

PCI for Chronic Total Occlusion :Evolving Technology

Evolving Technology

- Excimer Laser
- Ultrasound
- Radiofrequency
- Microdissection
- Fibrinolysis
- MDCT
- IC NaviView
- Magnetic RF Wire

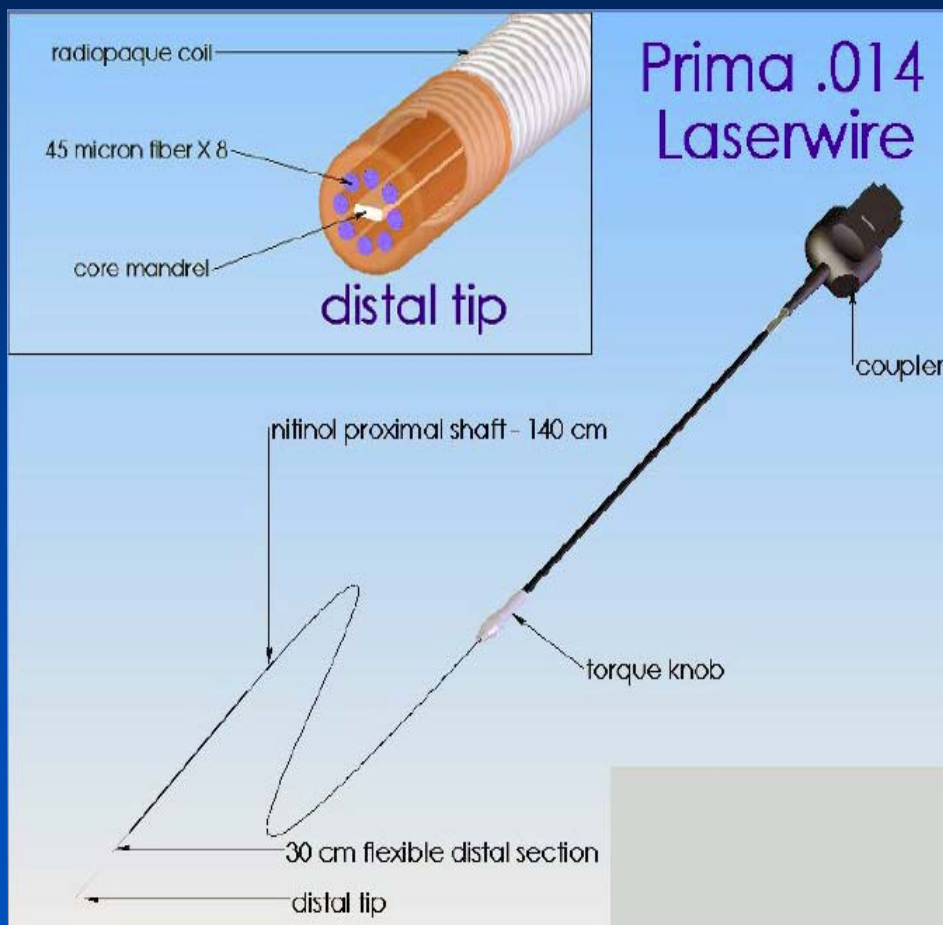
Evolving Technology Ablative Tools

Excimer laser

Prima Laser wire 0.014"

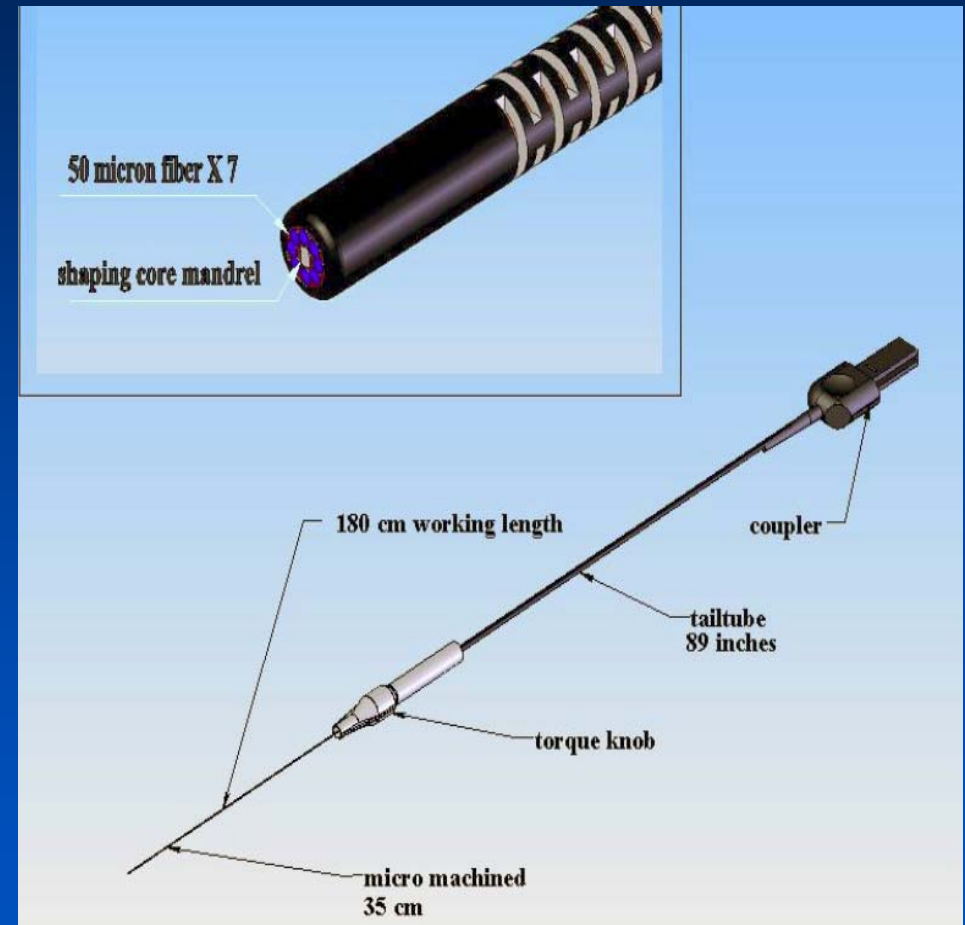
- **Specifications**

- Size = .014"
- Fiber = 8 fibers(45 microns)
- Coil = 30 cm radioopaque
- Proximal shaft = 150 cm
Nitinol hypotube Teflon coated
- Exchange length = 180 cm
- Active area = 0.127 mm²
- % active area = just over 11%
- Max energy = 1 – 1.2 mj



Superwise

- Next generation .014” laser guidewire
- Steering and handling characteristics similar to standard mechanical guidewires
- Laser ablation enhances CTO crossing ability (approximately 0.04 mm/pulse)
- 180 cm working length



Point 9 X-80 Catheter

- Two product configurations
 - Vitesse (Rx) 110-004
 - Extreme (OTW) 110-002
- 0.9 mm tip diameter
- .014 or smaller guidewire compatibility
- 6 French guide catheter compatibility
- 80 fluence, 80 hertz maximum laser parameters
- 10 second “on”, 5 second “off” lasing sequence



TOTAL: Total Occlusion Trial with Angioplasty by Using Laser GuideWire

- 18 European Centers, 303 patients
- **1^o Endpoint:** Reaching the True Lumen Within 30 Min of Fluoroscopic Time

	Laser Wire (n=144)	Mechanical Wire (n=159)	P Value
Primary Endpoint (%)	52.8	47.2	NS
Acute Adverse Events (%)	0	0.6	NS
Restenosis Rate at 6 mo (%)	45.5	38.3	NS
Reocclusion Rate (%)	25.8	16.1	NS

P.Serruys et al, *Eur Heart J* 2000;21;1797-1805

Debulking Prior To Stenting After Revascularization of Chronic Total Occlusions

*176 CTO Lesions Treated With Excimer Laser,
Directional or Rotational Atherectomy*

	Stent Alone (n=126)	Debulking+Stent (n=50)	P Value
Angio.Success (%)	97.1	100	NS
Final MLD (mm)	2.62 ± 0.7	2.70 ± 0.6	NS
Hospital MACE (%)	3.7	2.3	NS
MACE at FU (%)	19.6	25.6	NS
TLR (%)	14.4	16.3	NS

