

“HOW SHOULD I TREAT?”: NODULI CALCIFICI

Background & esperienze cliniche

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Roma

Intravascular ultrasound identification of calcified intraluminal lesions misdiagnosed as thrombi by coronary angiography

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Accurate identification of coronary atherosclerotic plaque composition is important for optimum patient management and transcatheter therapy. In particular, the presence of thrombus typically leads to protracted hospitalization, intravenous or intracoronary thrombolysis, prolonged systemic anticoagulation, and the use of transcatheter devices designed to remove thrombi. Furthermore, thrombi may be implicated in poor outcome after transcatheter therapy. Intraluminal filling defects are believed to be the most specific angiographic markers of thrombus. We report three patients with intracoronary filling defects initially diagnosed as thrombus; however, intravascular ultrasound (IVUS) imaging showed that these filling defects represented calcified nodules.

IVUS studies were performed with one of two commercially available systems. The first (Cardiovascular Imaging Systems Inc./InterTherapy Inc., Sunnyvale, Calif.) incorporated a single element 25-MHz transducer and an angled mirror mounted on the tip of a flexible shaft that was rotated at 1800 rpm within a 3.5F short monorail polyethylene imaging sheath to form planar cross-sectional images in real time. The second (Cardiovascular Imaging Systems) incorporated a single element 30-MHz beveled transducer within either a 2.9F long monorail imaging catheter having a common distal lumen design (the distal lumen alternatively accommodates the imaging core or the guide wire, but not both) or within a 3.2F short monorail imaging catheter. With both systems the imaging catheter was advanced 5 to 10 mm beyond the target lesion and the transducer was withdrawn automatically at 0.5 mm/sec within the imaging sheath to perform the imaging sequence. IVUS studies were recorded on 1/2-inch high resolution s-VHS tape for offline analysis.

Patient 1. A 78-year-old white man with a history of pneumoconiosis, gastrectomy for stomach cancer, congestive heart failure from dilated cardiomyopathy, and coronary artery disease was seen for progressive angina. A

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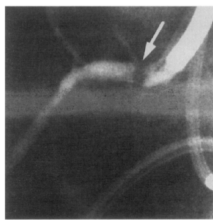


Fig. 1. Proximal right coronary artery filling defect (arrow) was initially thought to represent intracoronary thrombus. Patient was treated with prolonged systemic anticoagulation, intracoronary thrombolysis, and extraction atherectomy. IVUS imaging showed that filling defect was, in fact, calcified lesion protruding into lumen.

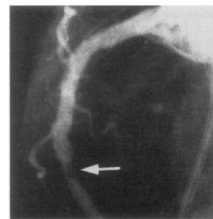
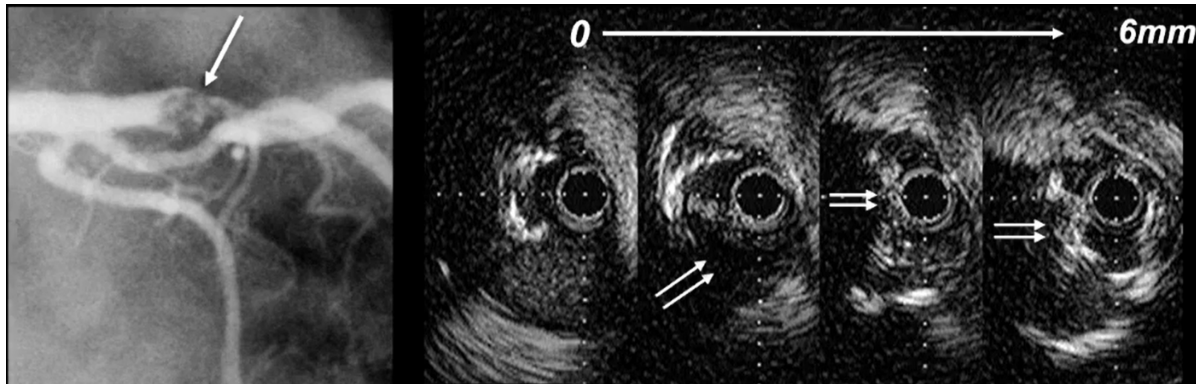


Fig. 2. Mid-right coronary artery filling defect (arrow) was initially thought to represent intracoronary thrombus. Patient was also treated with prolonged systemic anticoagulation. IVUS imaging showed that filling defect was, in fact, calcified lesion protruding into the lumen. Because of limited device availability, patient was referred for bypass graft surgery.

coronary angiogram showed a 95% ostial right coronary artery lesion with a round filling defect highly suggestive of thrombus. He was treated with heparin and sent home taking coumadin to dissolve the thrombus. However, he returned with worsening angina; coronary angiography still showed a large filling defect almost completely occluding the right coronary artery (Fig. 1). He was initially treated with an intracoronary urokinase infusion of 250,000 U followed by the use of a 2.2-mm transluminal extraction atherectomy cutter (Interventional Technologies, Inc., San Diego, Calif.) and 3.5-mm adjunct balloon



« We present three patients with classical angiographic features of intracoronary thrombus in whom IVUS imaging showed that the filling defects were not thrombi, but calcified (presumably atherosclerotic) masses.» 1990



Angiography is not Enough: Look to Believe



Complicated plaques of the abdominal aorta

Pizza

Courtesy of Prof. G. Sangiorgi



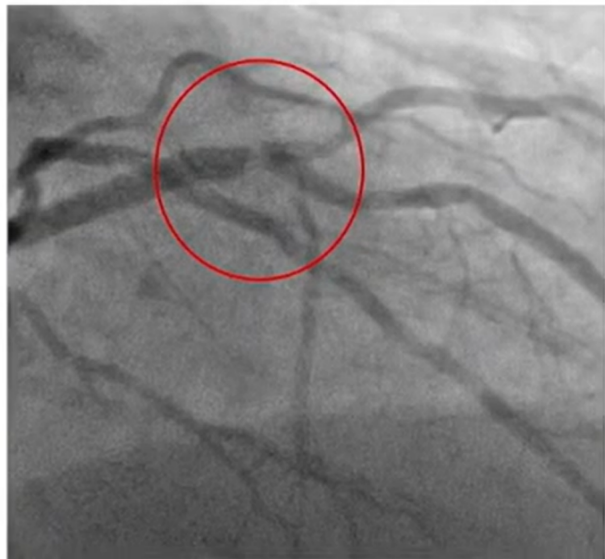
CALCIFIED NODULE

Heavily calcified lesion with calcified leading edge

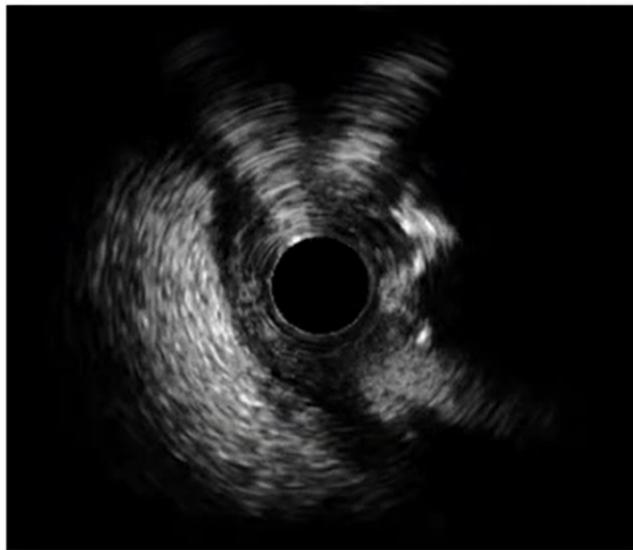
CONVEX protrusion into lumen (in contrast with plaque erosion)

Calcified coronary nodules (CCNs) represent a distinct form of coronary artery calcification, differing from both superficial and deep calcific deposits

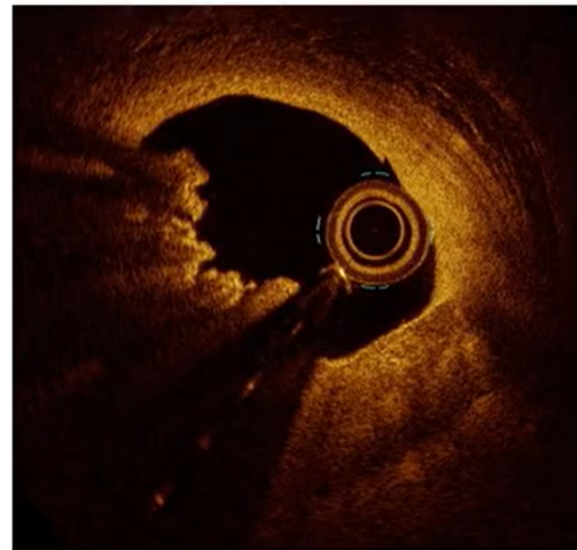




Angio



IVUS



OCT



Table 3. Modified AHA Classification Based on Morphological Description ([Table view](#))

	Description	Thrombosis
Nonatherosclerotic intimal lesions		
Intimal thickening	The normal accumulation of smooth muscle cells (SMCs) in the intima in the absence of lipid or macrophage foam cells	Absent
Intimal xanthoma, or "fatty streak"	Luminal accumulation of foam cells without a necrotic core or fibrous cap. Based on animal and human data, such lesions usually regress.	Absent
Progressive atherosclerotic lesions		
Pathological intimal thickening	SMCs in a proteoglycan-rich matrix with areas of extracellular lipid accumulation without necrosis	Absent
Erosion	Luminal thrombosis; plaque same as above	Thrombus mostly mural and infrequently occlusive
Fibrous cap atheroma	Well-formed necrotic core with an overlying fibrous cap	Absent
Erosion	Luminal thrombosis; plaque same as above; no communication of thrombus with necrotic core	Thrombus mostly mural and infrequently occlusive
Thin fibrous cap atheroma	A thin fibrous cap infiltrated by macrophages and lymphocytes with rare SMCs and an underlying necrotic core	Absent; may contain intraplaque hemorrhage/fibrin
Plaque rupture	Fibroatheroma with cap disruption; luminal thrombus communicates with the underlying necrotic core	Thrombus usually occlusive
Calcified nodule	Eruptive nodular calcification with underlying fibrocalcific plaque	Thrombus usually nonocclusive
Fibrocalcific plaque	Collagen-rich plaque with significant stenosis usually contains large areas of calcification with few inflammatory cells; a necrotic core may be present.	Absent

