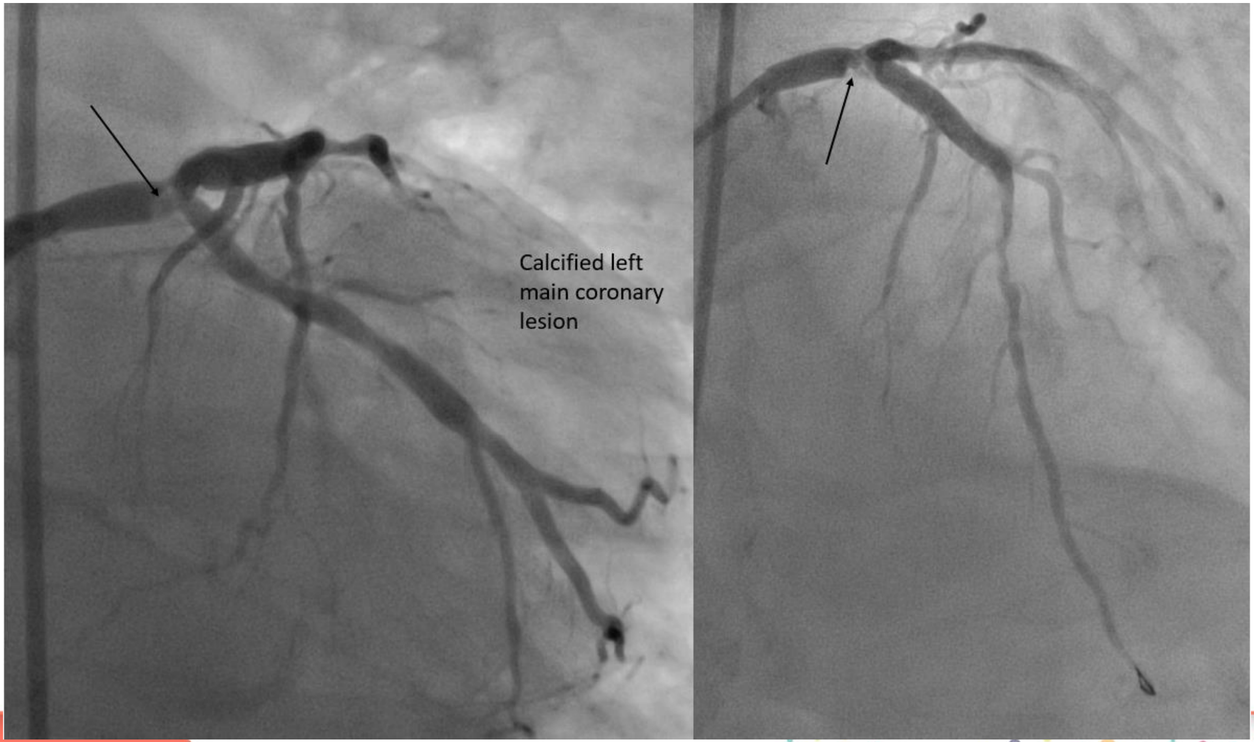
- Ultrafast CT is more sensitive than fluoroscopy, detecting coronary calcium in 90% versus 52% of cases
- Despite this, there are no clearly established criteria by which CCTA can predetermine how PCI should be performed
- CALCIFICATION REMODELING INDEX is a ratio of lumen area of the most severely calcified site to the lumen area of the proximal reference
- significantly correlated with the incidence of using rotational atherectomy (RA) to aid PCI, with an index ≤ 0.84 independently predicting the need for rotational atherectomy prior to stent implantation

. 2017 . Sep-Oct; .762-753:(5)18doi: 2017 bupE .2017.18.5.753.rjk/10.3348Jul .17

Diagnosis of coronary calcification

FLUOROSCOPY

- Angiography under-estimates the degree of calcification and is unable to estimate the depth within the plaque
- severe calcification can resemble and be mistaken for thrombus when severe calcific nodules prevent contrast penetration and appear as filling defects in the lumen

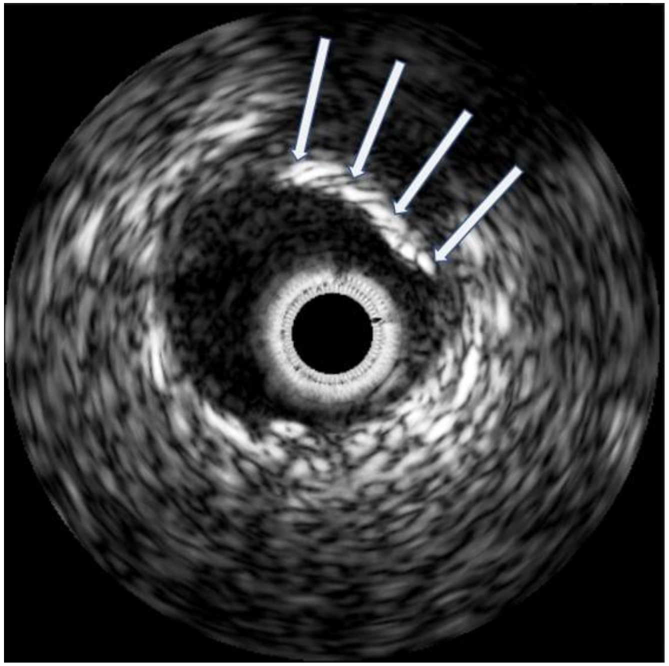


Diagnosis of coronary calcification

INTRA-VASCULAR ULTRASOUND (IVUS)

- Ultrasound has a resolution of 150–200μm but does **not** penetrate calcium. The leading edge of calcification can be visualized as a *bright hyperechoic deposit* but behind the calcium is a **blank** acoustic shadow and further details of the vessel wall are invisible

- Limitations of IVUS include inability of the catheter to cross highly calcified lesions. This usually implies significant calcification, and calcification modifying tools should be selected accordingly. IVUS is also unable to detect microcalcifications or the full thickness of calcium (IVUS cannot measure calcium depth).

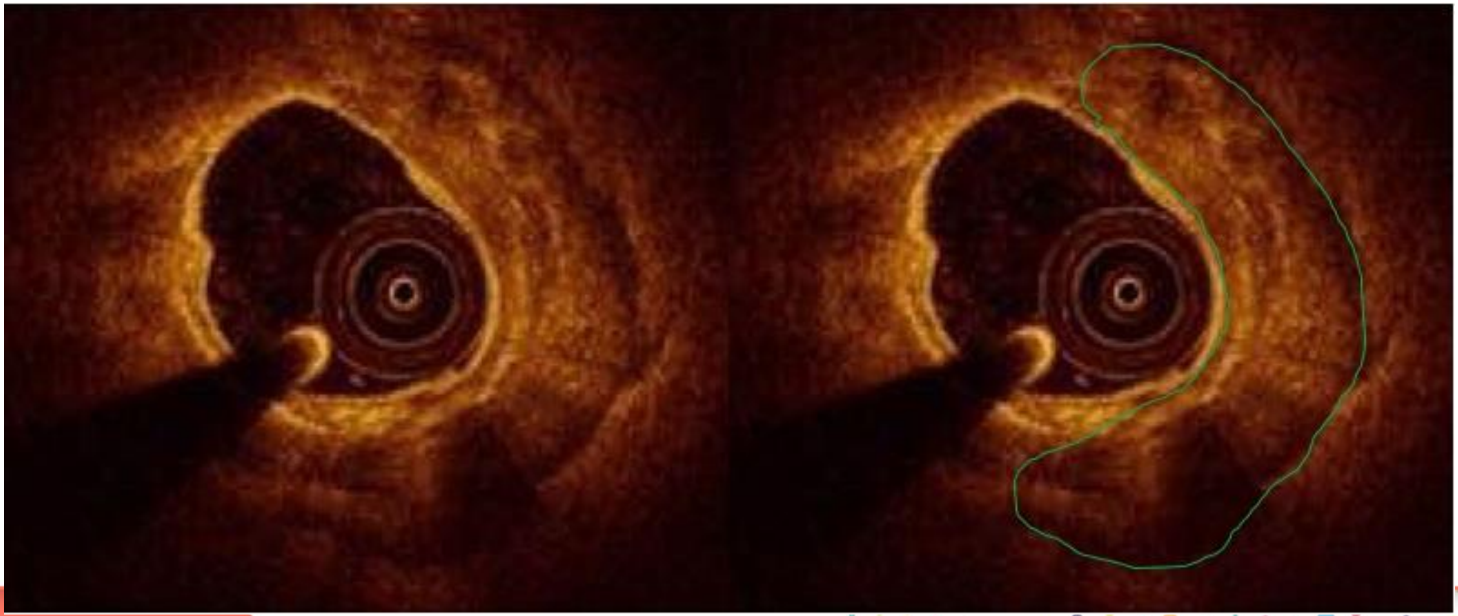


Diagnosis of coronary calcification

OPTICAL COHERENCE TOMOGRAPHY (OCT)

- OCT has a resolution of 10–20μm. It measures light backscatter and calcium is seen as a **low signal area** with well-delineated sharp borders

- OCT can assess calcium depth, area, and volume in addition to calcium arc and length. It can also detect microcalcifications



Classification of degree of calcification

Following measurements need to be acquired: the calcium arc; the length of the calcified segment; and the thickness of the calcium.