Gruberg et al, *JACC*, 2000

Evolving Technology Ablative Tools

Ultrasound

Description of Procedure



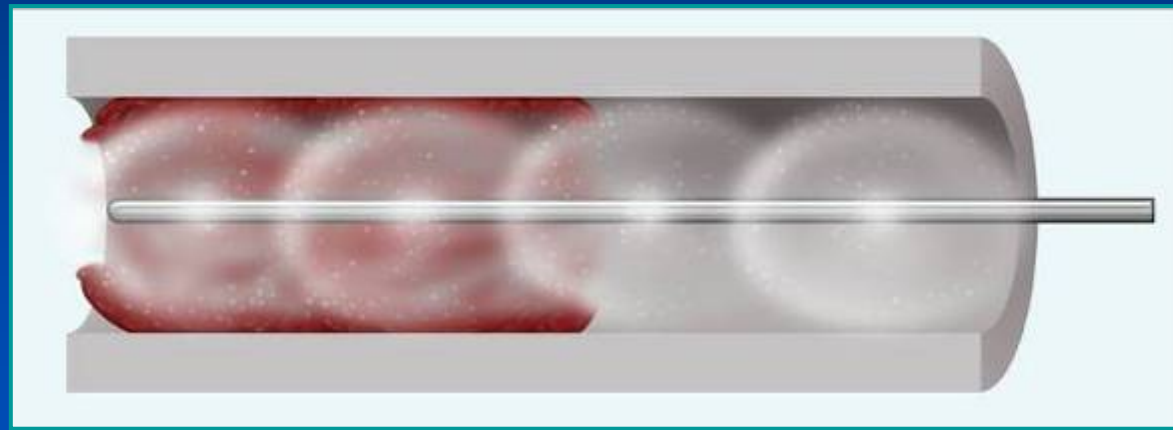
- Generator provides an electrical signal to the reusable handpiece



- Handpiece converts the signal to acoustic energy
- Small diameter flexible guidewire vibrates at 20 kHz, ablating tissue via cavitation along distal 20 cm active length

OmniWave Technology

- OmniWave Technology is the first technology that delivers controlled acoustic energy along the active section of a flexible 0.004” – 0.025” wire



OmniWave Technology Energy Delivery

First-Generation Ultrasonic Energy Delivery vs. OmniWave™ Technology

Previous tip-based energy delivery



OmniWave Technology energy delivery

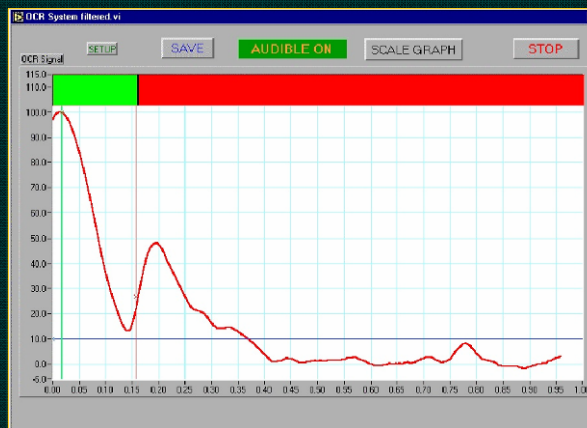


Evolving Technology Ablative Tools

Radiofrequency

OCR Waveform Displays

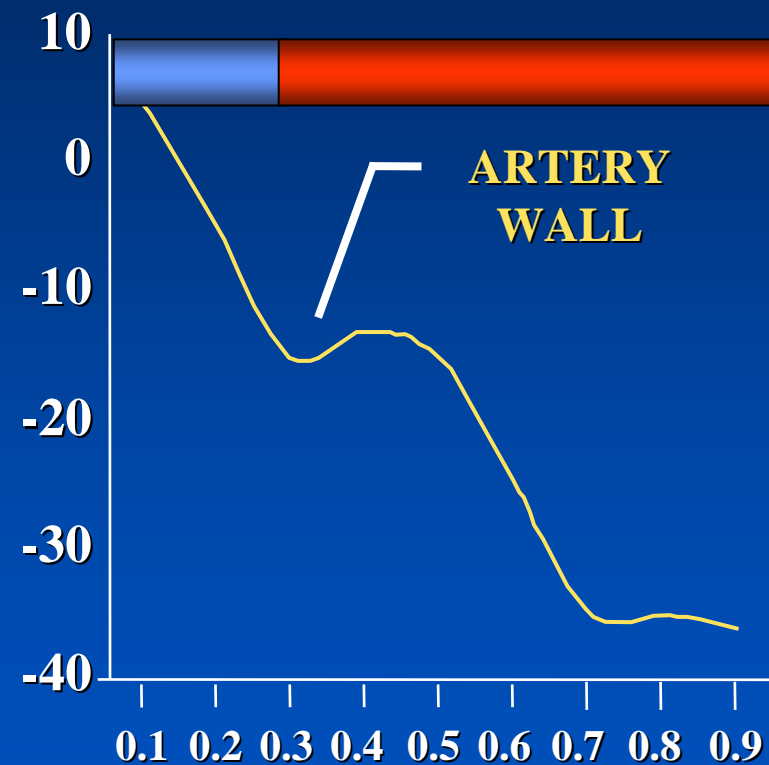
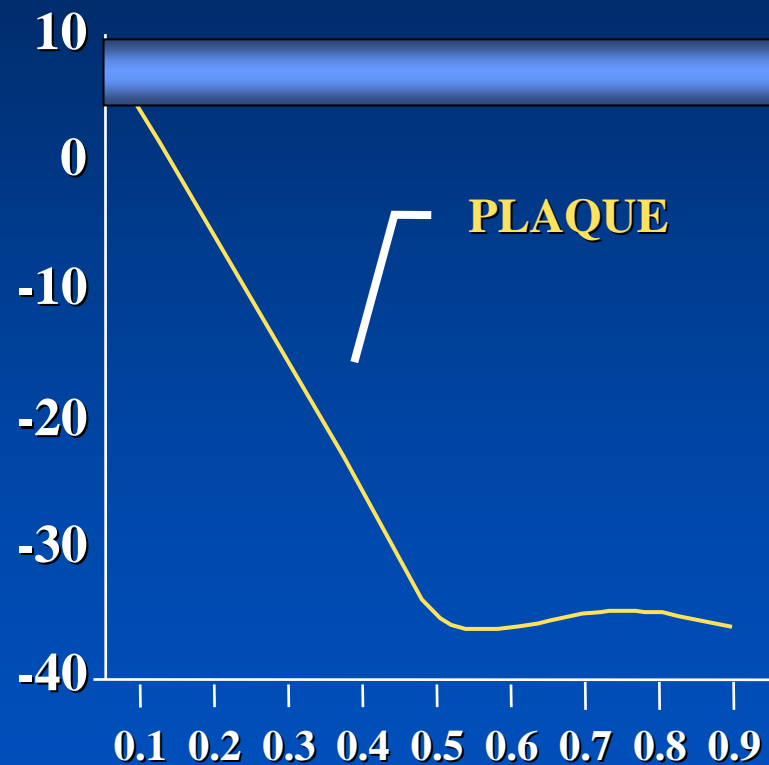
Simple Display Feature



Investigational Device, Not available for sale in the US.

CTO: Technical Challenges

OCR Monitor Signal



OCR SafeSteer System

- *Forward looking guidance system, using OCR to determine tissue types (plaque vs arterial wall).*
- Designed to navigate through total occlusion.