Arteriosclerosis, Thrombosis, and Vascular Biology

Volume 20, Issue 5, May 2000; Pages 1262-1275

<https://doi.org/10.1161/01.ATV.20.5.1262>



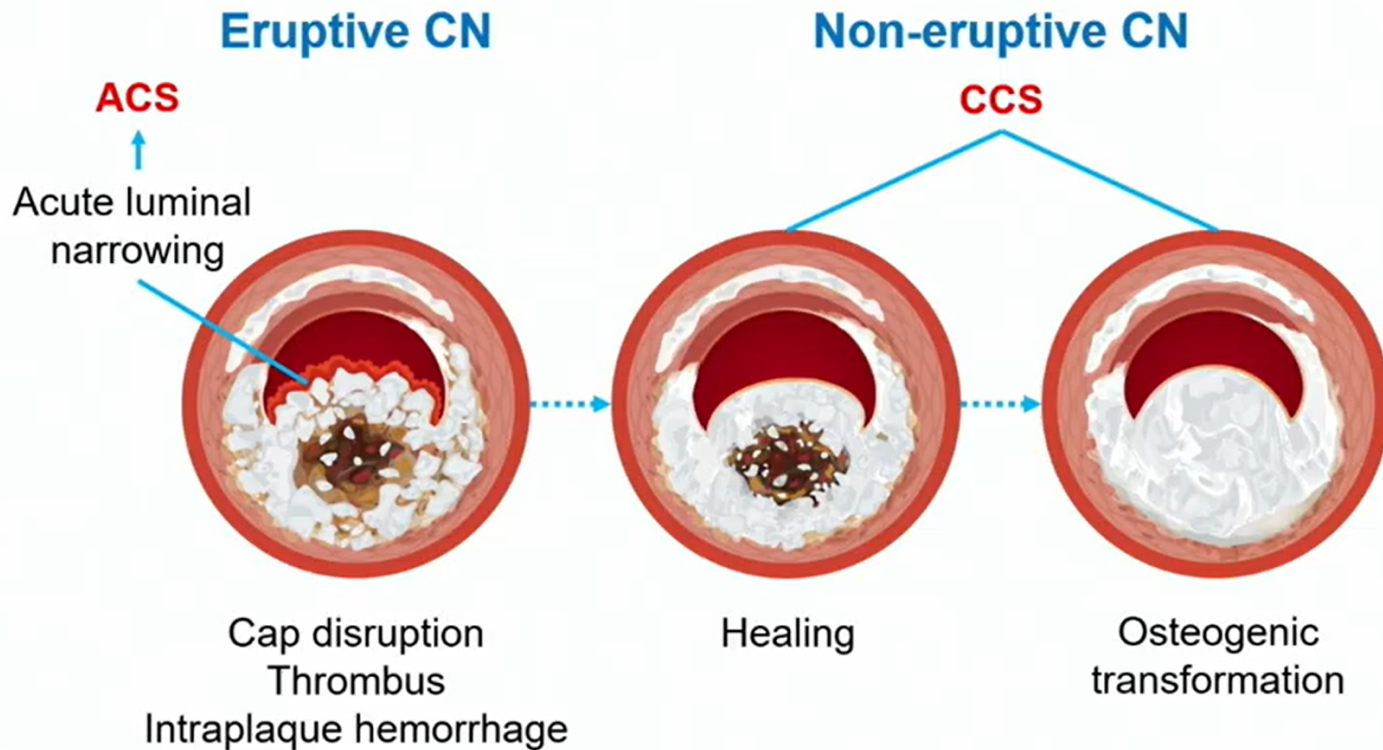
VASCULAR BIOLOGY

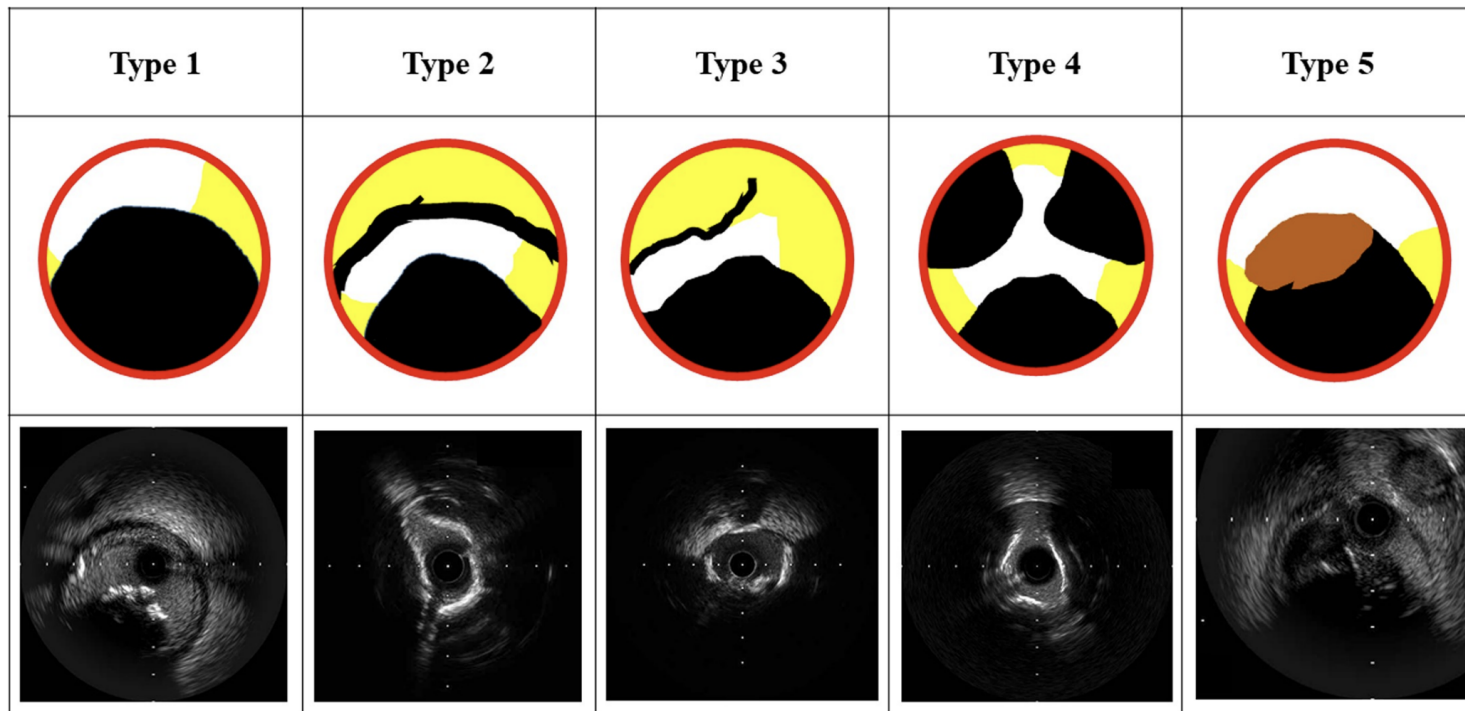
Lessons From Sudden Coronary Death

A Comprehensive Morphological Classification Scheme for Atherosclerotic Lesions

Renu Virmani, Frank D. Kolodgie, Allen P. Burke, Andrew Farb, and Stephen M. Schwartz







Watanabe Y et al. (2020) Comparison of clinical outcomes of intravascular ultrasound-calified nodule between percutaneous coronary intervention with versus without rotational atherectomy in a propensity-score matched analysis. PLoS ONE 15(11): e0241836



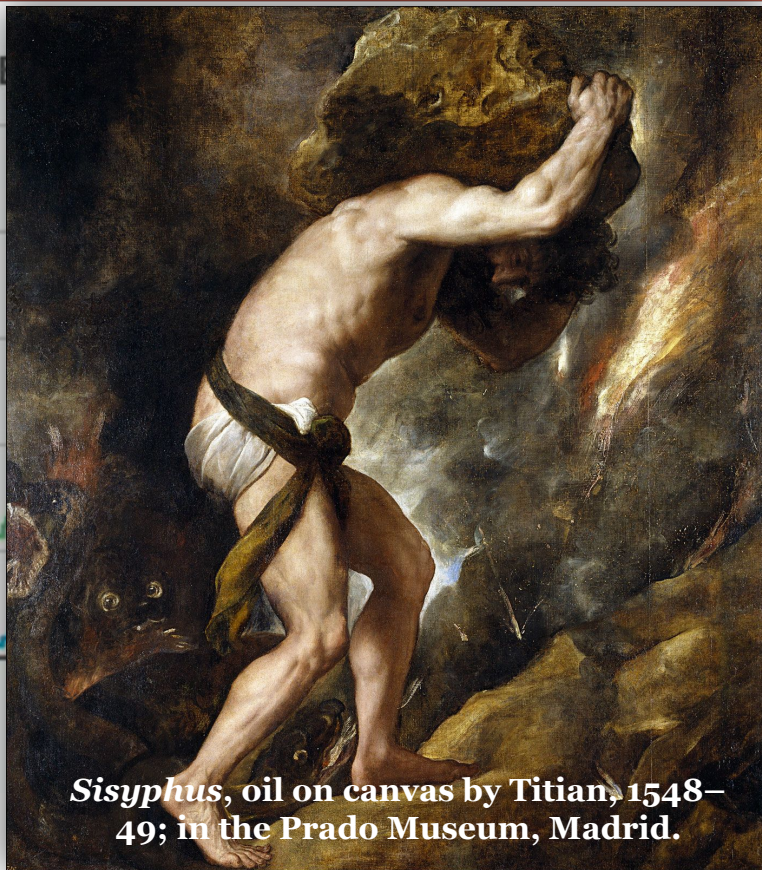
Why does it matter?



Morofuji T, et al. CCI. 2021;97:10-19



Why does it matter?



Sisyphus, oil on canvas by Titian, 1548–49; in the Prado Museum, Madrid.

0.001

With calcified nodule

No calcified nodule

5

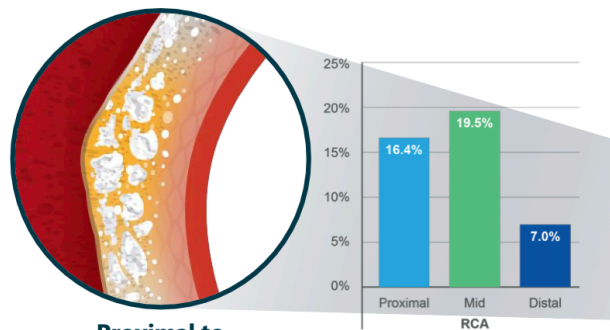


**5% in autopsy data set for patients presenting with ACS
(compared to 65% and 30% for rupture and erosion)**

**OCT study pre-intervention in ACS showed:
44% plaque rupture, 31% plaque erosion and 8% CNs**

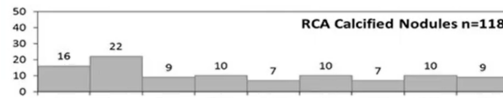
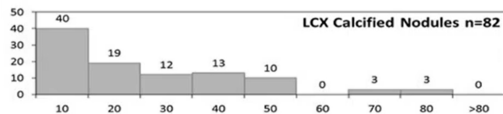
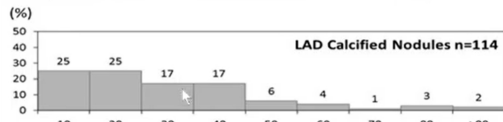
More common in CKD, T2DM, HTN, advanced age