Proposed a CAC scoring system based on IVUS / OCT findings:

- For OCT:
  - Calcium arc: 180°-270° (2 points); ≥270° (3 points)
  - Calcium length: >5mm (1 point)
  - Calcium thickness: >0.5mm (1 point)
- For IVUS:
  - Calcium arc: 180°-270° (2 points); ≥270° (3 points)
  - Calcium length: >5mm (1 point)
  - Add 1 point to score if length >5mm and arc ≥270°

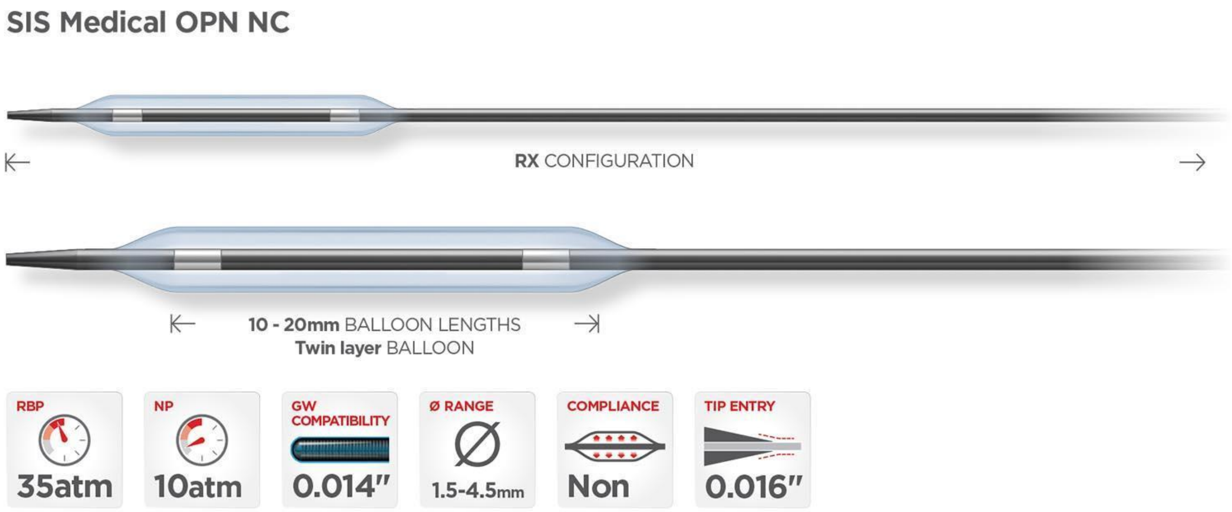
CAC Severity	Score (IVUS or OCT)
Mild	0
Moderate	1-2
Severe	3-5

Severe calcification requires calcium modification as the first step in a PCI procedure. In the presence of moderate calcification, operators should have a low threshold for use of calcium-modifying technologies.

Tools for management of coronary calcification during PCI

HIGH- AND VERY HIGH-PRESSURE NON-COMPLIANT BALLOONS

- NC balloons should be considered as the first choice of treatment *for mild to moderate* calcification (calcium arc <90º)
- OPN NC balloon (SIS Medical) , Super High Pressure Balloon
- success rate of >90% for undilatable lesions compared to conventional NC balloons, with less than 1% rate of coronary rupture



Tools for management of coronary calcification during PCI

CUTTING AND SCORING BALLOONS

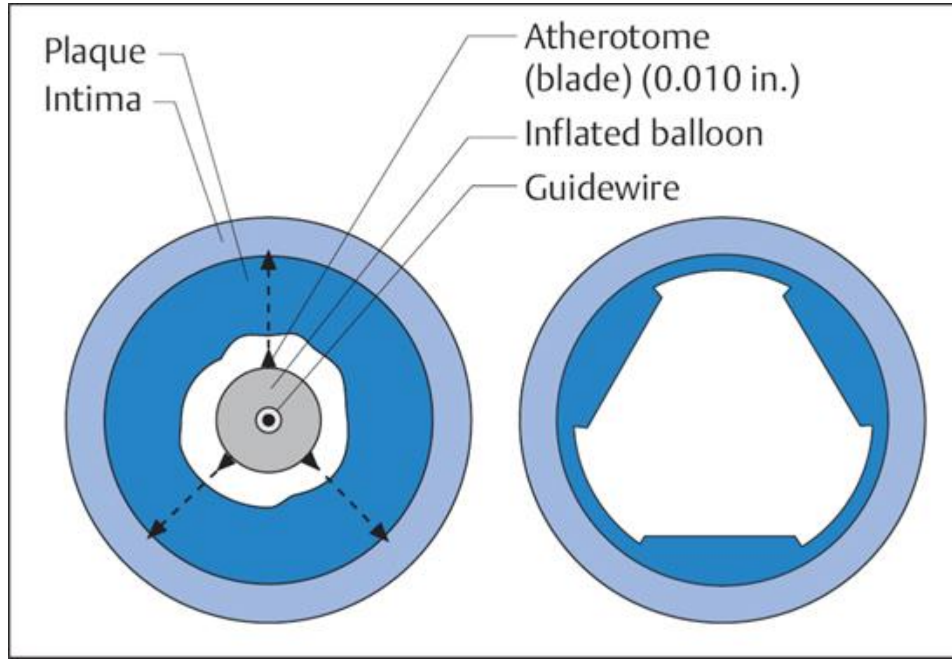
- Cutting balloons have three or four metal microblade on the surface
- In an IVUS-based study, cutting balloon achieved larger luminal gain than regular balloons in calcified lesions
- Subsequent randomized data comparing conventional balloon to cutting balloon angioplasty for de novo undilatable lesions showed similar procedural success rates and 6-month restenosis rates, at the expense of greater perforation rates in the cutting balloon group. This data, and their relatively large crossing profiles (1.04 to 1.17mm) has limited their use in current clinical practice. The ESC and AHA guidelines have restricted their use to resistant lesions.

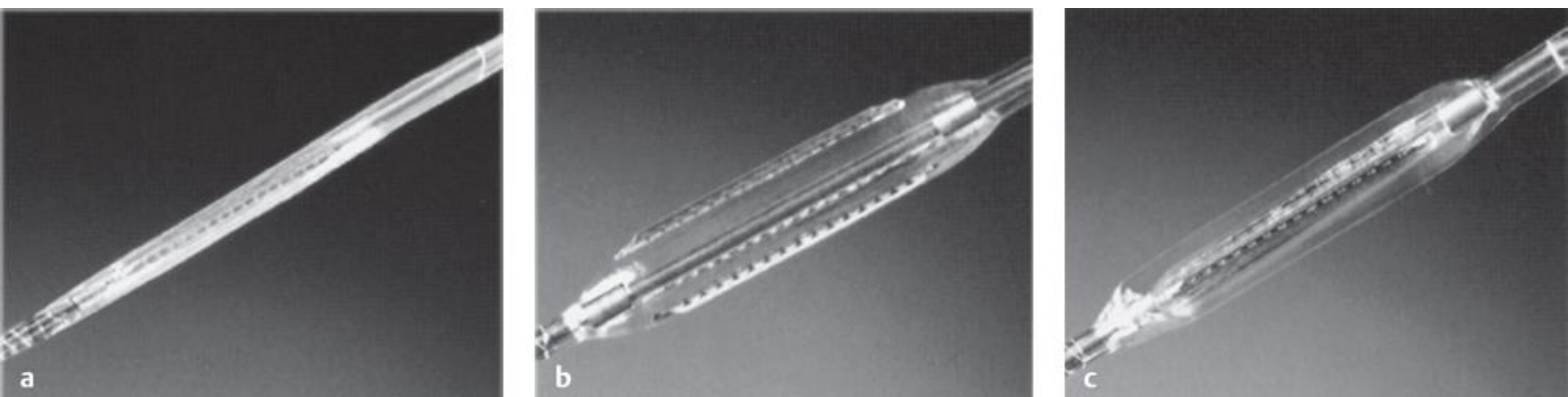
Tools for management of coronary calcification during PCI