The Crosser™ System

- *Generator*
converts line power into high frequency current
- *Transducer*
converts electric current into mechanical vibration
- *The Crosser catheter*



The Crosser™ System

Clinical Experiences

54 pts with 56 CTO, Refractory to guidewire
Mean occlusion length 27 mm (8~46 mm)

- Average time spent 2:43 min
- MACE (2 NQMI) 3.6 % (2/56)
- Clinical perforation 0 %

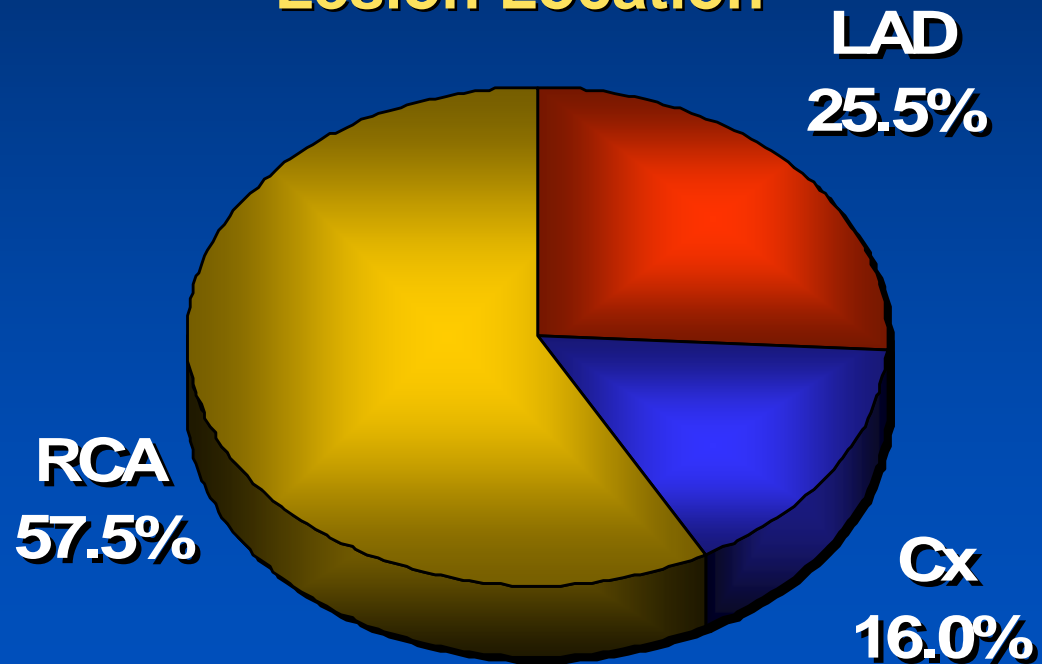
*High frequency mechanical recanalization
is a promising technology.*

G. Sutsch et al, JIM 2004

The prospective Guided Radiofrequency Energy Ablation of Total Occlusions (GREAT) trial

116 Lesions 21 Centers with CTO "Failure to Cross"

Lesion Location



GREAT Trial

116 pts 21 Centers

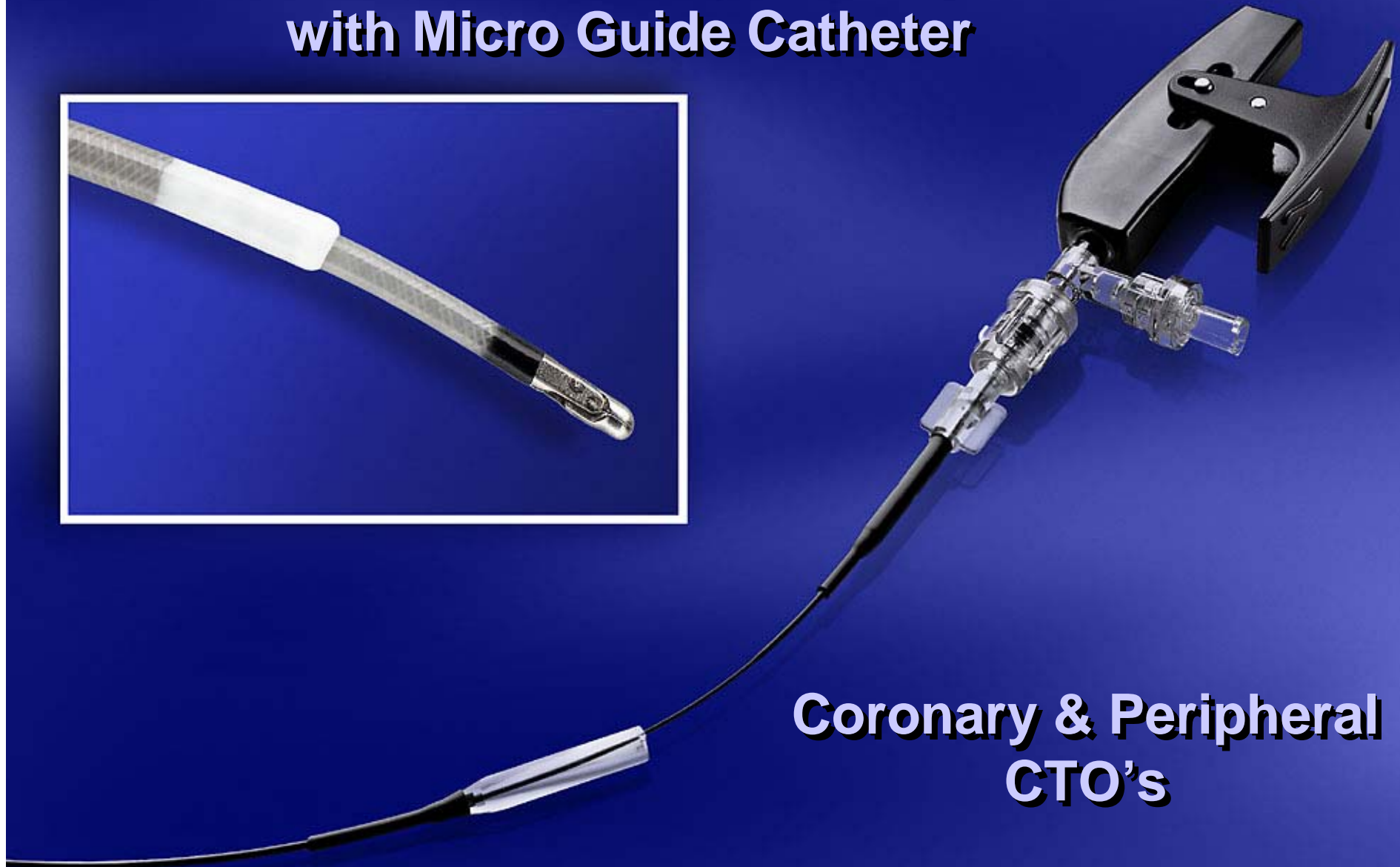
- Device Success 54.3%
- Complications
 - Clinical Perforations 2.6% (3)
 - Device related 0.9% (1)
 - MACE (6 NQMI) 5.2%
 - MACE + Clinical Perforations 6.0% (7)

Baim DS et al. Am J Cardiol 2004;94:853-858

Evolving Technology Mechanical Tools

Blunt Microdissection

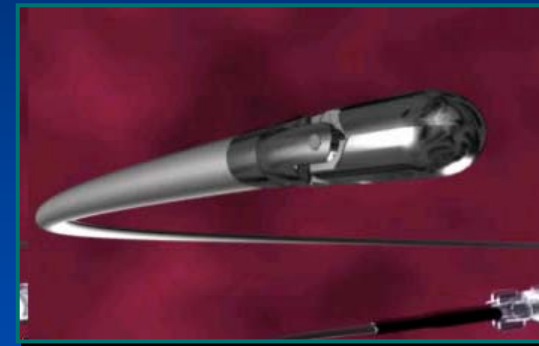
LuMend Frontrunner® X39 CTO Catheter with Micro Guide Catheter