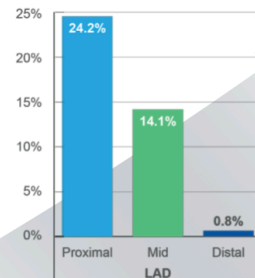
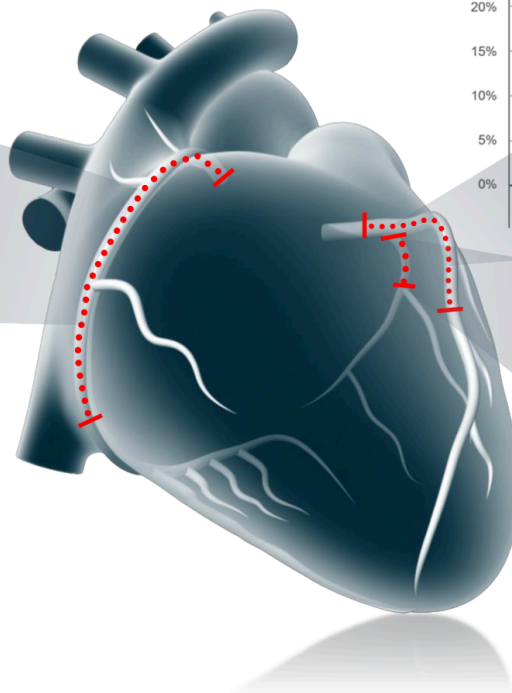


Proximal to mid RCA

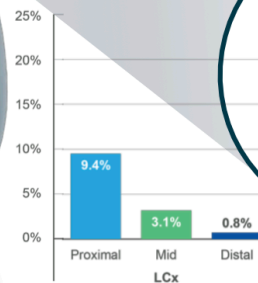
Distance (mm) from ostium to calcified nodules site



Xu et al. Circulation 2012; 126:537-45

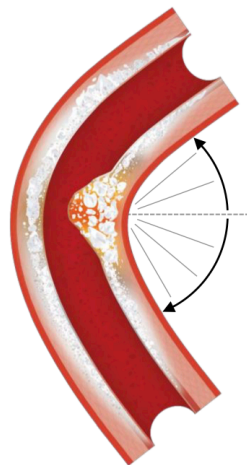
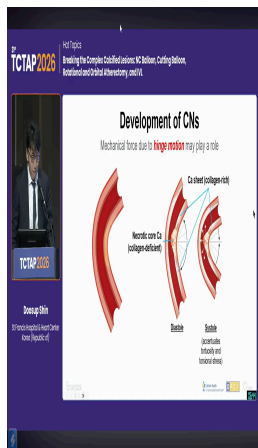


Proximal to mid LAD

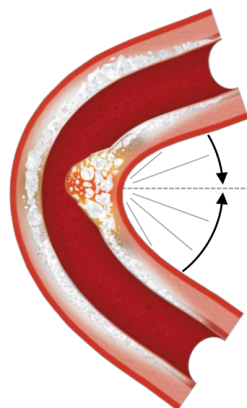


Proximal LCx

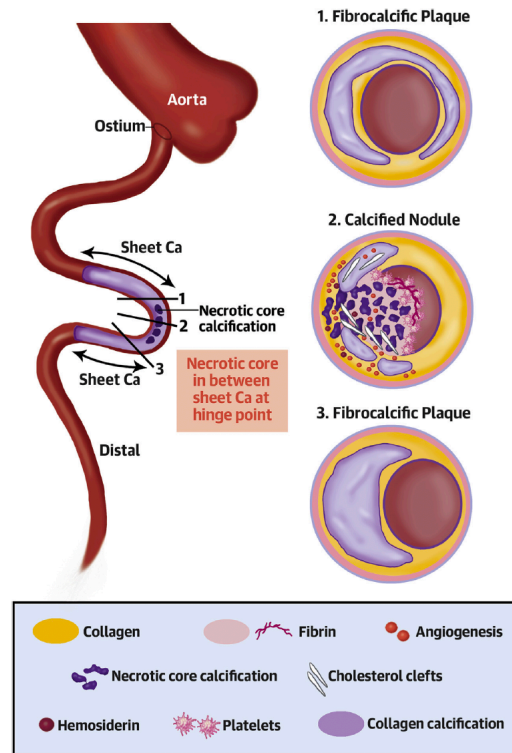




Diastolic



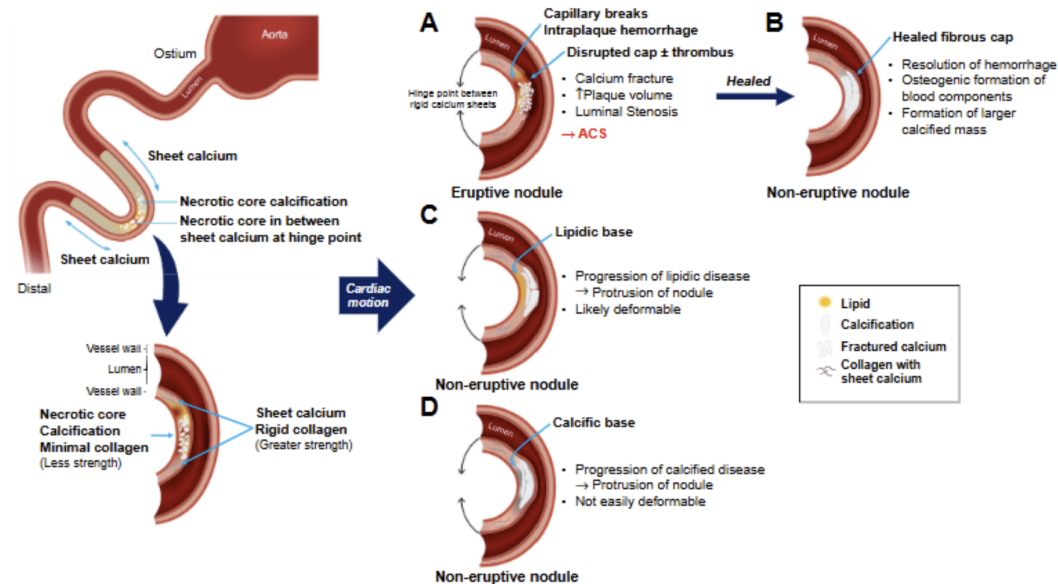
Systolic (accentuates tortuosity and torsional stress)



Torii, S. et al. J Am Coll Cardiol. 2021;77(13):1599-611.

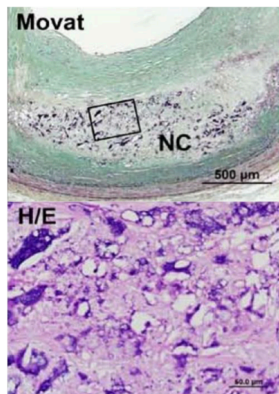


FIGURE 1 Schematic Mechanism of Development of CNs

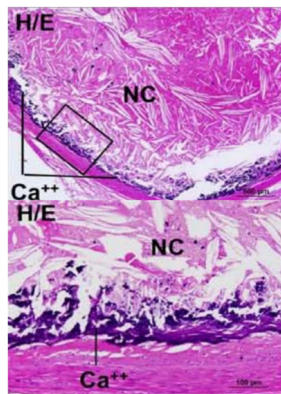


Calcified nodules (CNs) arise from the site of eccentric calcifications with fragmented calcified necrotic core (left-sided figures). Relatively collagen-free eccentric calcification is sandwiched between flanking segments of calcified sheets with greater tensile strength in the presence of the collagen matrix. (A) The mechanical forces from hinge motion can cause fracture of the collagen-free calcifications. Calcium fragments protrude the fibrous cap, leading to an eruptive CN, and damage surrounding capillaries, leading to intraplaque hemorrhage. (B) The intraplaque hemorrhage may resolve with osteogenic transformation of blood components incorporating the small calcified fragments into a larger calcified mass with an intact fibrous cap, resulting in a noneruptive CN. A progression of a noneruptive CN can result from the protrusion of eccentric calcification caused by the progression of (C) underlying lipidic or (D) calcified disease at the base. ACS = acute coronary syndrome.