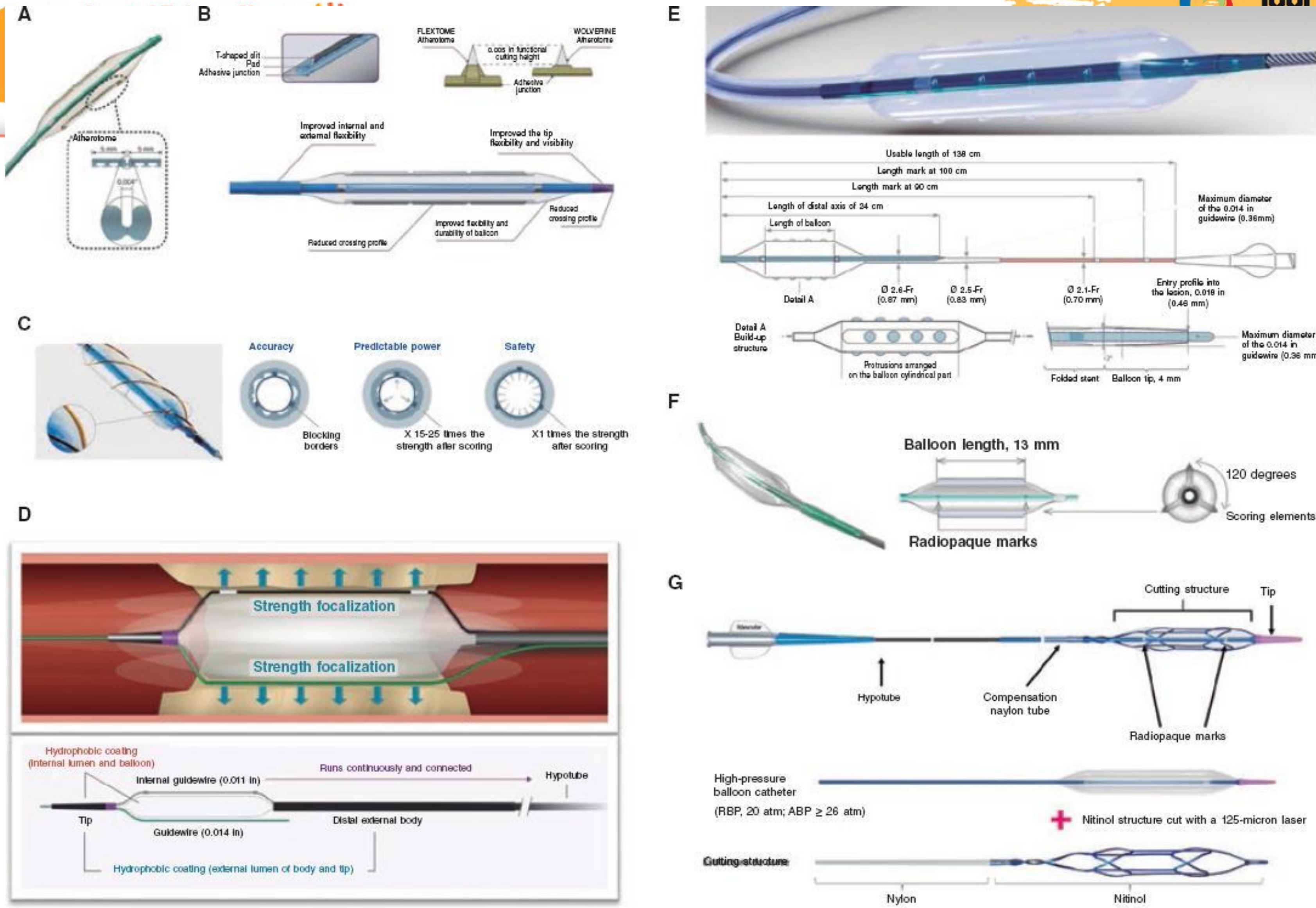
CUTTING AND SCORING BALLOONS

- Scoring balloons are semi-compliant balloons encircled by nitinol spiral wires
- allowing for focal, concentrated pressure (or force) during inflation
- Their indications for use are similar to cutting balloons, but generally are more deliverable due to lower crossing profiles (0.81-1.27mm) and greater flexibility. They can also be fully expanded at relatively lower inflation pressure therefore lowering the risk of perforation and severe dissections

1. AngioSculpt Scoring Balloon (Spectranetics, Colorado Springs, CO) and the drug-coated version, AngioSculpt X (Spectranetics, Colorado Springs, CO) are semi-compliant balloons with three spiral rectangular Nitinol scoring elements with a crossing profile of 0.91mm.
2. NSE Alpha (B Braun) has three triangular flexible nylon elements on the balloon surface that are attached only at the proximal and distal edges (crossing profile 1.27mm).
3. Scoreflex (Orbus Neich) is a semi-compliant balloon with two fixed Nitinol wires on opposite sides of the balloon surface with a crossing profile of 0.81mm.


Plaque
Intima
Atherotome
(blade) (0.010 in.)
Inflated balloon
Guidewire


a
b
c



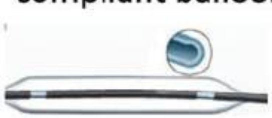
. Characteristics of modified balloons. **A:** Cutting balloon (Boston Scientific, United States). **B:** WOLVERINE (Boston Scientific, United States). **C:** AngioSculpt (Spectranetics, United States). **D:** Scoreflex (OrbusNeich, Hong Kong). **E:** Grip (Acrostak, Switzerland). **F:** NSE-Alpha (B.Braun, Germany). **G:** Naviscore (iVascular, Spain).

July/August 2022

Specialty Balloons: When and How

Using cutting, scoring, and very high-pressure balloons in PCI.

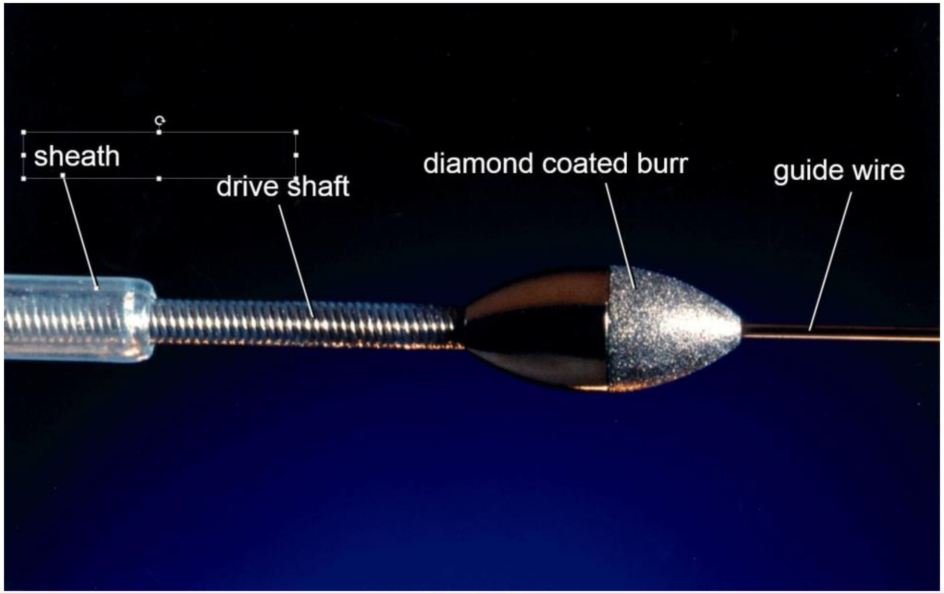
By Antonio Mangieri, MD, and Antonio Colombo, MD