**Coronary & Peripheral
CTO's**

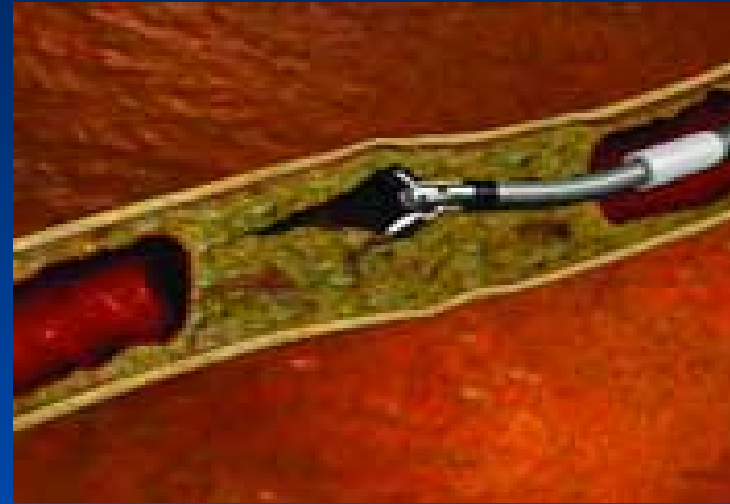
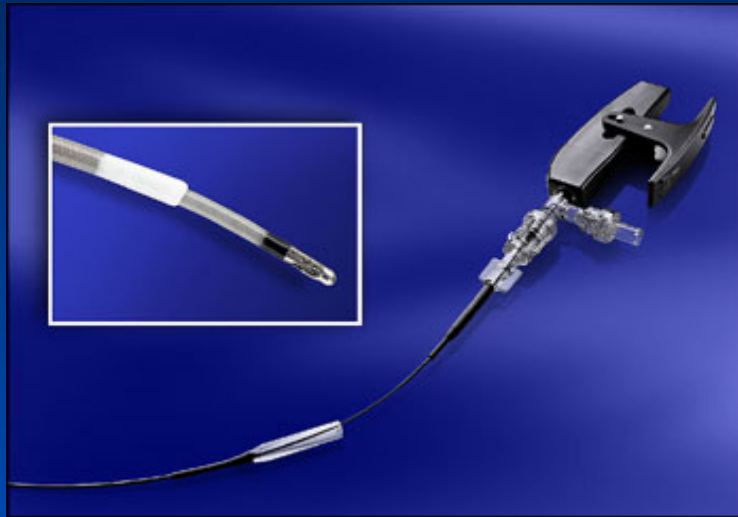
Frontrunner™ CTO Catheter

- Indicated for Chronic Total Occlusions
- Controlled Blunt Micro Dissection Technique
- Multiple distal tip openings
- 4.0 & 4.5 French catheter platforms
- No external energy source



FrontRunner Catheter

Controlled Blunt Micro-Dissection



- Blunt controlled passage through occlusion
- Uses elastic properties of adventitia vs. inelastic fibrocalcific plaque

Frontrunner™

EXTRA RADIUS **XR**



25° Distal Tip Angle



36° Distal Tip Angle

Frontrunner™ CTO Catheter

Controlled Blunt Micro-Dissection Technique

- Gently separates atherosclerotic plaque in various tissue planes, creating a passage through the CTO
- Uses elastic properties of adventitia versus inelastic properties of fibrocalcific plaque to create fracture planes



LuMEND FRONTRUNNER CORONARY CATHETER CONTROLLED BLUNT MICRO-DISSECTION TECHNIQUE

LuMend Frontrunner[®] X39 CTO Catheter

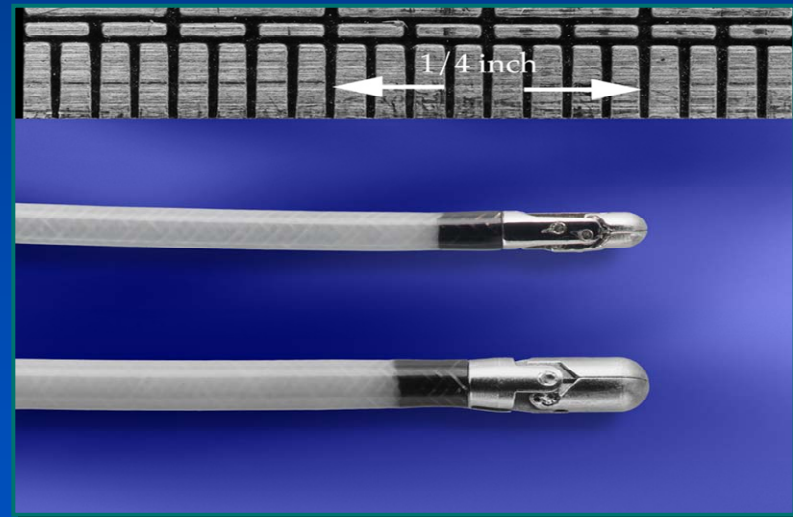
- .039" (2.8F) distal tip size
- 2.3mm opening
- 55% reduction in catheter surface area vs. original Frontrunner
- Shortened distal rigid segment (improves tip shape and steerability)
- Guide wire like handling/size



Frontrunner X39



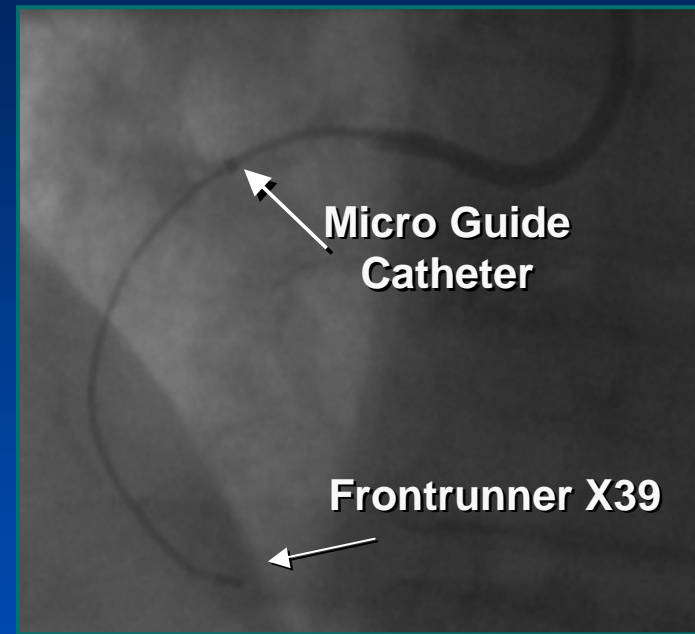
X39 compared to .035" guide wire



X39 compared with the original
Frontrunner

LuMend Frontrunner® Micro Guide Catheter

- Support/Transitional catheter used with Frontrunner X39
 - PTCA balloon/guide wire concept*
- Tapered tip
- 4.5 French/127cm working length
- Torqueable braided shaft
- 7 French guide cath recommended
- Easy transition of ancillary devices to and from occlusion site
 - Wires, balloons, etc.*



Frontrunner Technique

Actuation, Retraction, and Torque

1. Firm engagement before actuation
2. Feel for resistance, and look for slow opening
3. Retract after every actuation and confirm jaw closure
4. Torque back into position before next actuation
 - Assures closure
 - Improves engagement

Equipment Selection

Guiding Catheters

1. 6F vs 8F
2. Left Coronary
 - JL4 vs XB vs AL
3. Right Coronary
 - JR4 vs HS vs AL (.75 vs 1)

Frontrunners

1. Curved vs Straight jaws
2. Curved 25 degree vs 36 degree
3. Small vs Large jaws
4. New devices
 - Bottlenose, FR 4.0, FR 2.8



Frontrunner™ CTO Catheter

Clinical Trial

- Prospective, controlled multi-center trial
- 107 patients enrolled
- CTO patients refractory to a ten minute (fluoroscopy time) guide wire attempt
- Success defined as placement of guide wire beyond CTO in the true vessel lumen
- Mean Lesion Length: 22mm
- Range of Lesion Length: 2-53mm

Frontrunner™ CTO Catheter Clinical Trial

Results (Lesion length=23mm)

Outcome	Number (n=107)	Rate (n=107)
Successful delivery to CTO	96	89.7%
Advanced distal to CTO	66	61.7%
Wire placed distal to CTO in true vessel lumen	60	56.1%

Frontrunner™ CTO Catheter Clinical Trial

Complications (Potentially Device Related)

- Perforation
 - With tamponade or hemopericardium 0
 - Without tamponade or hemopericardium 2 (1.9%)
- AMI
 - Q-Wave 0
 - Non Q-Wave CK>3x 2 (1.9%)
- Other 4 (3.7%)
 - Includes one death

Adverse events evaluated by independent adjudication CEC/DSMB.

Clinical Outcomes of FrontRunner Catheter

- N =909
 - Pre-approval phase: 119 (using the largest device),
 - Post-approval phase: 197 (using a smaller, more flexible catheter),
 - Current design: 593 (using X-39 Frontrunner)
- Lesion length: >30mm in 21%
- Success rate
 - Pre-approval phase: 56%
 - Post-approval phase: 59%
 - Current design: 61%
- Perforation: 0.9%

Yang YM, et al. Catheter Cardiovasc Interv 2004;63:462

FrontRunner Catheter

Milan Experiences

50 pts with 50 CTO, Refractory to guidewire
Mean occlusion length 38.3 ± 22 mm

- Overall Device Success 50 % (25)
- Coronary perforation 17.3 % (9)
- Adverse events @ 30 days 15.7 % (8)
7 non-Q wave MI, 1 sudden death

Relatively high risk of perforation !