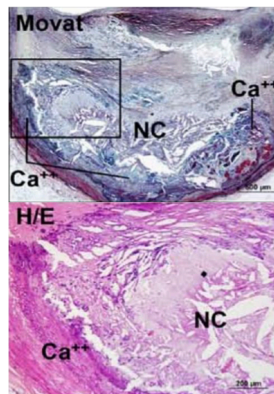




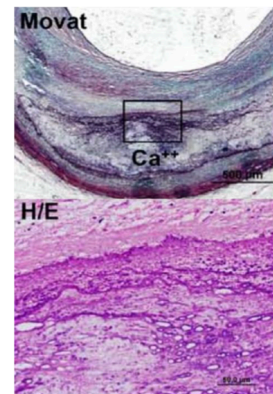
**Macrophage
Calcification**



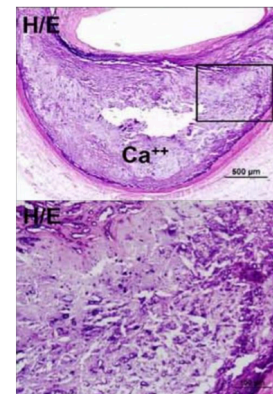
Edge Calcification



Progression around NC



Sheet Calcification



Calcified plates

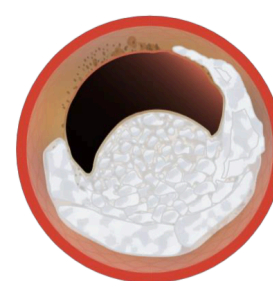
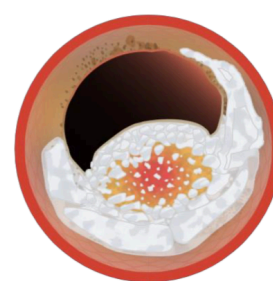
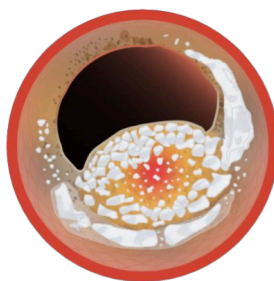
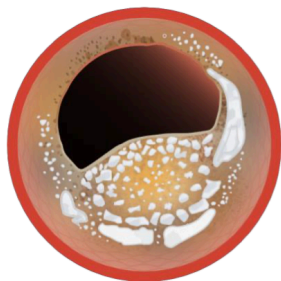
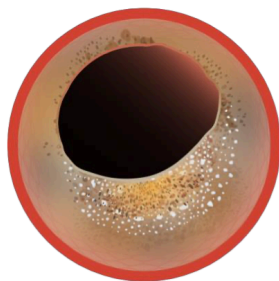
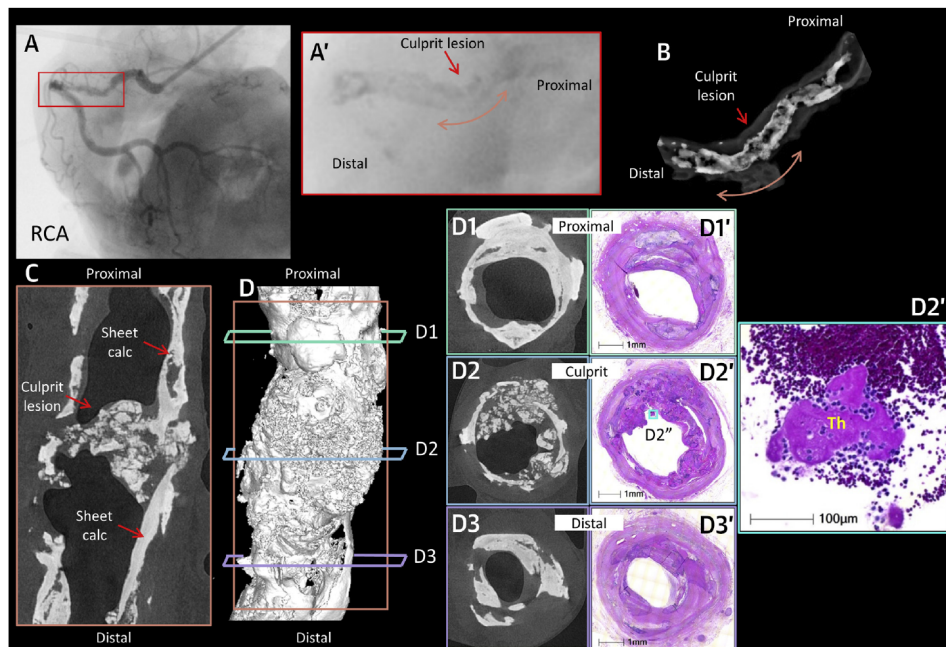
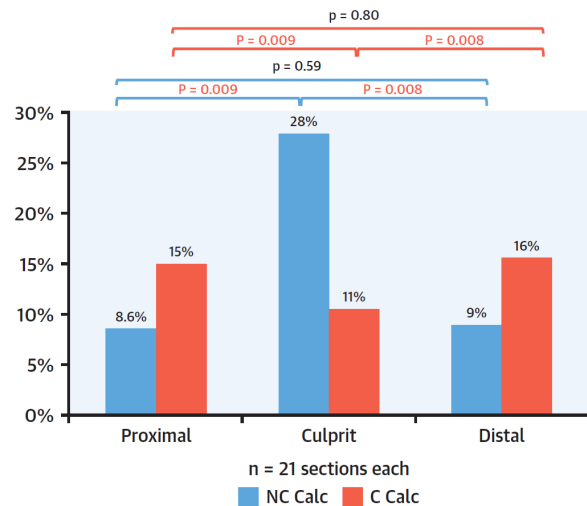
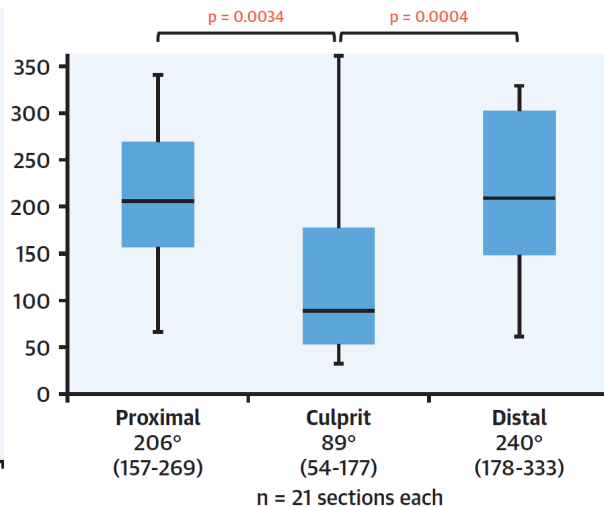
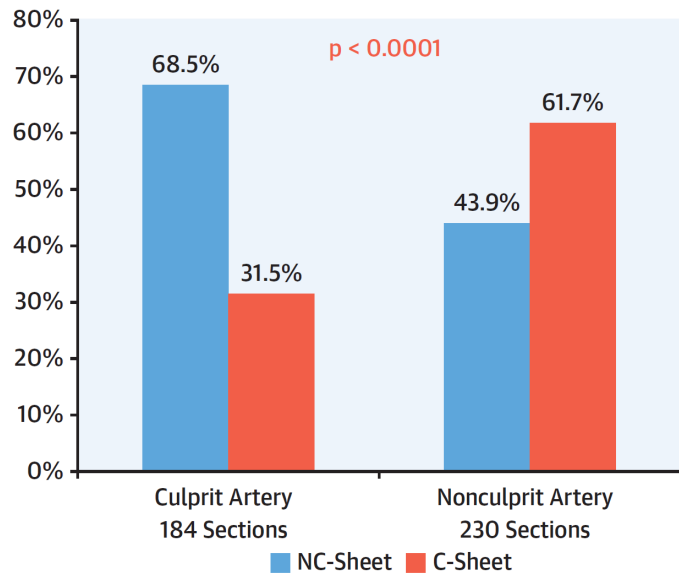


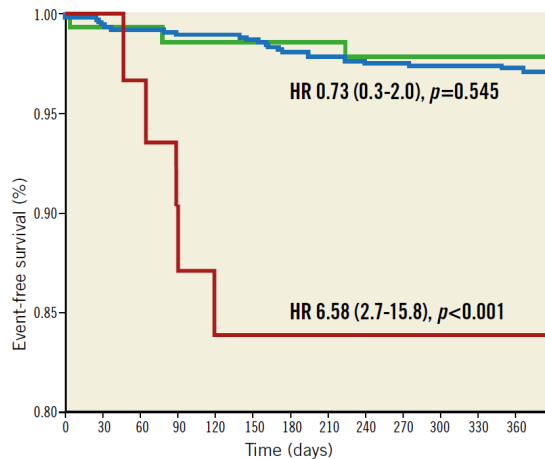
FIGURE 8 Angiogram, Fluoroscopy, Radiograph, MicroCT Images of CN With Adjacent Flanking Sections and Corresponding Histological Sections



A 62-year-old woman with a past medical history of hypertension, dialysis-dependent renal failure, and a history of smoking. Postmortem angiogram (A) and fluoroscopy (A', red-boxed area in A) demonstrated tortuous proximal RCA with severe stenosis and calcification. Radiograph from the region of the culprit site following removal from the heart shows severe calcification of the RCA (B). MicroCT of the longitudinally bisected half of the right coronary artery (C), and corresponding 3-dimensional whole artery microCT showing only calcification (D). Lines D1 to D3 in D represent the sites of corresponding histological sections. D1 to D3 are microCT and the corresponding histological cross-sections (D1' to D3' H&E stain) from culprit sites (D2, D2') and proximal (D1, D1') and distal (D3, D3') flanking sections. D2'' is a high-power image of the blue boxed area in D2', showing fibrin-platelet thrombus attachment at the culprit lesion of CN. Abbreviations as in Figure 1.







— no calcified nodules
— calcified nodules without disruption of the superficial intimal fibrous layer
— calcified nodules with disruption of the superficial intimal fibrous layer

The CLIMA Study

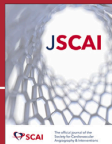
	Patients with events (37)	Patients without events (966)	p-value
Plaque length, mm	18.11±9.91	14.8±11.71	0.092
Calcified nodule base, mm	0.70±0.22	0.79±0.32	0.383
Calcified nodule height, mm	0.23±0.06	0.30±0.09	0.035
Maximum calcific arc, °	120.69±90.28	103.82±74.54	0.215
Lumen area at calcified nodule site, mm ²	6.20±4.72	7.60±3.51	0.232
Calcified nodules with FC disruption, n (%)	6 (16.8)	24 (2.5)	<0.001
Calcified nodules without FC disruption, n (%)	4 (10.8)	146 (15.1)	0.471
Multiple calcified nodules, n (%)	3 (8.1)	30 (3.10)	0.094

Values are expressed as number (%) or as mean±standard deviation.

	Patients without calcified nodules (823)	CND patients (30)	CNWD patients (150)	p-value
Cardiac death+target vessel MI, n (%)	27 (3.28)	6 (20)	4 (2.7)	<0.001
Death, n (%)	25 (3)	5 (16.63)	4 (2.7)	<0.001
Non-cardiac death, n (%)	7 (0.9)	1 (3.33)	1 (0.7)	0.353
Cardiac death, n (%)	18 (2.18)	4 (13.3)	3 (2)	0.001
Myocardial infarction, n (%)	22 (2.67)	2 (6.66)	2 (1.3)	0.228
Other vessel MI, n (%)	12 (1.45)	0 (0)	1 (0.7)	0.602
Target vessel MI, n (%)	10 (1.21)	2 (6.66)	1 (0.7)	0.022
Target vessel revascularisation, n (%)	22 (2.67)	2 (6.66)	1 (0.7)	0.108

EuroInterventional
n
2020;16:380-386





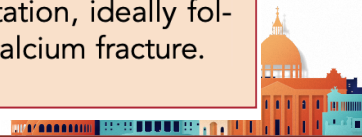
Standards and Guidelines

SCAI Expert Consensus Statement on the Management of Calcified Coronary Lesions

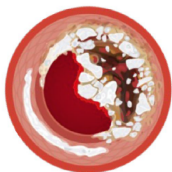
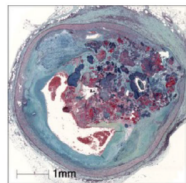


Consensus Tips for Calcified Nodules

- Intracoronary imaging can identify CN in relation to overall calcium distribution, assess guide wire bias, and provide reference vessel size to assist in calcium modification device selection.
- OA in lesions with a CN often requires slow device motion (1 mm/s), a high number of passes (>5), and higher speed (120,000 rpm).
- To improve RA burr contact with a CN, consider upsizing the burr-to-artery ratio to 0.6 or 0.7 if the lumen is large and there is unfavorable guide wire bias or consider using the RotaWire Extra Support to change the guide wire bias, as needed.
- For IVL, sizing should be 1:1 with the reference vessel diameter, and more pulses are often required to modify CN vs non-CN lesions.
- Prior to stenting, perform NC 1:1 balloon dilatation, ideally followed by imaging to confirm the presence of calcium fracture.