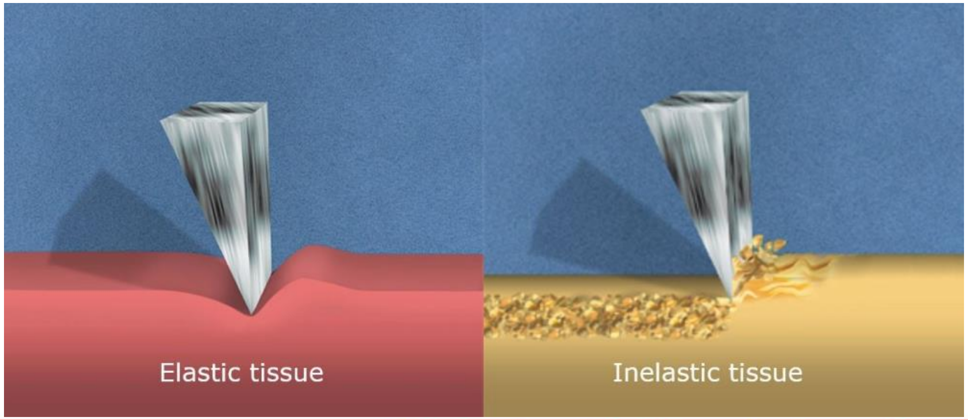
	Calcified lesions	Calcific nodules	Fibrotic lesions	Stent underexpansion	In-stent restenosis
Cutting balloon 	👍👍	👍	👍👍	👍	👍👍
Scoring balloon 	👍👍	👍	👍	👍	👍👍
Super non compliant balloon 	👍👍	👎👎	👎	👍👍	👍

Tools for management of coronary calcification during PCI

ROTATIONAL ATHERECTOMY (RA)

- David Auth first proposed a rotational debulking device in the 1980's
- RA is performed by advancing a high-speed rotating metallic burr through a calcified plaque.

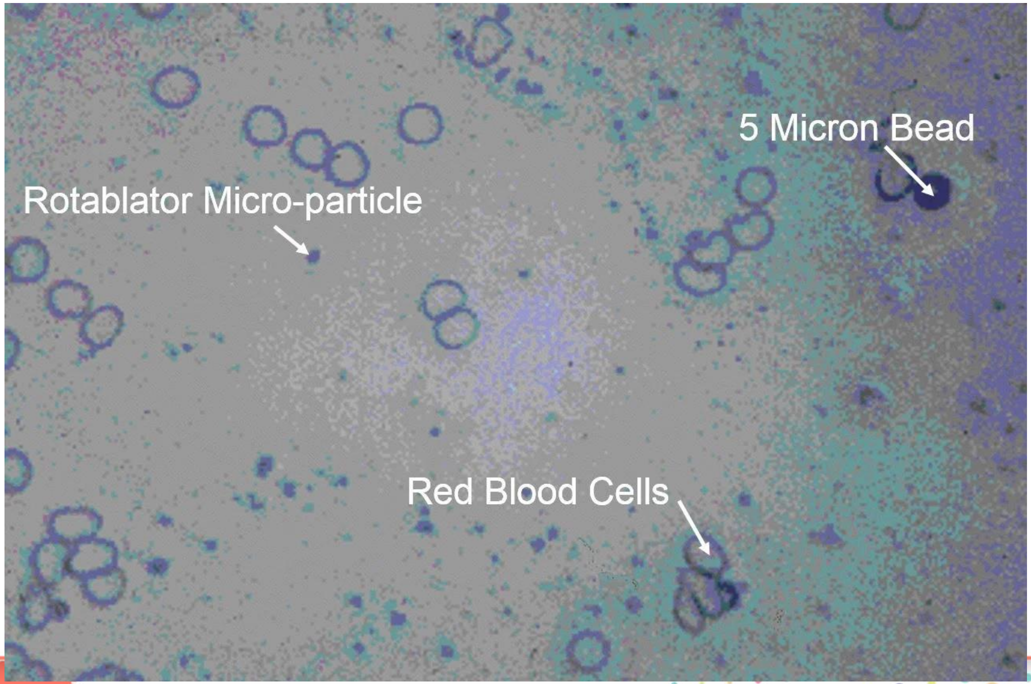




Tools for management of coronary calcification during PCI

ROTATIONAL ATHERECTOMY (RA)

- At rotational speeds of greater than 60000 revolutions per minute (rpm), the burr-to-vessel surface friction is virtually eliminated, thereby reducing surface drag and allowing unimpeded forward-and-back movement of the burr through the diseased vessel
- The abraded plaque is reduced to micro-particles which are 5-10µm in diameter

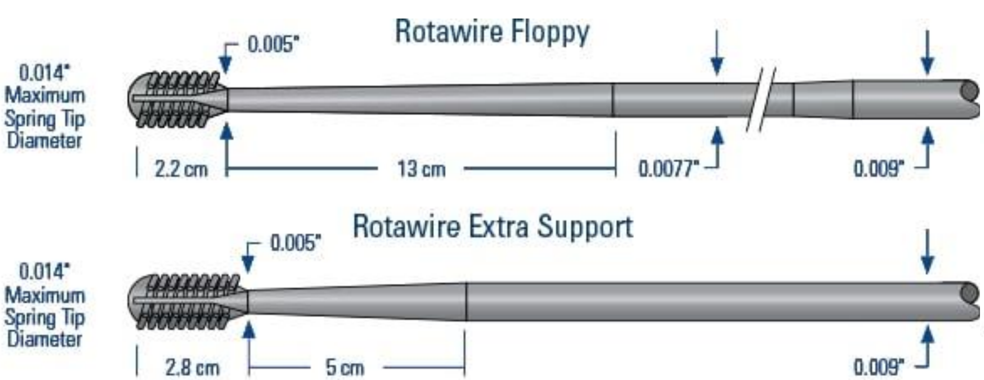


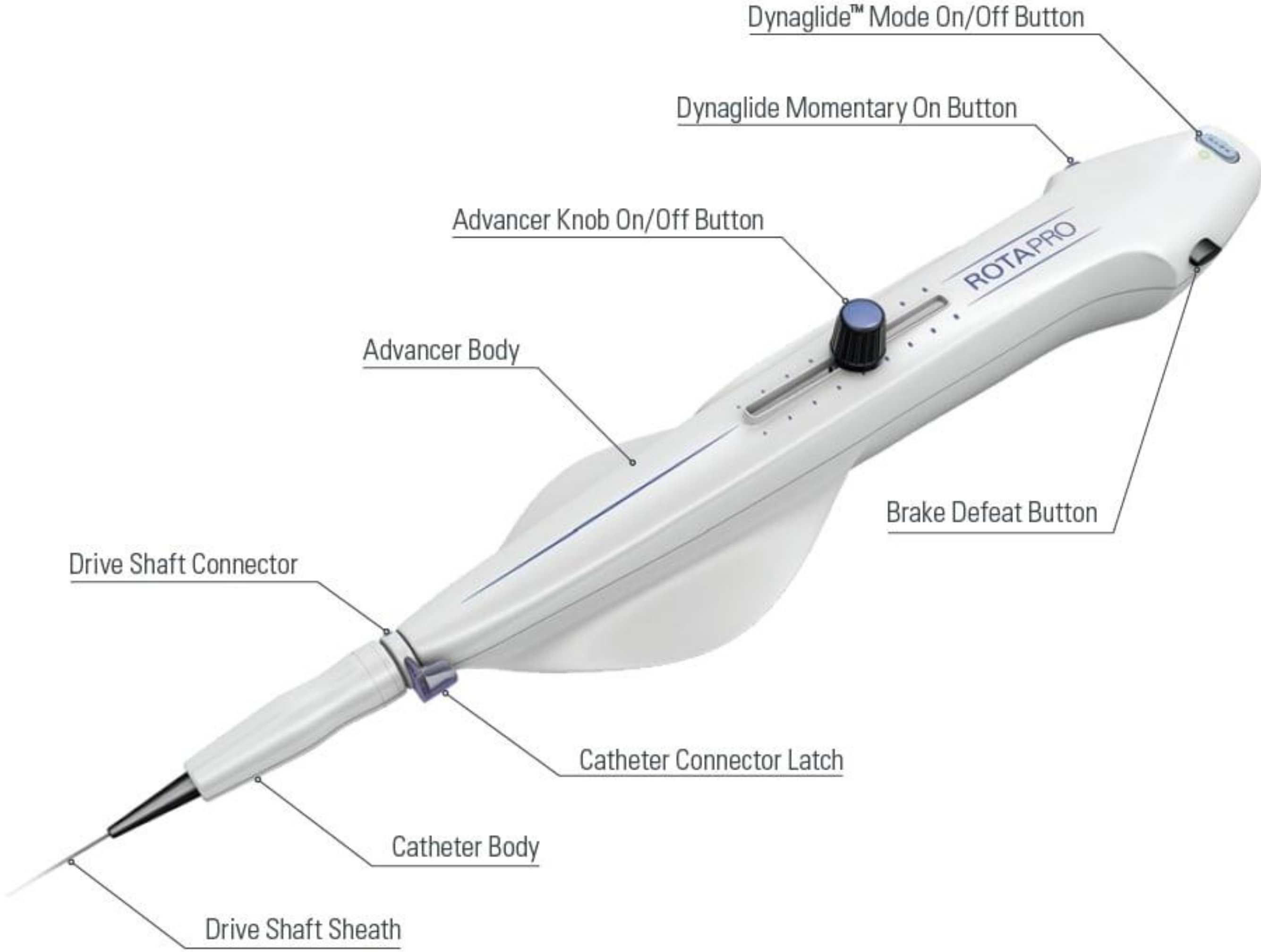
Tools for management of coronary calcification during PCI