A Colombo et al, ACC 2004

FrontRunner Catheter

Advantages

- Torqueable
- Guide support
- Directable/Steerable
- Hydrophilic coating
- Blunt tip to avoid perforation
- Avoids side branches

Disadvantages

- Difficult anatomy: tortuosity, small vessel, heavy calcium
- Expensive
- 8 Fr guiding for curved jaw
- Failure Modes

Evolving Technology Mechanical Tools

Fibrinolysis

IntraCoronary Lytic Infusion for Failed PCI of CTO

- 85 patients with CTO \geq 3 months, failed PCI
- 8 hour infusion (Guide + IC Catheter)
- 61 tPA 0.25 mg/hr (weight adjusted)
- 24 TNK 0.5 mg/hr
- IV Heparin, ACT 200-250 seconds
- Hematoma 8%; Transfusion 3.5%

O'Neill, et al JACC 2005;46:793-8

IC Lytic Infusion for CTO

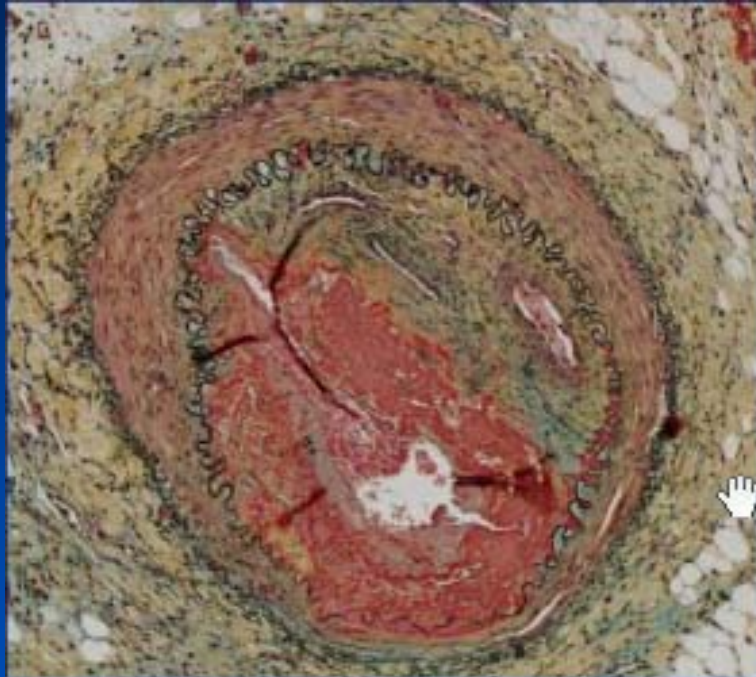
- Lytic Infusion did not directly recanalize the CTO – but did “facilitate wire crossing” – ?
Mechanism – clot lysis or activation of other proteolytic enzymes (Matrix metalloproteinases)

Matrix Metalloproteinase

- Zinc and calcium-dependent enzymes that catalyze the breakdown of protein
- MMP-1, MMP-2, MMP-9, MMP-3
- Degrade all extracellular matrix components
- 3 broad categories:
Collagenases, gelatinase, and stromelysins

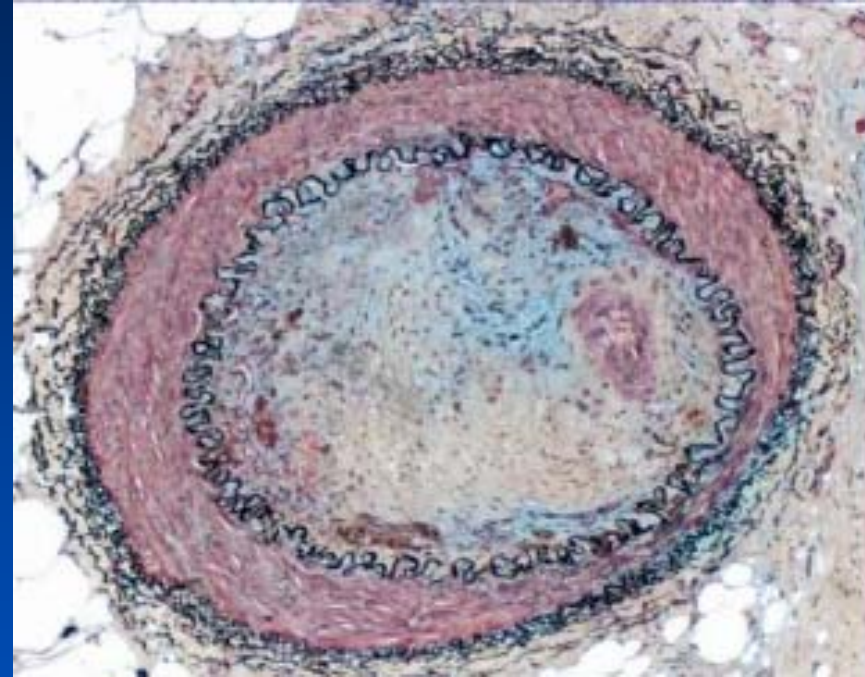
Strauss BH et al, Circulation 2003;108:1259-62

Guide-Wire Crossing at 72 hours



Success

Collagenase 450 ug

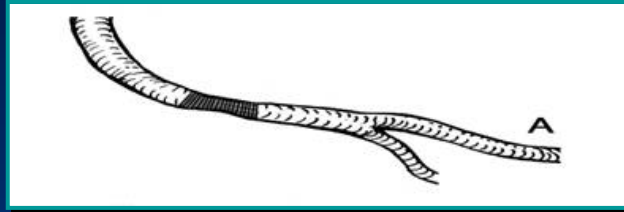


Failure

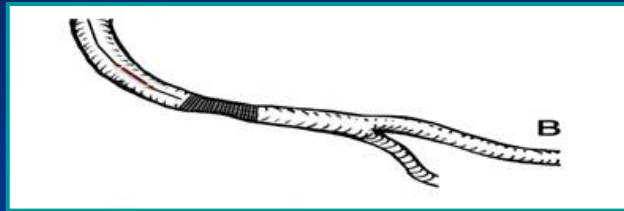
Placebo

Strauss BH et al, Circulation 2003;108:1259-62

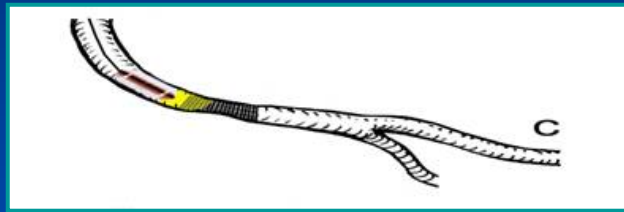
Description of Procedure



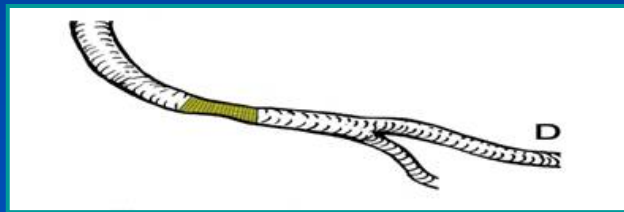
A: Chronic Total Occlusion



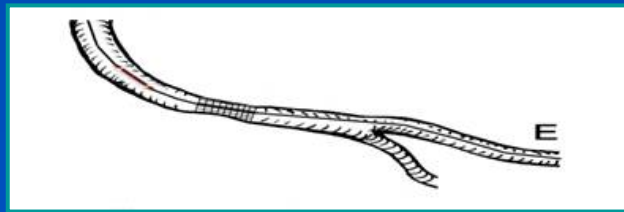
B: Failure to Cross with Guide Wire (Choice PT, Wizdom)



C: Infusion of Collagenase through Wire Port



D: Collagenase Diffusion Through Occlusion



E: Successful Guide Wire Crossing

Chronic Total Occlusion Revascularization

Alternative Technologies



- FlowCardia CROSSER System
 - High frequency mechanical revascularization
 - Monorail, and OTW
 - 0.014" wire and 6 Fr guide compatible
 - Straight and angled tip configurations

Investigational Product Only. Not Available for Sale in the U.S.