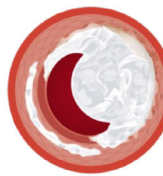
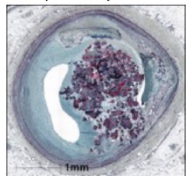


A Eruptive CN (mostly deformable)



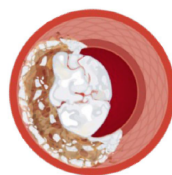
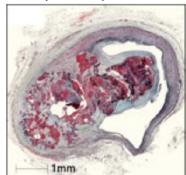
- Disrupted fibrous cap
- Overlying thrombus
- Soft component – lipid, fibrin, intraplaque haemorrhage
- Mostly deformable

B Non-eruptive CN (likely non-deformable)



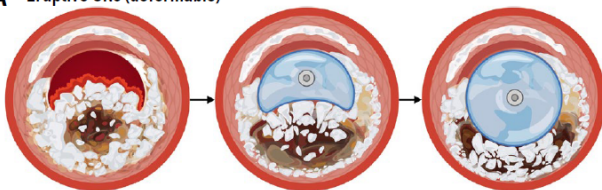
- Intact fibrous cap
- Hard component – calcium
- Non-deformable

C Non-eruptive CN (may be deformable)

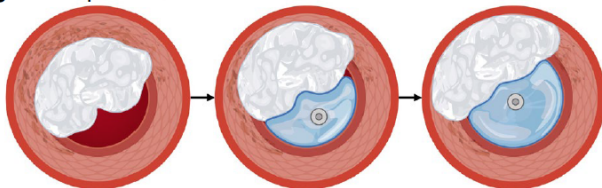


- Intact fibrous cap
- Soft component – fibrin, intraplaque haemorrhage, lipid
- Deformable

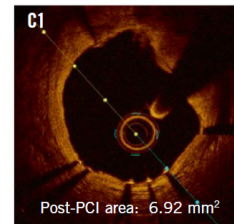
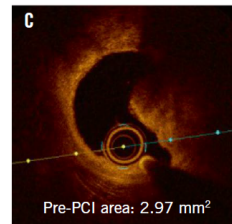
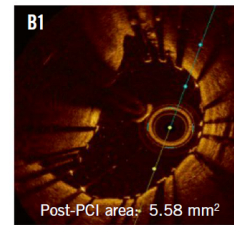
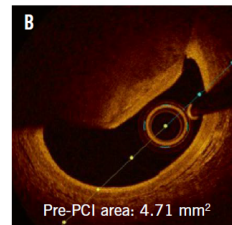
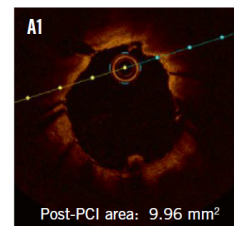
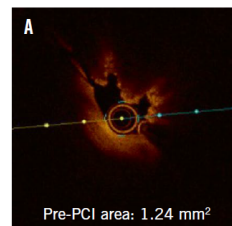
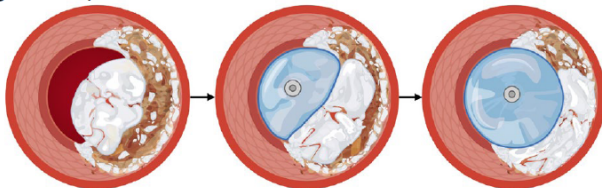
A Eruptive CNs (deformable)



B Non-eruptive CNs (non-deformable)



C Non-eruptive CNs (deformable)



EuroIntervention

2025;21:e1424-e1433

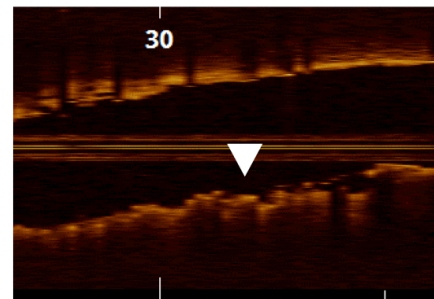
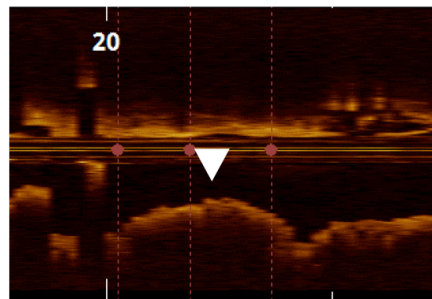
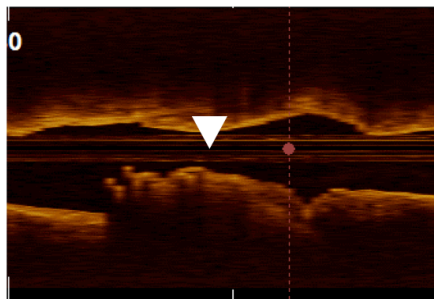
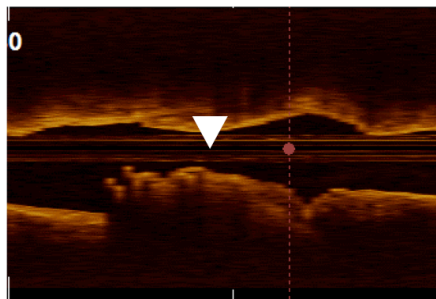
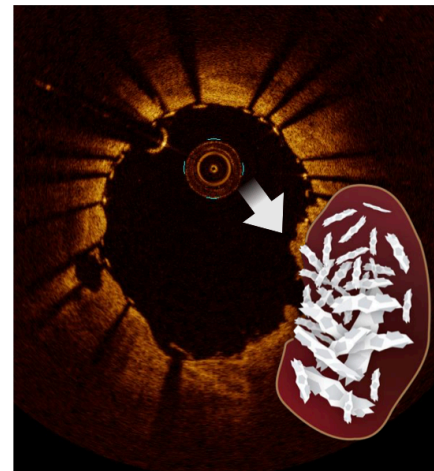
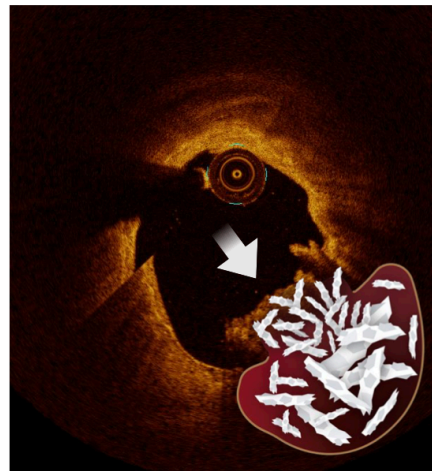
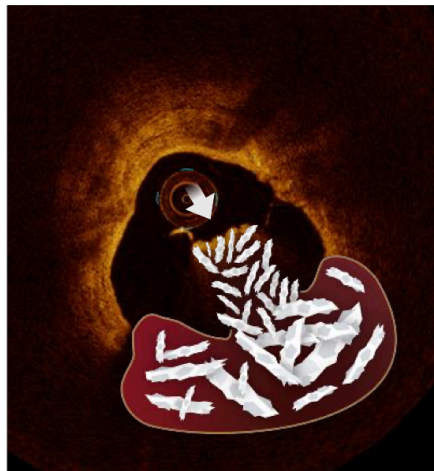
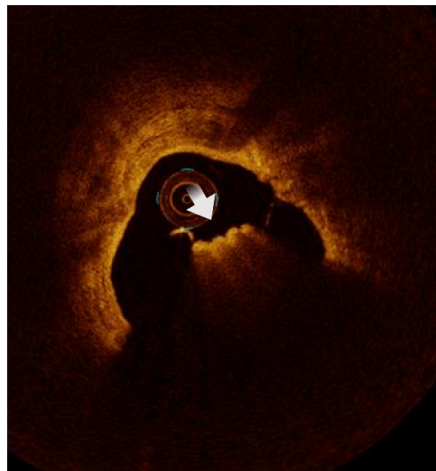
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DOI: 10.4244/EIJ-D-25-00296

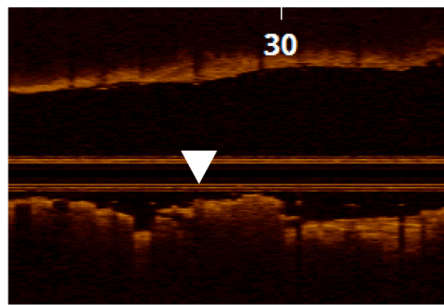
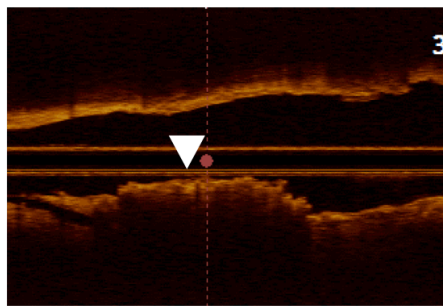
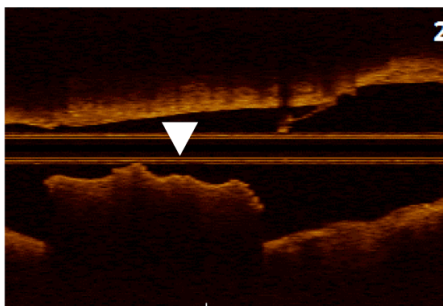
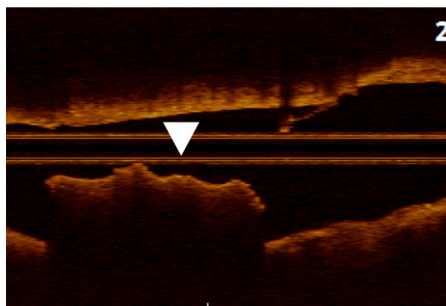
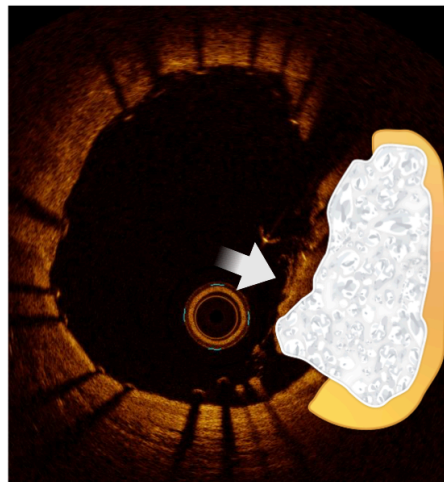
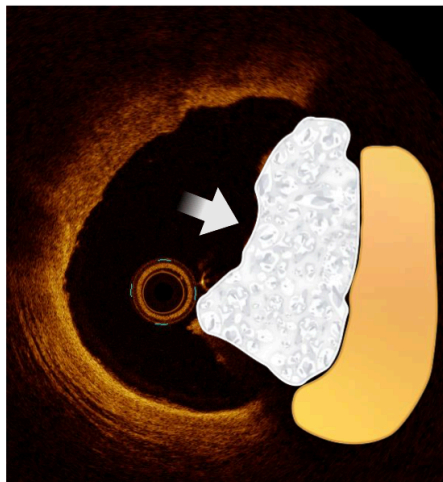
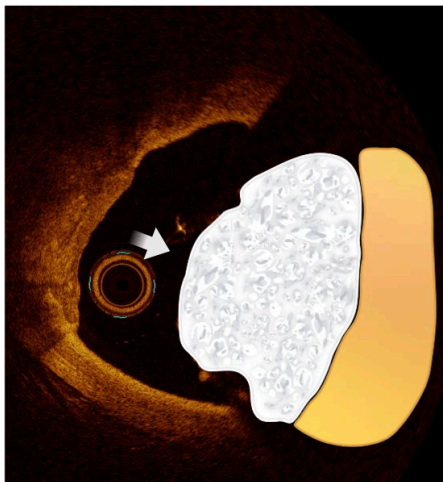
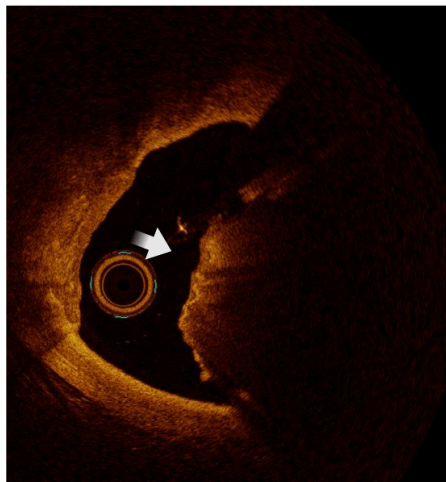