ROTATIONAL ATHERECTOMY (RA)

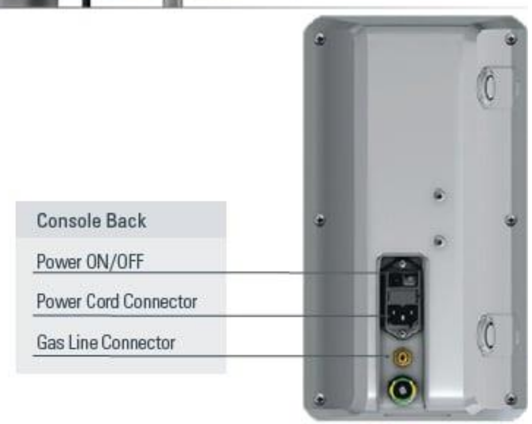
The Rotablator^{TM} rotational atherectomy system & Rotapro^{TM} $^{(2018)}$

- RotaWire^{TM} guide wires
- Burrs : The distal end of the burr head is coated with 2000 to 3000 microscopic (20 to 30 microns) diamond crystals, with approximately 5 microns of each the crystal protruding from the nickel coating. The proximal end of the burr is smooth
- Advancer >> RotaLink^{TM} Advancer, RotaLink^{TM} PLUS ، Rotapro




Dynaglide™ Mode On/Off Button
Dynaglide Momentary On Button
Advancer Knob On/Off Button
Advancer Body
Brake Defeat Button
Drive Shaft Connector
Catheter Connector Latch
Catheter Body
Drive Shaft Sheath
ROTAPRO


160 RPM K
Event Time 0:01
Procedure Time 1:01
ROTAPRO™
Rotational Atherectomy System
Rotational Speed Display (Tachometer)
Event Timer
Procedure Timer
Reset Button
Turbine Pressure Control Knob (Adjusts RPM)
Advancer Connections
Compressed Gas Connector
Electrical Connector
Fiber Optic Connector


Console Back
Power ON/OFF
Power Cord Connector
Gas Line Connector


Rotaglide™

Tools for management of coronary calcification during PCI

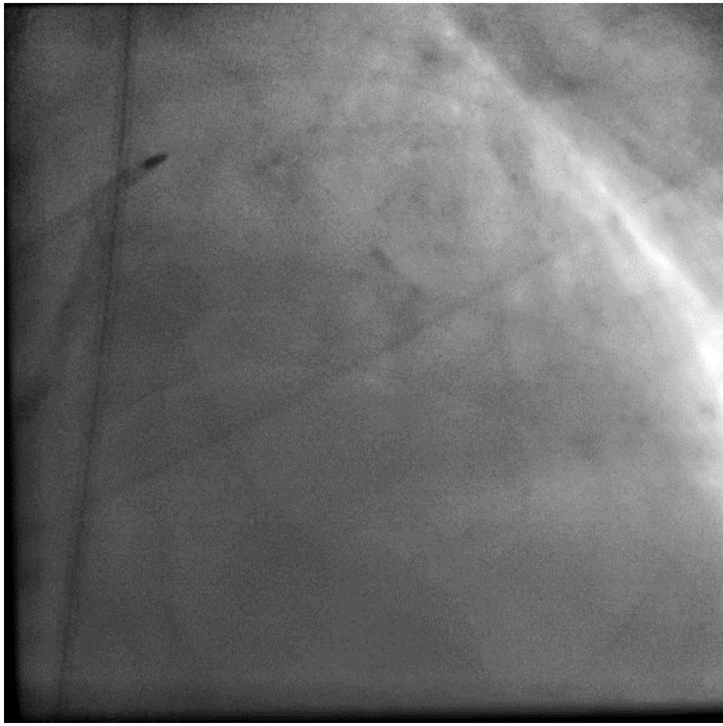
ROTATIONAL ATHERECTOMY (RA)

RA performed best when decelerations > 5000rpm drop were cumulatively less than 5 seconds. Revolution speeds (140000 to 180000 rpm) and a repetitive pecking motion of the burr into the proximal portion of the lesion to avoid large decelerations have yielded the most favourable outcomes .

This motion pattern of the burr allows for frequent intermittent blood flow through the ablated segment, improving wash-out of the debris and potentially reducing heat generation as well as vessel spasm.

A rotational speed greater than 60000 rpm is needed to overcome frictional forces and facilitate the passage and retrieval of the burr

- On the other hand, very high rotational speeds have been reported to increase distal embolization and procedural myocardial infarction, as a result of excessive heat generation and platelet activation



ELSEVIER

JACC: Cardiovascular Interventions

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Coronary

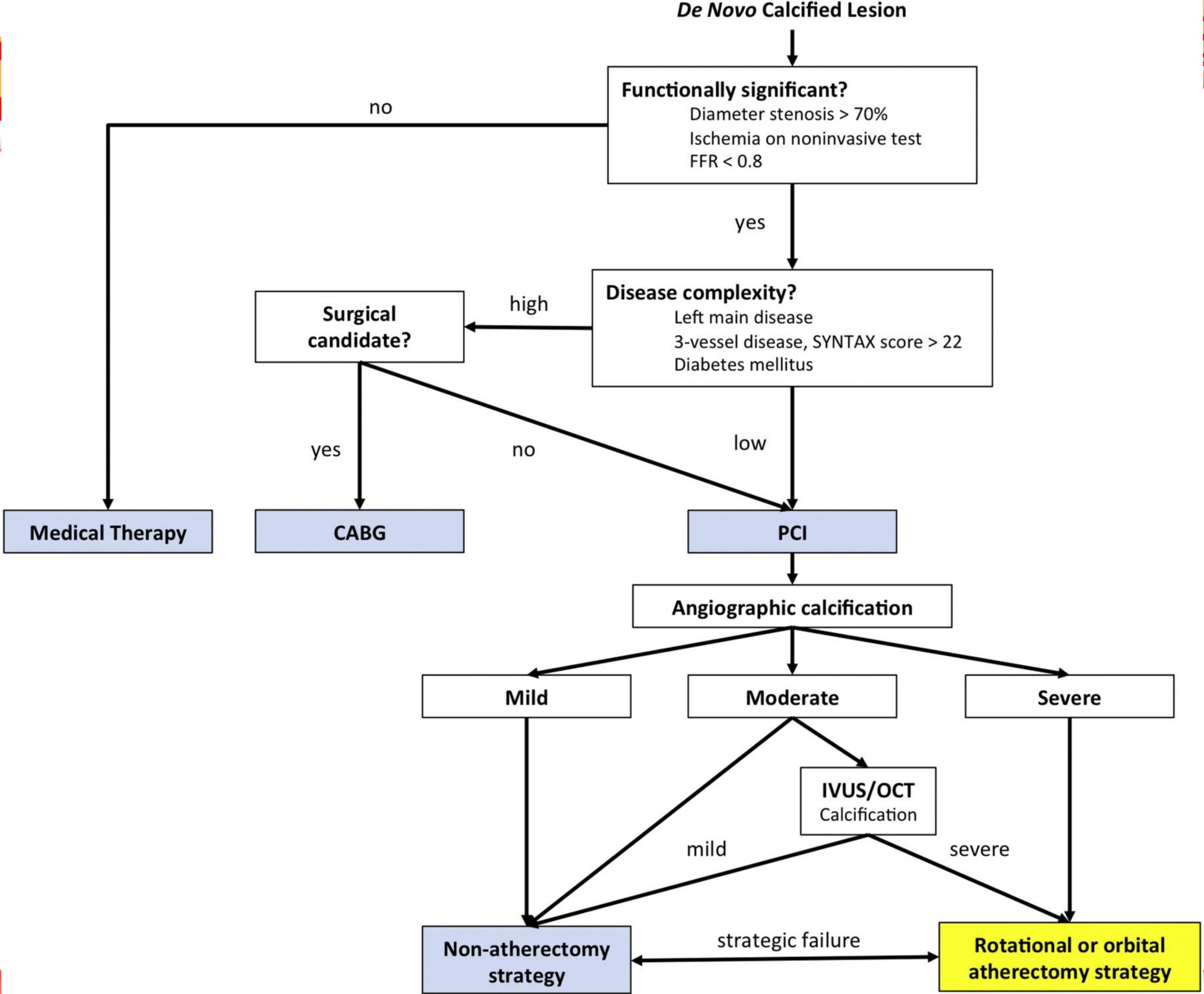
State-of-the-Art Paper

Current Status of Rotational Atherectomy

Matthew I. Tomey MD, Annapoorna S. Kini MD, Samin K. Sharma MD

Zena and Michael A. Wiener Cardiovascular Institute, Mount Sinai Medical Center, New York, New York