Chronic Total Occlusion Evolving Technology and Strategy

New Generation

- MSCT
- IC NaviView
- Magnetic RF Wire

Multislice CT Coronary Angiography

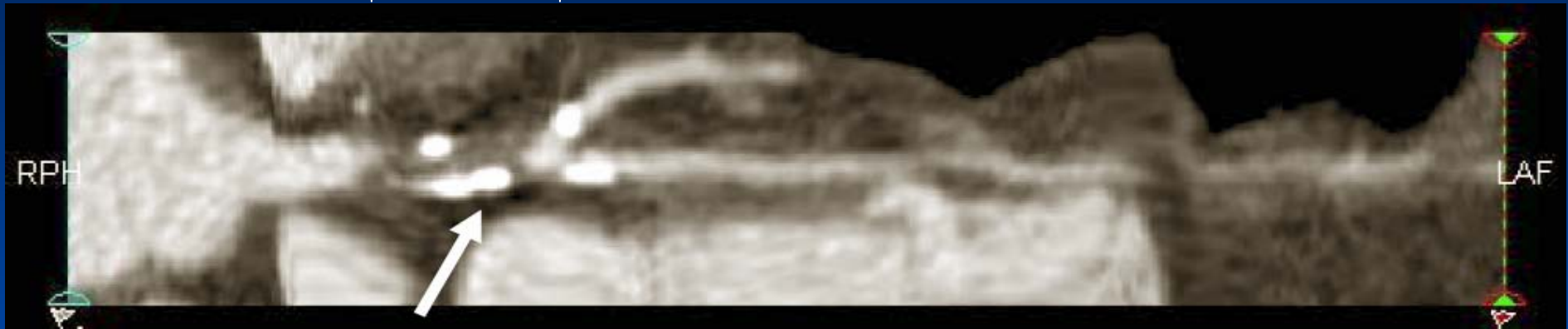
- Quantification of the length of the occlusion
- Definition of plaque composition
- Identification of calcification
- Evaluation of distal vessel
- Definition of the intra-occlusion angle

Multislice CT Coronary Angiography

- CT angiography is able to provide complementary data to that of the conventional angiography that may be relevant to the success of the CTO recanalization.
- May provide a more precise lesion length, accurate data on plaque composition and calcium extent and location and intraplaque angle.

Multislice CT Coronary Angiography Predictors of success/failure

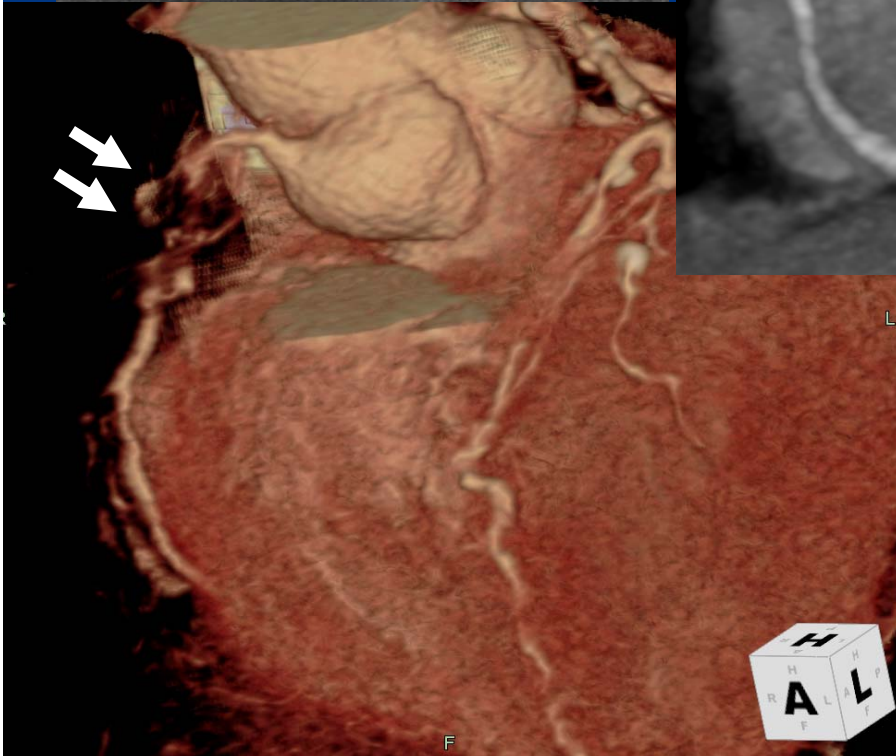
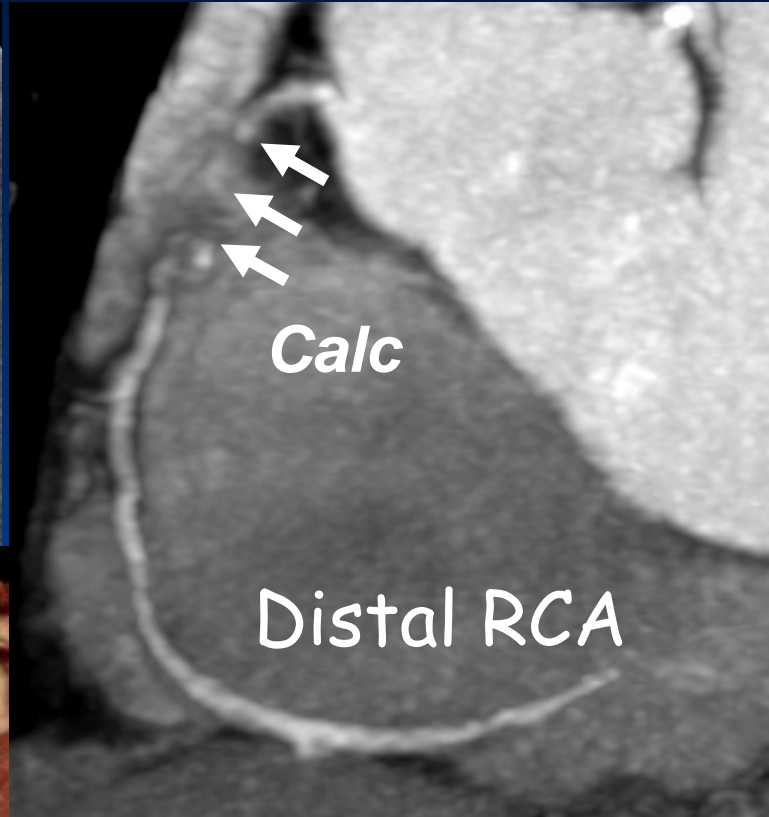
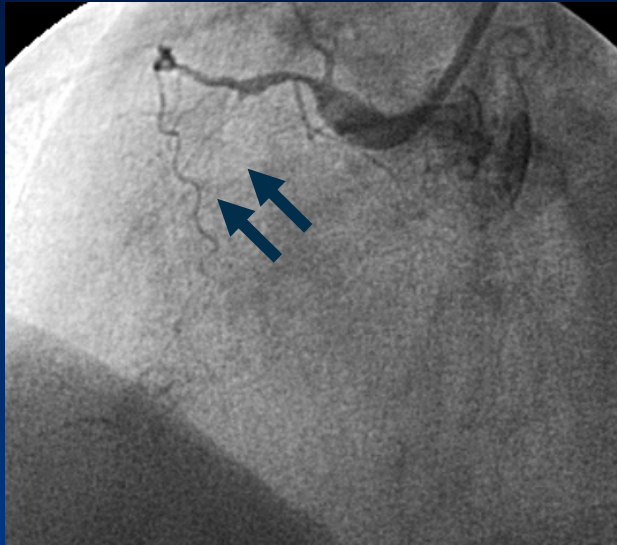
Length <15 mm (+)