State-of-the-Art
by EuroIntervention

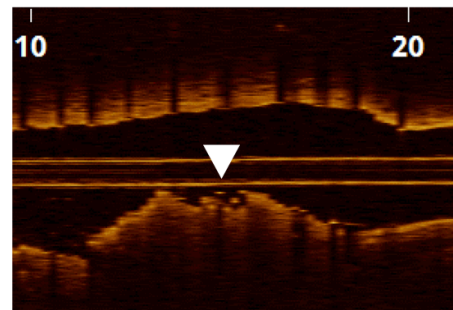
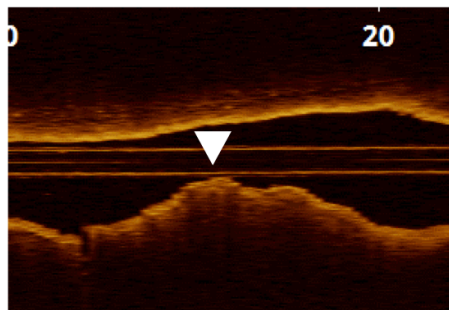
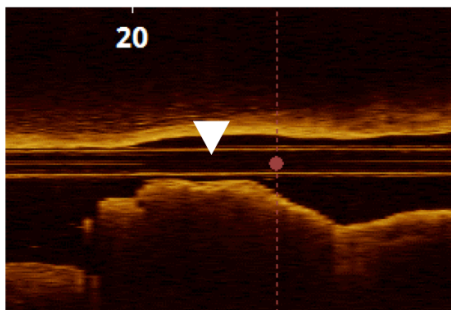
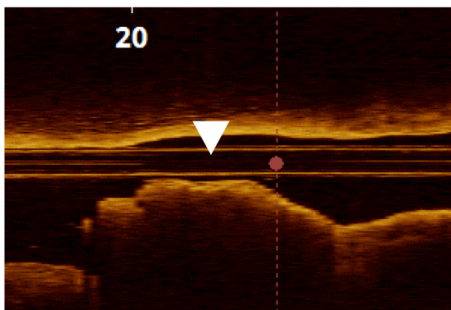
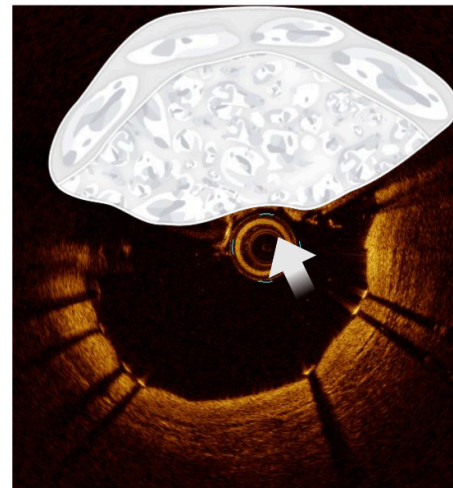
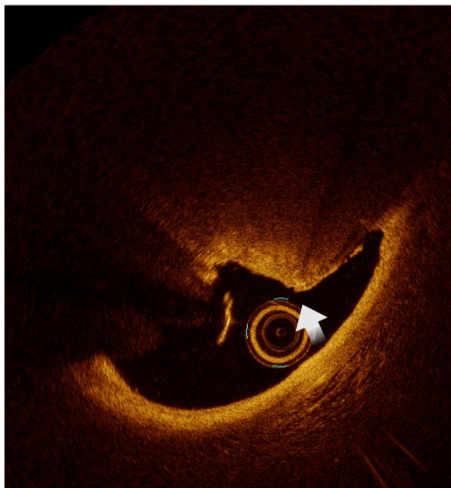




Non Eruptive (deformable) CN PCI



Non Eruptive (non - deformable) CN PCI



JACC: CARDIOVASCULAR INTERVENTIONS

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VOL. 16, NO. 9, 2023

NEW RESEARCH PAPER

CORONARY

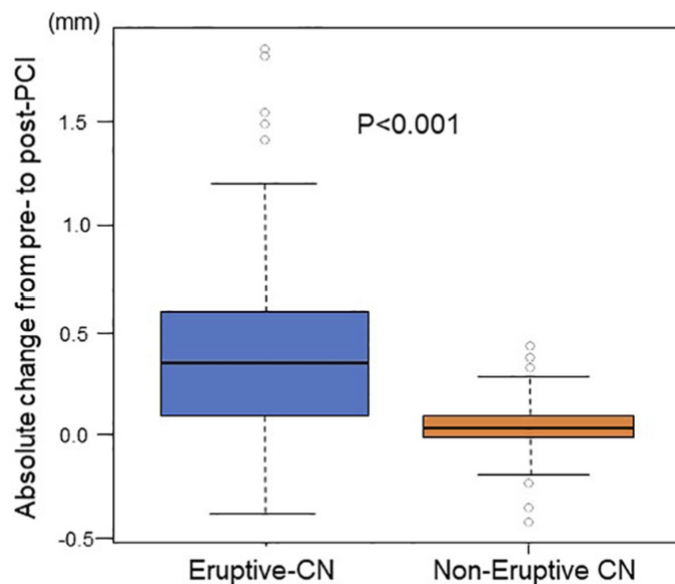
Impact of Eruptive vs Noneruptive Calcified Nodule Morphology on Acute and Long-Term Outcomes After Stenting



Takao Sato, MD,^{a,b,c} Mitsuaki Matsumura, BS,^a Kei Yamamoto, MD,^{a,b,c} Evan Shlofmitz, DO,^b
Jeffrey W. Moses, MD,^{a,b,c} Omar K. Khalique, MD,^{a,b} Susan V. Thomas, MPH,^b Anna Tsoulis,^b
David J. Cohen, MD, MSc,^{a,b} Gary S. Mintz, MD,^a Richard A. Shlofmitz, MD,^b Allen Jeremias, MD, MSc,^{a,b}
Ziad A. Ali, MD, DPHIL,^{a,b} Akiko Maehara, MD^{a,c}

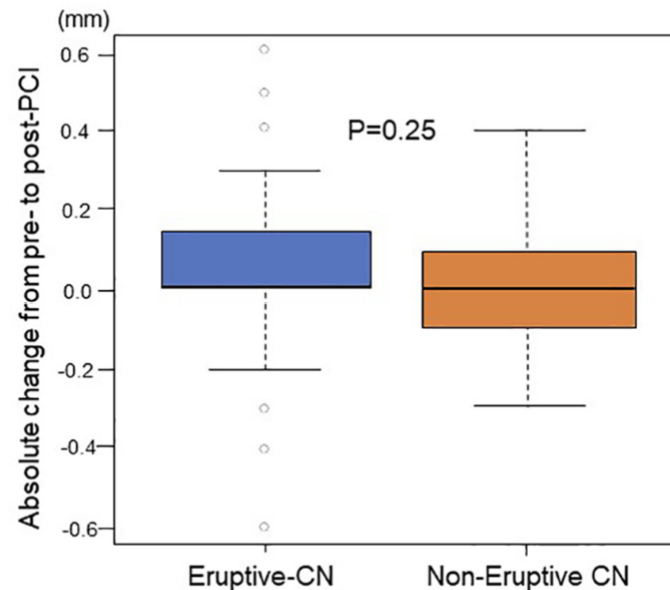


A Circumference



Median (Q1, Q3) 0.33 (0.13, 0.58) 0.03 (-0.02, 0.11)

B Length



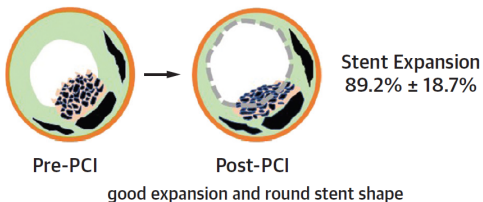
Median (Q1, Q3) 0.0 (0.0, 0.15) 0.00 (-0.10, 0.10)



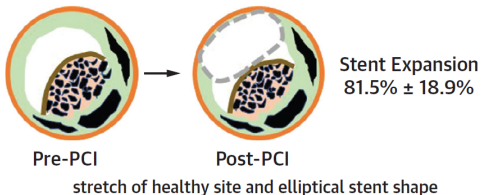
CENTRAL ILLUSTRATION Study Findings and Outcomes

Impact of Eruptive vs Noneruptive Calcified Nodules on Stent Expansion and TLF

Eruptive-CN, n = 126 patients



Noneruptive CN, n = 104 patients



■ Fibrous Cap ■ Calcium ■ Fibrin

Sato T, et al. *J Am Coll Cardiol Interv.* 2023;16(9):1024-1035.

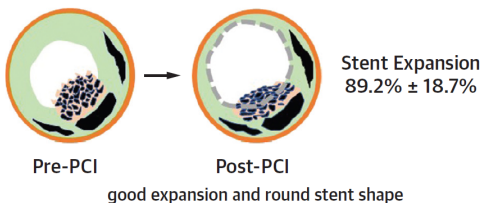
Compared with the noneruptive calcified nodule (CN), the eruptive CN had better stent expansion but a worse long-term outcome. PCI = percutaneous coronary intervention; TLF = target lesion failure.



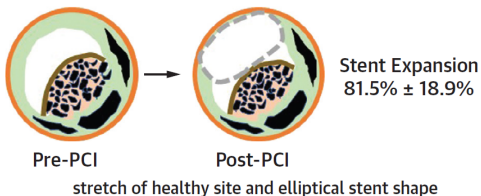
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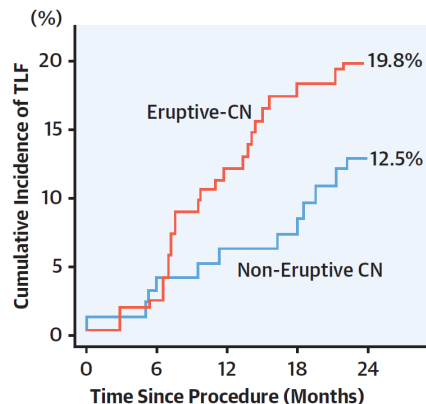


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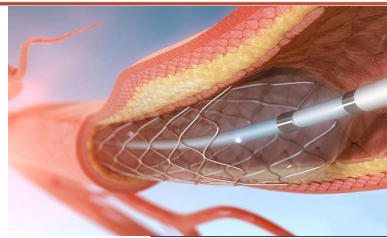


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The official journal of the Japan Atherosclerosis Society and
the Asian Pacific Society of Atherosclerosis and Vascular Diseases



Original Article

J Atheroscler Thromb, 2023; 30: 649-662. <http://doi.org/10.5551/jat.63667>

Clinical Outcomes and Unique Restenosis of Calcified Nodule in Heavily Calcified Coronary Artery

Hiroyuki Jinnouchi, Kenichi Sakakura, Yousuke Taniguchi, Takunori Tsukui, Yusuke Watanabe, Kei Yamamoto, Masaru Seguchi, Hiroshi Wada and Hideo Fujita



346 lesions received RA during the study period (Jan 2017 to Dec 2020)

- 29 lesions: no newer-generation drug-eluting stent
- 6 lesions: OCT/OFDI

311 lesions was reviewed using IVUS

- 2 lesions: IVUS was not passed before stenting.
- 12 lesions: IVUS could not observe the whole stent after the final procedure
- 32 lesions: IVUS was manually pullbacked.
- 9 lesions: data was not available.
- 6 lesions: no frame with calcification ($\geq 180^\circ$)
- 1 lesion: poor IVUS image to analyze