Received 16 June 2013, Revised 5 December 2013, Accepted 19 December 2013, Available online 13 March 2014.


De Novo Calcified Lesion
Functionally significant?
Diameter stenosis > 70%
Ischemia on noninvasive test
FFR < 0.8
no
yes
Disease complexity?
Left main disease
3-vessel disease, SYNTAX score > 22
Diabetes mellitus
high
Surgical candidate?
yes
no
low
Medical Therapy
CABG
PCI
Angiographic calcification
Mild
Moderate
Severe
IVUS/OCT
Calcification
mild
severe
Non-atherectomy strategy
strategic failure
Rotational or orbital atherectomy strategy

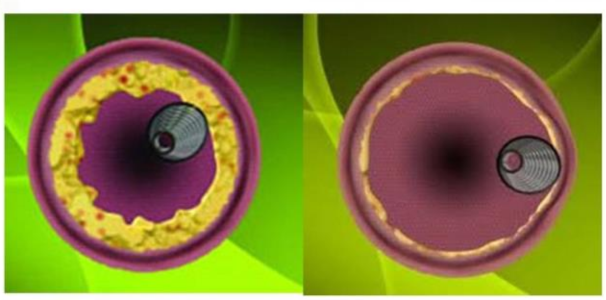
Labelled contra-indications for rotational atherectomy
1. Occlusions through which a guidewire will not pass
2. Last remaining vessel with compromised left ventricular function
3. Saphenous vein grafts
4. Angiographic evidence of thrombus prior to treatment with the Rotablator system. Such patients may be treated with thrombolytics. When the thrombus has been resolved for two to four weeks, the lesion may be treated with the Rotablator system
5. Angiographic evidence of significant dissection at the treatment site. The patient may be treated conservatively for approximately four weeks to permit the dissection to heal before treating the lesion with the Rotablator System
Relative contra-indications for rotational atherectomy
1. Severe 3-vessel or unprotected left main disease
2. Unavailability of bypass surgery
3. Lesion length in excess of 25 mm
4. Severe left ventricular dysfunction (ejection fraction < 30%)
5. Lesion angulation in excess of 45°
6. Shock or hypotension
7. Rotational atherectomy in the sub-intimal space

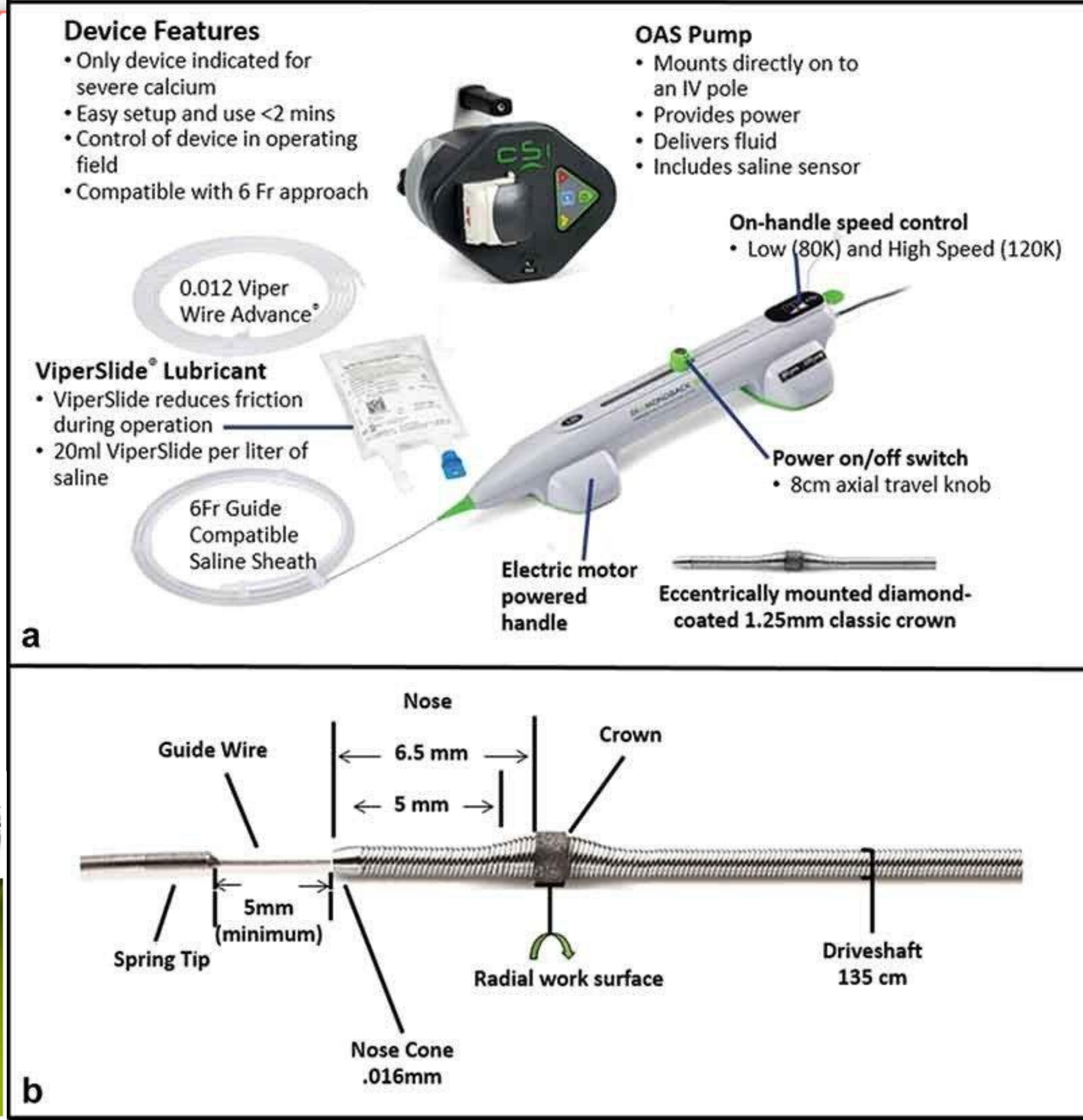
Tools for management of coronary calcification during PCI

ORBITAL ATHERECTOMY SYSTEM (OAS)

- The Diamondback 360°® System (Cardiovascular Systems, Inc., St Paul, MN, USA)
- 80,000 or 120,000 rpm
- The average particle size created by OAS is 2.04μm; 98.3% of particles are smaller than a red blood cell; and 99.2% of particles are smaller than the diameter of a capillary