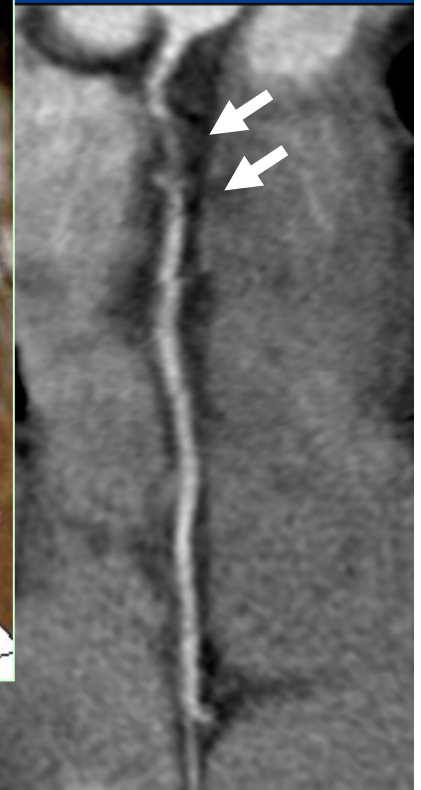
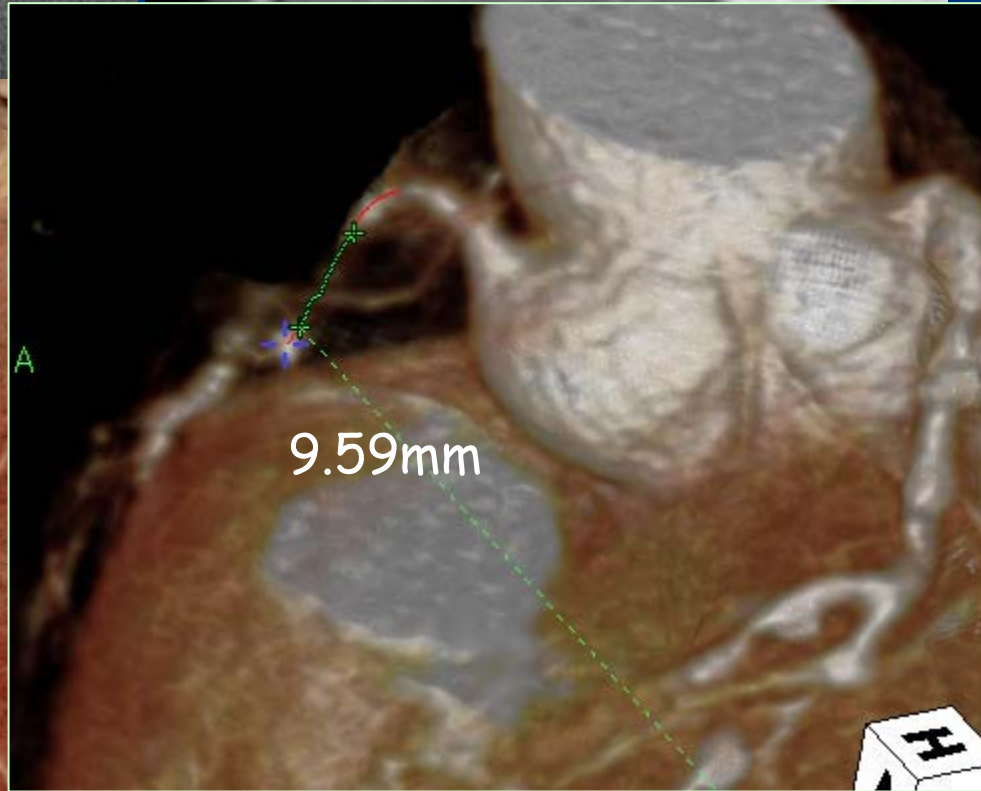
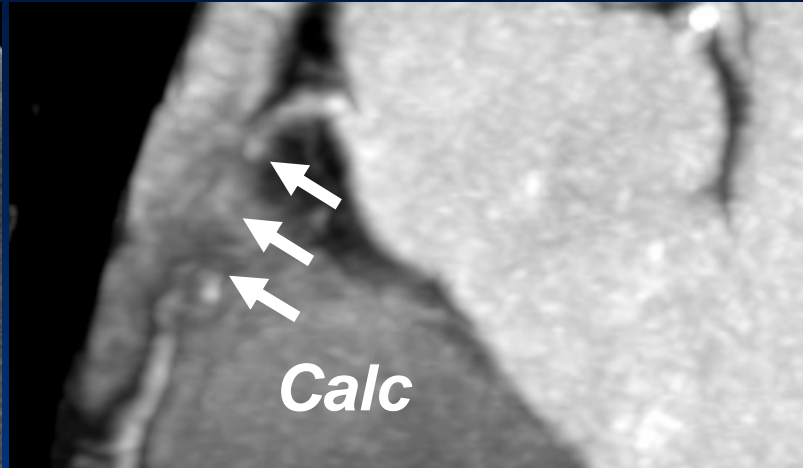
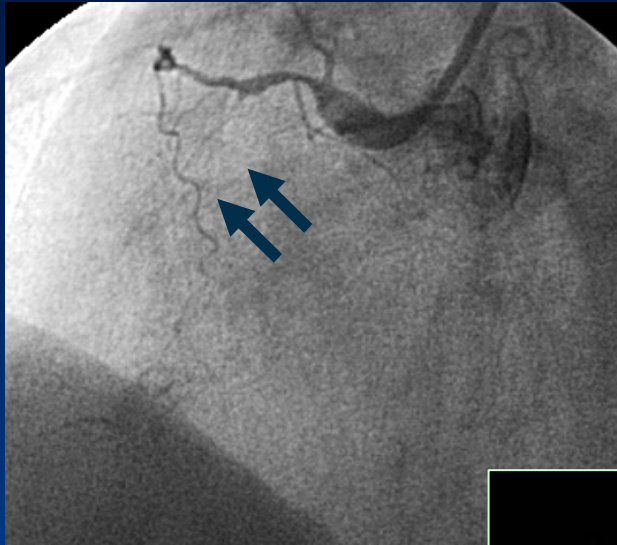


Severe calcification (-)

- Blunt stump
- Occlusion length >15 mm
- severe calcification

Mollet NR et al, Am J Cardiol 2005;95:240-243





Identify Point on CT Data

Navigant Workstation [Widal TCT 05 Live Case : Full]

Procedure Mode View Settings Help

5° 0%

Confirm AP PA LAO RAO LL RL INF SUP ARB 3D Vessel STEREOAXIS

Cronus™
Moderate Support
Guidewire
Stereotaxis, Inc. 001-001457

List	ID	Direction	Adj
ic-left			
ic-right			
cardinal			

Manual Auto

ID	Fluoro Point	ID	Preop Point
MT		BCI	

Add Selected Points Adjust Reset All

Alignments

Navigation
LAD Vector

Store Edit Delete

Reference
Set Remove

ANTERIOR
00:00 00:00

LEFT
00:00 00:00

SUPERIOR
00:00 00:00

Preop View (LAO = 86.5, CAUD = 83.9)

Nav Fluoro B (LAO = 50.8, CRAN = 30.2)