Final study population (n=249)

The CN group (n=100)

The non-CN group (n=149)

	All (n=249)	CN group (n=100)	Non-CN group (n=149)	p-value
Patient characteristics				
Age (years)	76 (70 - 81)	75 (70 - 81)	76 (70 - 81)	0.69
Men - n, (%)	179 (71.9)	78 (78.0)	101 (67.8)	0.09
Hypertension - n, (%)	244 (98.0)	97 (97.0)	147 (98.7)	0.39
Diabetes mellitus - n, (%)	139 (55.8)	66 (66.0)	73 (49.0)	0.009
Hyperlipidemia - n, (%)	232 (93.2)	92 (92.0)	140 (94.0)	0.61
Current smoker - n, (%) (n=247)	43 (17.4)	13 (13.3)	30 (20.1)	0.17
Left ventricular ejection fraction (%) (n=194)	59.8 (48.8 - 66.9)	58 (46 - 66)	62 (50 - 68)	0.18
Chronic renal failure on hemodialysis - n, (%)	65 (26.1)	39 (39.0)	26 (17.5)	0.0003
Statin treatment - n, (%)	229 (92.0)	92 (92.0)	137 (92.0)	1.00
Lesion characteristics				
Culprit lesion in acute coronary syndrome - n, (%)	43 (17.3)	22 (22.0)	21 (14.1)	0.12
Chronic total occlusion - n, (%)	1 (0.4)	0 (0.0)	1 (0.7)	1.00
Target coronary artery				<0.001
Left main- left anterior descending artery - n, (%)	184 (73.9)	58 (58.0)	126 (84.6)	
Left circumflex artery - n, (%)	12 (4.8)	5 (5.0)	7 (4.7)	
Right coronary artery - n, (%)	53 (21.3)	37 (37.0)	16 (10.7)	
Specific target coronary artery				
Any ostial lesion- n, (%)	49 (19.7)	29 (29.0)	20 (13.4)	0.003
Reference diameter (mm)	2.4 (2.1-2.8)	2.6 (2.2 - 3.0)	2.2 (2.0 - 2.6)	<0.0001
Lesion length (mm)	23 (13-35)	23 (12 - 34)	23 (13 - 36)	0.36
Moderate to severe angulation	108 (43.4)	47 (47.0)	61 (40.9)	0.36
Severe calcification, n (%)	248 (99.6)	99 (99.0)	149 (100.0)	0.40
Final burr size				0.003
1.25-mm	43 (14.8)	15 (15.0)	23 (15.4)	
1.5-mm	197 (67.9)	62 (62.0)	114 (76.5)	
1.75-mm	15 (5.2)	5 (5.0)	6 (4.0)	
2.0-mm	35 (12.1)	18 (18.0)	4.0 (4.0)	
Mean stent diameter (mm)	2.8 (2.5-3.0)	2.8 (2.6 - 3.0)	2.6 (2.5 - 3.0)	<0.0001
Stent length (mm)	38 (24-54)	32 (20 - 52)	38 (28 - 56)	0.08
Type of stent				0.08
BP-EES	174 (69.9)	62 (62.0)	112 (75.2)	
BP-SES	11 (4.4)	5 (5.0)	6 (4.0)	
DP-EES	37 (14.9)	17 (17.0)	20 (13.4)	
DP-ZES	21 (8.4)	14 (14.0)	7 (4.7)	
Hybrid stents	6 (2.4)	2 (2.0)	4 (2.7)	
Final burr-to-artery ratio	0.64 (0.55-0.73)	0.59 (0.51 -	0.65 (0.58 -	0.0007
IVUS before RA/ after RA, n (%)	142 (57.0)/107 (43.0)	56 (56.0)/44 (44.0)	86 (57.7)/63 (42.3)	0.80
Follow up period, days	676 (379-1038)	780 (465-1102)	590 (278-989)	0.03

Values are presented as median (interquartile range), or n (%) for categorical variables. BP, biodegradable polymer; DP, durable polymer; EES, everolimus-eluting stent; SES, sirolimus-eluting stent; ZES, zotarolimus eluting stent; CN, calcified nodule; IVUS, intravascular ultrasound; RA, rotational atherectomy.

Table 4. Clinical Outcomes between CN and Non-CN Groups

	Event rate (%) in the crude population			<i>p</i> -value
	Overall (<i>n</i> =249)	CN (<i>n</i> =100)	Non-CN (<i>n</i> =149)	
Target-vessel MI	23 (9.2)	15 (15.0)	8 (5.4)	0.02
Definite stent thrombosis	2 (0.8)	2 (2.0)	0 (0.0)	0.10
CD-TLR	50 (20.1)	29 (29.0)	21 (14.1)	0.008

P-value in the crude-population was analyzed by the log-rank method. CD-TLR, clinically-driven target lesion revascularization; CN, calcified nodule; MI, myocardial infarction.



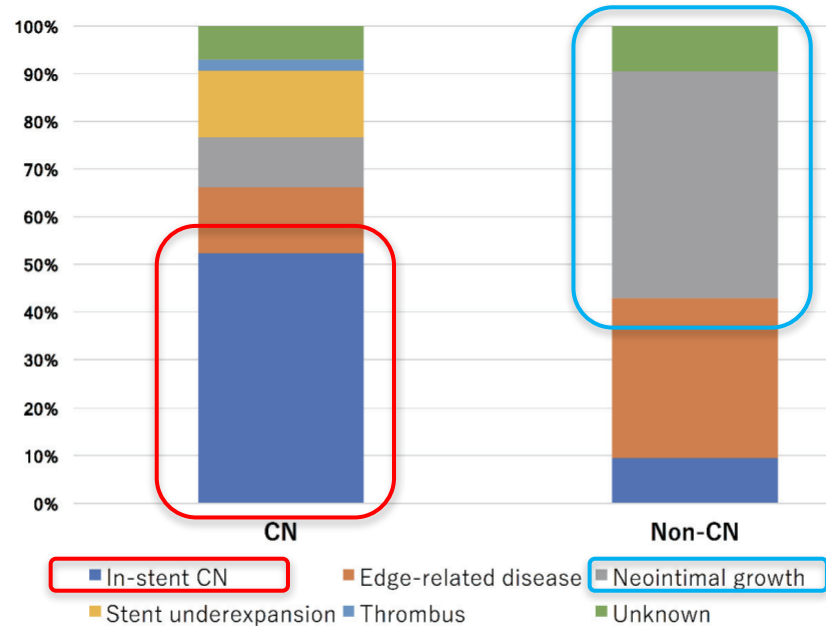
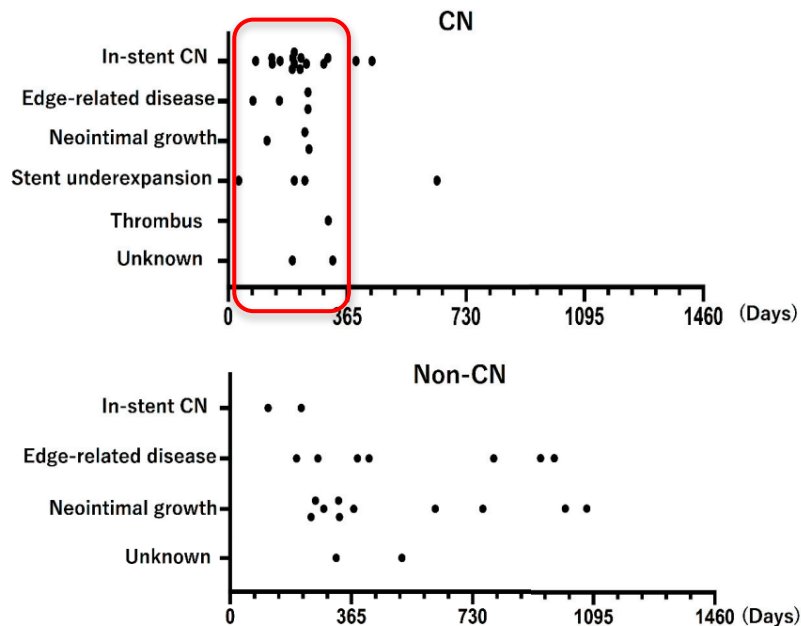


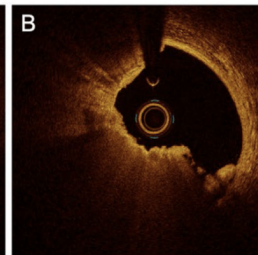
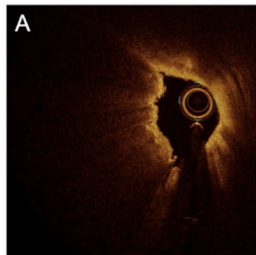
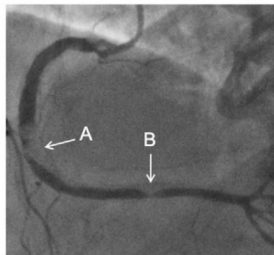
Fig. 3. Prevalence of reasons for CD-TLR in the CN and non-CN groups
CD-TLR, clinically driven target lesion revascularization; CN, calcified nodule.



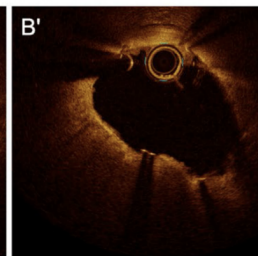
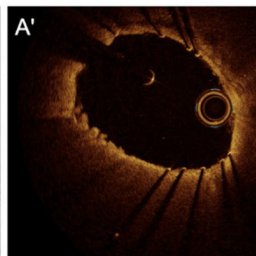
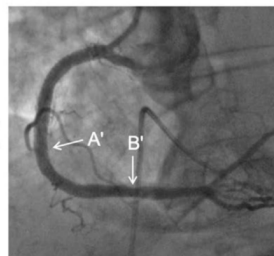
FIGURE 1 Coronary Angiography and Optical Coherence Tomography of the RCA at Index Intervention

Index Procedure

Pre-PCI



Post-PCI



(Top) Baseline imaging via coronary angiography and optical coherence tomography demonstrated significant calcified disease from the ostial to distal right coronary artery (RCA) with obstructive calcified nodules in the mid (A) to distal (B) vessel. (Bottom) Imaging after orbital atherectomy and percutaneous coronary intervention (PCI) demonstrated well-expanded stents without evidence of nodular protrusion, including in the mid (A') and distal (B') RCA.