Diamondback 360® Coronary Orbital Atherectomy

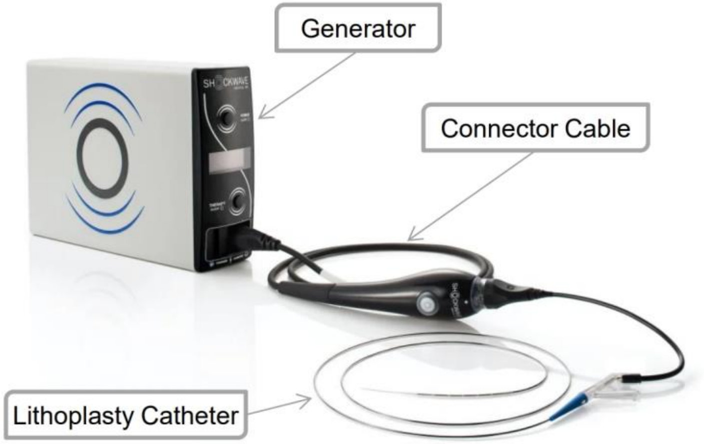


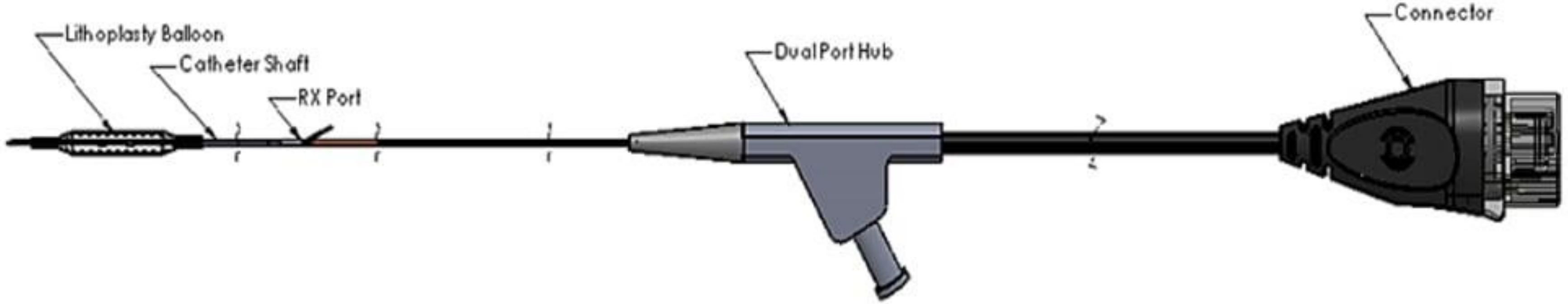


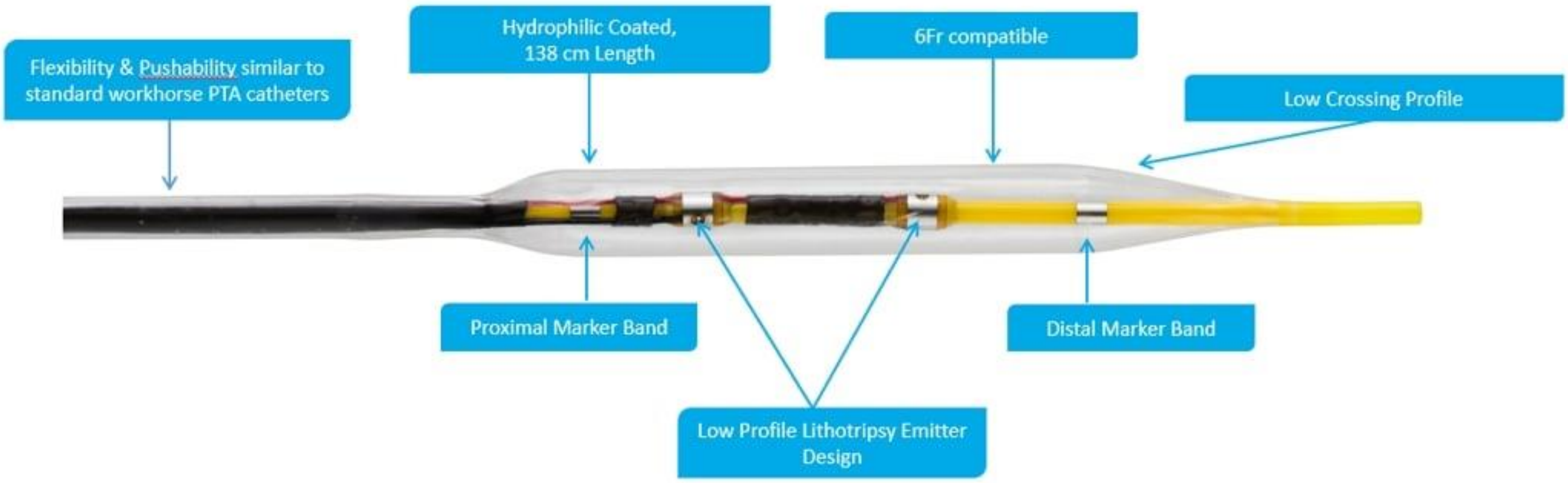
Tools for management of coronary calcification during PCI

INTRACORONARY LITHOTRIPSY / INTRAVASCULAR LITHOTRIPSY

- IVL is an innovative technology, adapted from the treatment of kidney stones
- IVL makes use of a traditional balloon catheter with multiple emitters implanted in the catheter within the mounted balloon segment. These emitters produce high-speed sonic pressure waves that pass through soft tissue and result in significant shear stress to selectively fracture intimal and medial calcium within the vessel wall




Lithoplasty Balloon
Catheter Shaft
RX Port
Dual Port Hub
Connector

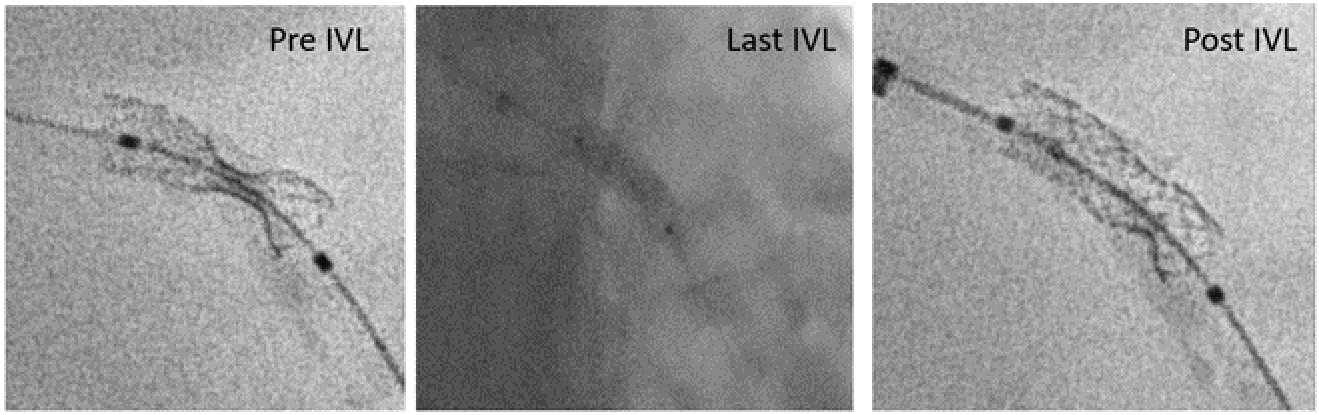

Flexibility & Pushability similar to standard workhorse PTA catheters
Hydrophilic Coated, 138 cm Length
6Fr compatible
Low Crossing Profile
Proximal Marker Band
Distal Marker Band
Low Profile Lithotripsy Emitter Design


Im: 1/300
Se: 11
RM_14032018
Kings College
R201803141022255
Cardiac
Fluoroscopy
WL: 128 WW: 256 [D]
LAO: 41
3/14/2018 11:34:40 AM