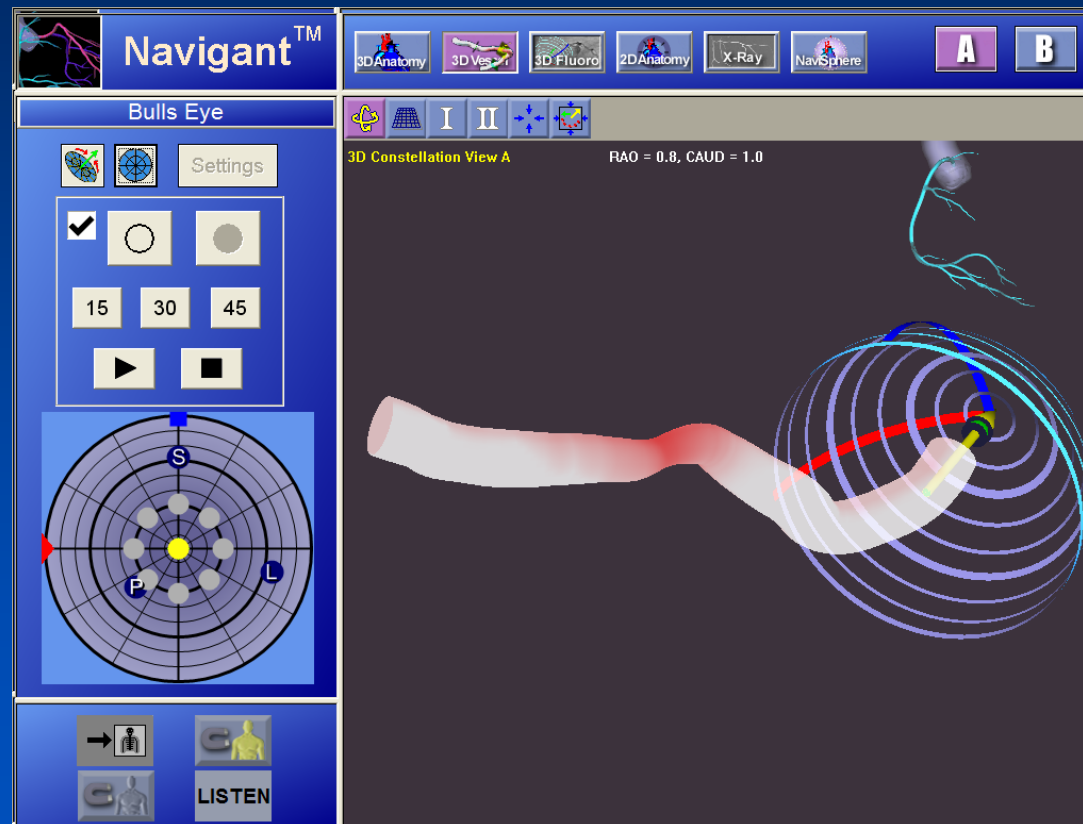
AXIOM Artis dFC Magnetic Navigation



- Magnets outside the body control the catheter, which is equipped with a specially magnetized tip

IC NaviView* – From the Touch Screen

- Simply touch the vessel location to align the guidewire



* Powered by Paieon Inc., 3-D Reconstruction Software

AUTO 15° Small 0% Confirm AP PA LAO RAO LL RL INF SUP ARB 3D Vessel STEREOTAXIS

NO DEVICE SELECTED

Please click on the down arrow to select a navigable device.

Preop View (LAO = 45.0, CRAN = 0.0)

ANTERIOR

Points & Constellations

Group	<input type="checkbox"/>	<input type="checkbox"/>	ID	Annot...
F Group 1	<input checked="" type="checkbox"/>	<input type="checkbox"/>	D	
P Isosurface - 2	<input type="checkbox"/>	<input checked="" type="checkbox"/>	E	
P Group 2	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		

ANTERIOR

00:00 5:17

Preop View (LAO = 45.0, CRAN = 0.0)

ANTERIOR

Alignment

Manual Auto

ID	Fluoro Point	ID	Preop Point
B		D	
C		E	

Add Selected Points Adjust Reset All

LEFT

00:00 7:55

Nav Fluoro A (LAO = 36.7, CRAN = 0.9)

Nav Fluoro B (RAO = 27.1, CRAN = 1.0)

Presets

List	ID	Direction	Adj
ic-left			
ic-right			
cardinal			

SUPERIOR

00:00 11:32

Nav Fluoro A (LAO = 36.7, CRAN = 0.9)

Nav Fluoro B (RAO = 27.1, CRAN = 1.0)

Bulls Eye

15 30 45 60

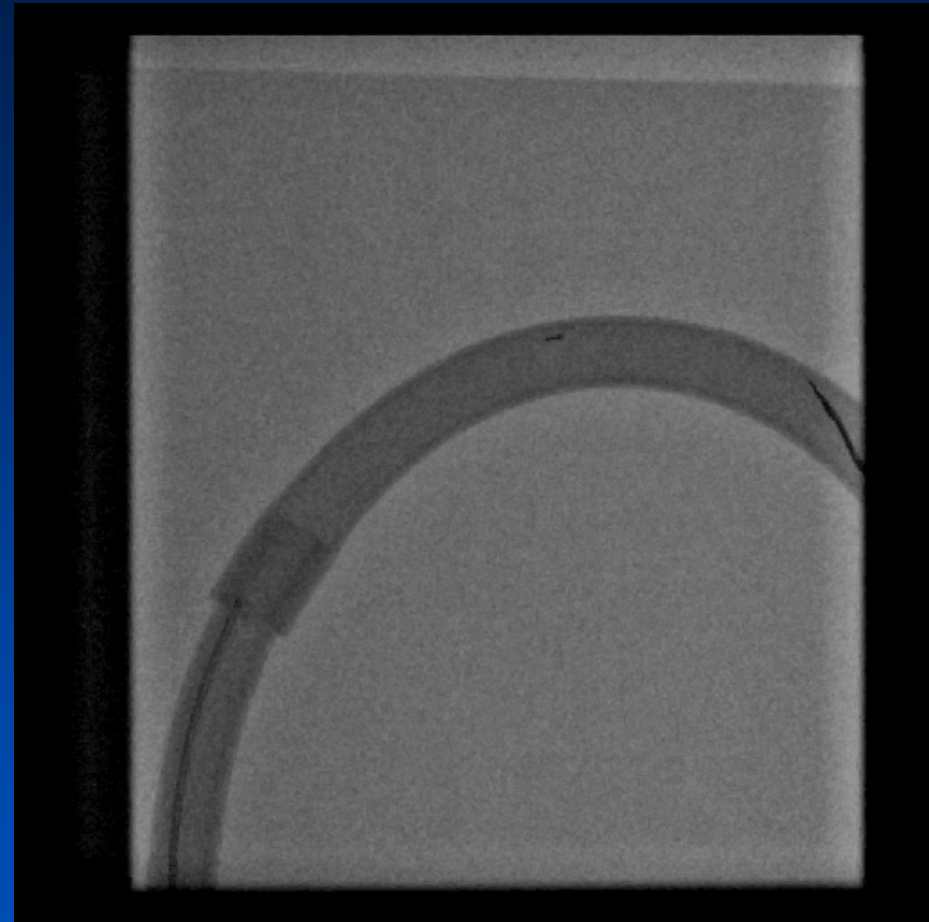
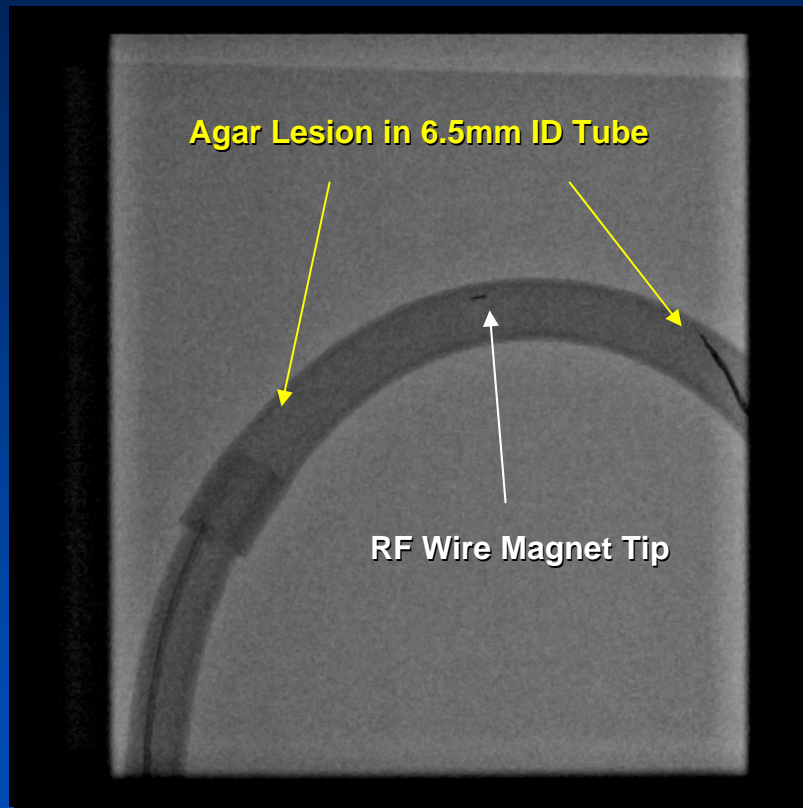
Field Tool

Zoom = 2.2

Zoom = 1.8

Prototype Magnetic RF Wire* Steering and Ablation

Test in Agar Lesion Phantom



Methodology: Magnetic directional enhancement of .014" / .018" RF guidewire

Clinical Advantages: Provides distal tip steerability and flexibility (for optimized magnetic tip deflection)- while providing ablative energy at tip

* Developed in collaboration with Baylis Medical