Tools for management of coronary calcification during PCI

INTRACORONARY LITHOTRIPSY / INTRAVASCULAR LITHOTRIPSY

- **STENT UNDEREXPANSION**



Tools for management of coronary calcification during PCI

INTRACORONARY LITHOTRIPSY / INTRAVASCULAR LITHOTRIPSY

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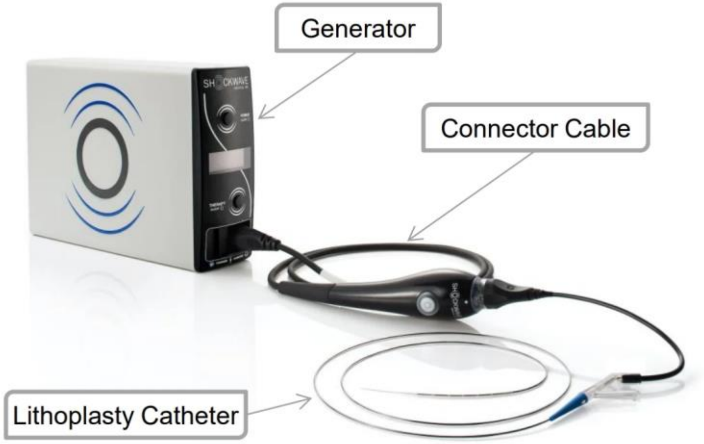
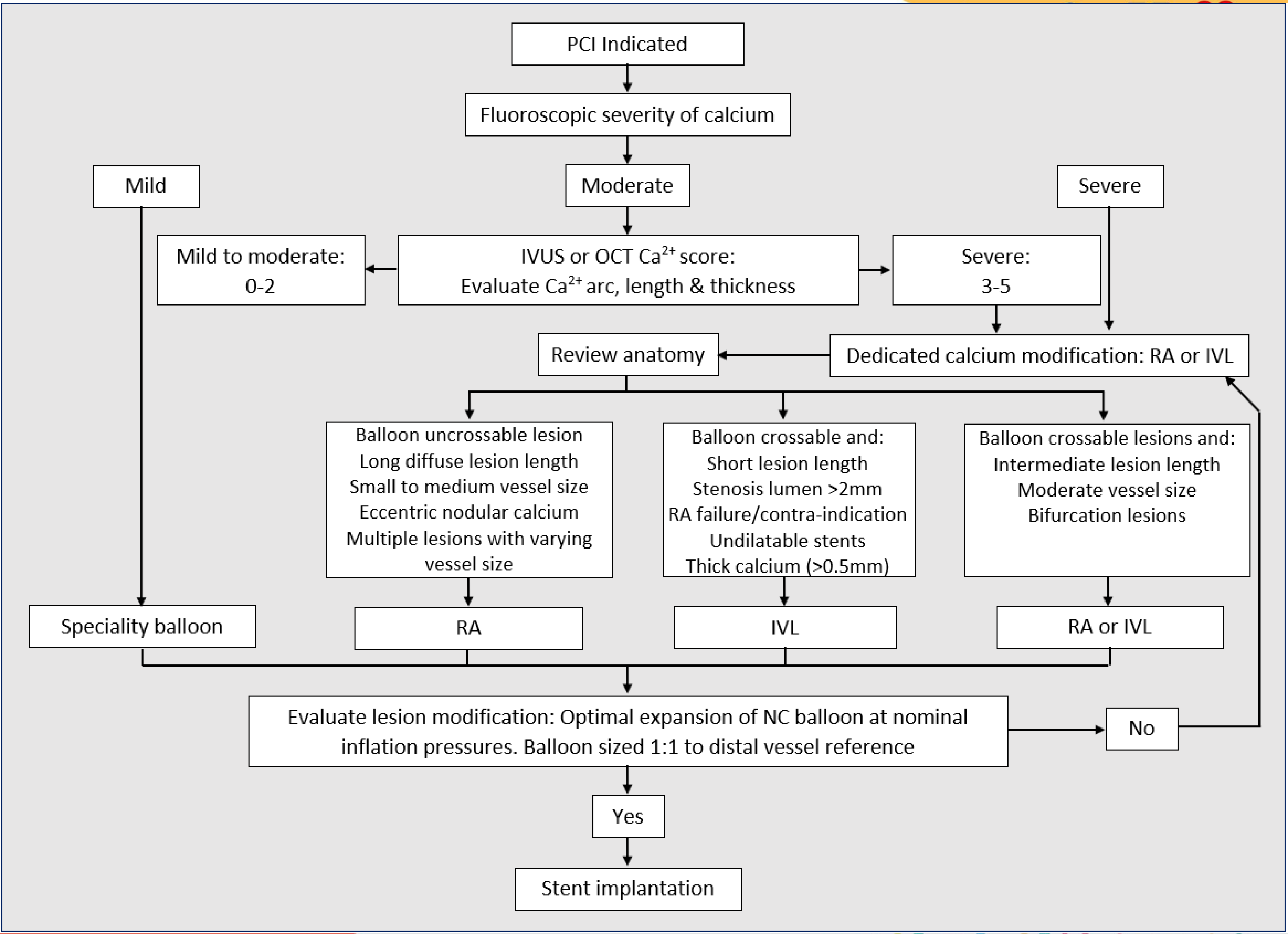


LESIONS WHERE IVL IS FAVORED:

- Large vessels with residual minimal luminal diameters ≥2mm. Even with the largest burr sizes, rotational atherectomy may not modify the lesion significantly and in this instance IVL should be the preferred choice.
- In lesions with a calcium thickness of ≥0.5mm, IVL may also be favored due to its ability to modify deep calcium as opposed to rotational atherectomy which may only ablate superficial calcium.
- Lesions involving bifurcations such as the distal LMS, IVL has the advantage of not having to remove a coronary wire from the side branch.
- In extreme tortuosity or angulation rotational atherectomy may be contraindicated due to the risk of burr stall, perforation, or wire fracture.

LESIONS WHERE ATHERECTOMY IS FAVORED:

- The smallest IVL catheter is 2.5mm, therefore IVL cannot be used in vessels smaller than 2.5mm.
- In diffuse long lesions, atherectomy may be preferred as the whole length of the lesion can be modified with the use of one burr as opposed to using multiple IVL catheter balloons.
- In eccentric and nodular calcified lesions, especially where wire bias will favor contact of the burr tip with the calcium, rotational atherectomy will be appropriate.
- In lesions where a balloon cannot cross the lesion, rotational atherectomy should be chosen.


PCI Indicated
Fluoroscopic severity of calcium
Mild
Moderate
Severe
Mild to moderate: 0-2
IVUS or OCT Ca^{2+} score: Evaluate Ca^{2+} arc, length & thickness
Severe: 3-5
Review anatomy
Dedicated calcium modification: RA or IVL
Balloon uncrossable lesion
Long diffuse lesion length
Small to medium vessel size
Eccentric nodular calcium
Multiple lesions with varying vessel size
Balloon crossable and:
Short lesion length
Stenosis lumen >2mm
RA failure/contra-indication
Undilatable stents
Thick calcium (>0.5mm)
Balloon crossable lesions and:
Intermediate lesion length
Moderate vessel size
Bifurcation lesions
Speciality balloon
RA
IVL
RA or IVL
Evaluate lesion modification: Optimal expansion of NC balloon at nominal inflation pressures. Balloon sized 1:1 to distal vessel reference
No
Yes
Stent implantation

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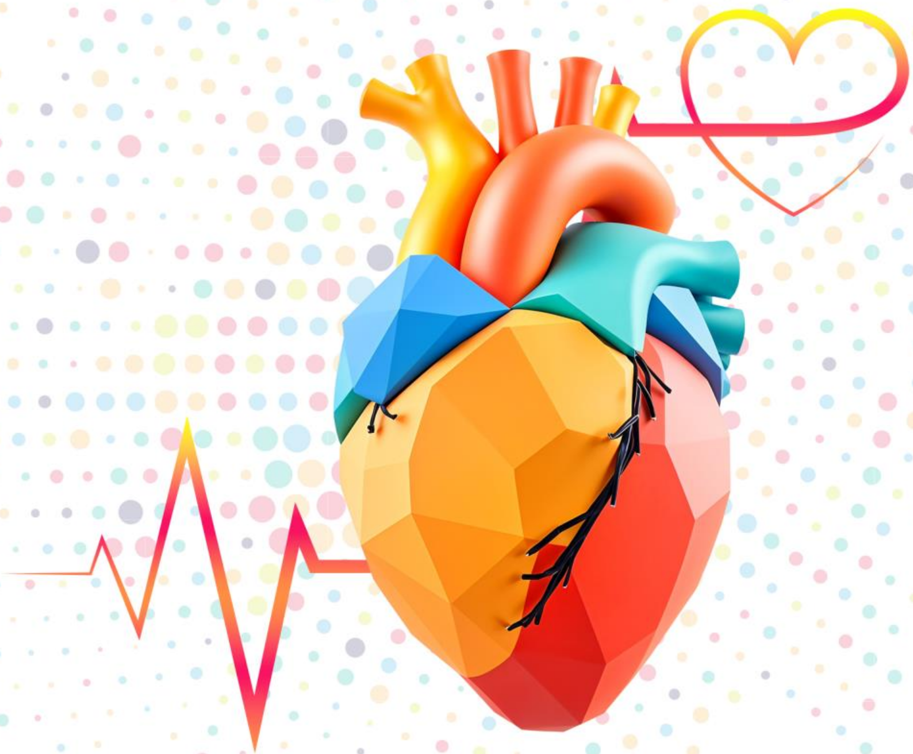

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