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Recurrent Calcified Nodule Protrusion in the RCA

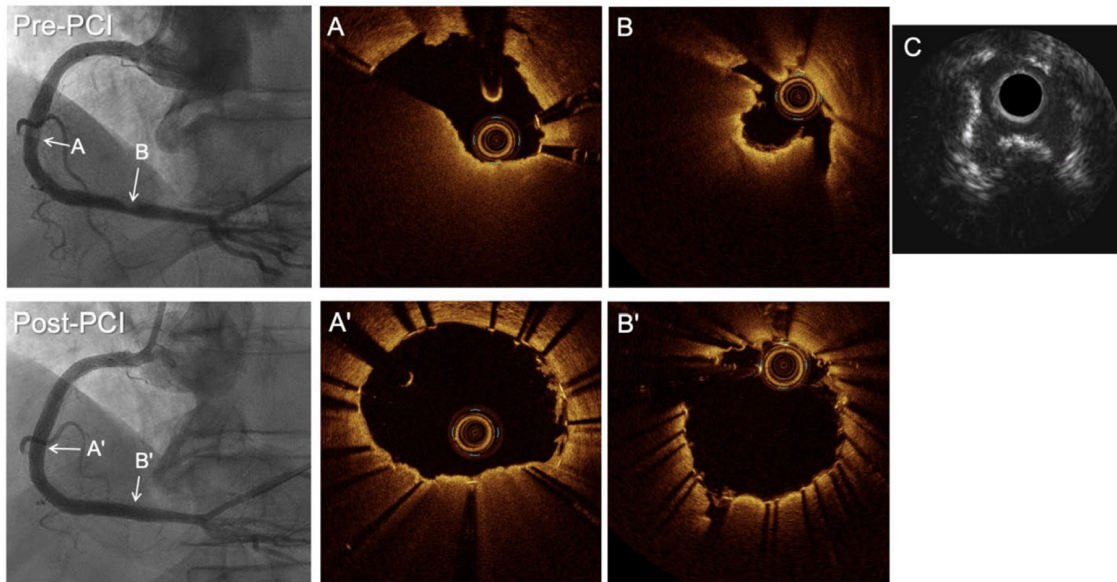
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OCTOBER 9, 2023:2463-2465



FIGURE 2 Imaging Evidence of CN Reprotrusion at 5 Weeks

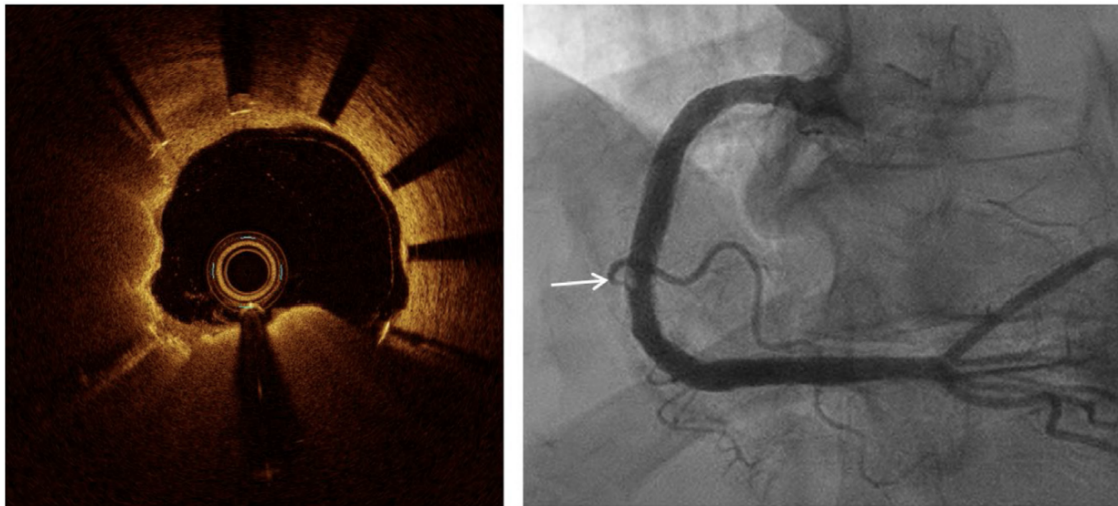
Follow-up with recurrent CN



(Top) Recurrent protruding calcified nodules (CNs) were noted in the mid (A) to distal (B) RCA. (B) Optical coherence tomography image indicated that the tissue inside the stent was a calcified nodule, and this was confirmed on (C) intravascular ultrasound imaging. (Bottom) Final imaging after reintervention with balloon angioplasty and repeat treatment with a drug-eluting stent demonstrated excellent results in the mid (A') and distal (B') stented segments.



FIGURE 3 Angiography and Optical Coherence Tomography 6 Weeks After Second Intervention of the RCA



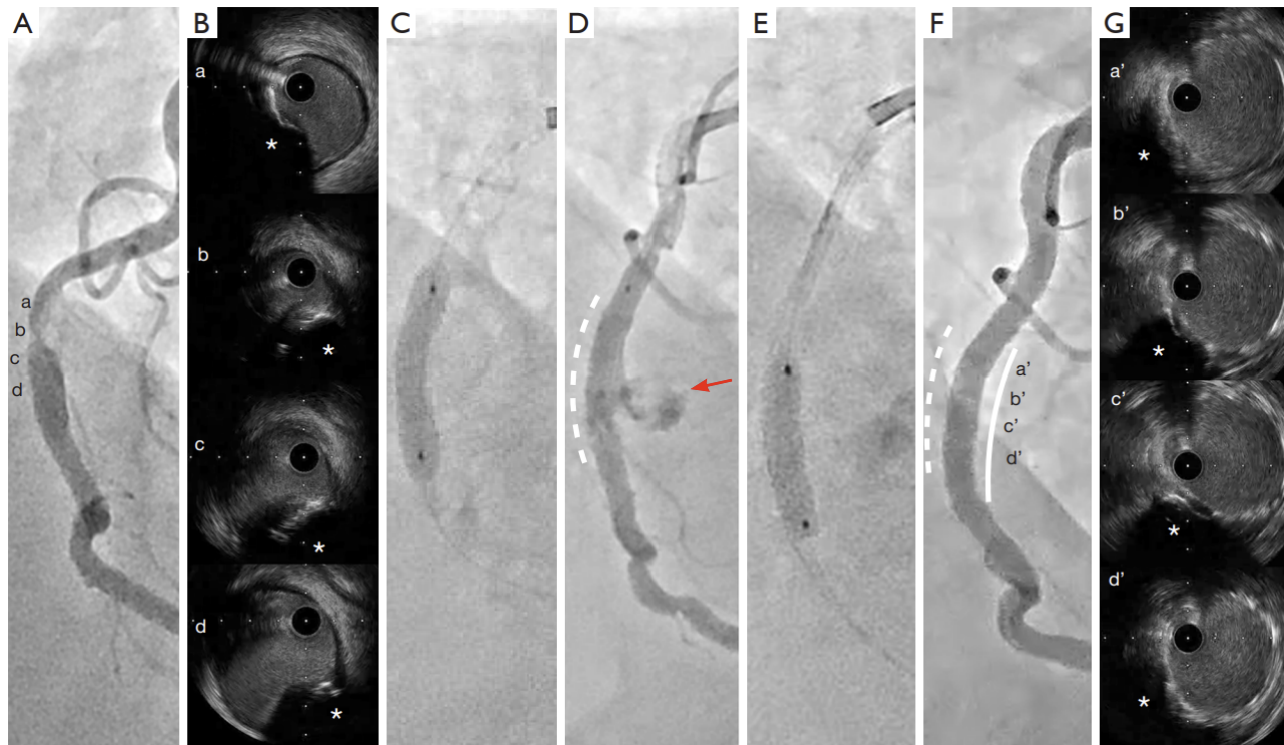
Relook imaging demonstrated recurrent but non-flow-limiting protruding calcified nodules (CNs) in a previously stented region of the right coronary artery (RCA) via optical coherence tomography (left panel) and coronary angiography (right panel). Arrow indicates area of protruding CN on angiography.

Madhavan *et al*
Recurrent Calcified Nodule Protrusion in the RCA

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OCTOBER 9, 2023:2463-2465

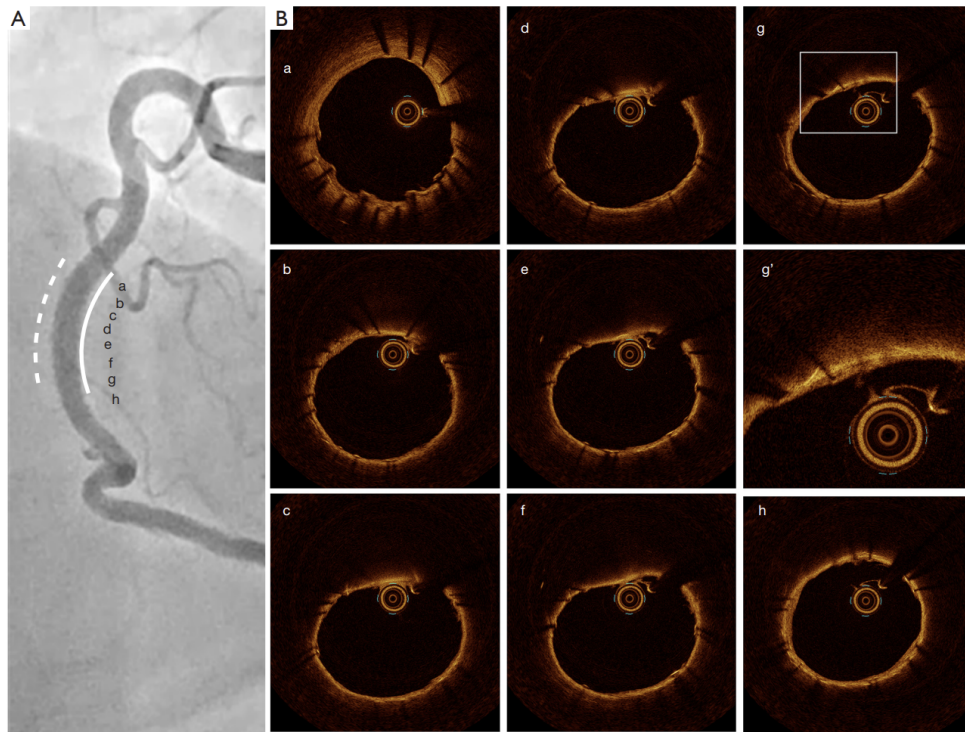




Cardiovasc Diagn Ther 2024;14(5):974-981 | <https://dx.doi.org/10.21037/cdt-24-216>



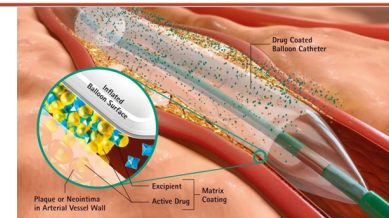
**7 months
Angiographic – OCT
Follow - up**



**2 year
NO CD-TLR**

Cardiovasc Diagn Ther 2024;14(5):974-981 | <https://dx.doi.org/10.21037/cdt-24-216>





Circulation Journal
Circ J 2025; **89**: 303–311
doi:10.1253/circj.CJ-24-0588

ORIGINAL ARTICLE
Coronary Intervention

Clinical Outcomes of Percutaneous Coronary Intervention Using Drug-Coated Balloons for De Novo Coronary Lesions With Eruptive Calcified Nodules as Detected by Optical Coherence Tomography

Kento Fukui, MD; Masahiro Koide, MD, PhD; Kazuaki Takamatsu, MD;
Hikaru Sugimoto, MD; Yuki Takeda, MD; Satoshi Akabame, MD, PhD;
Tomotsugu Seki, MD, MPH; Kan Zen, MD, PhD; Satoaki Matoba, MD, PhD



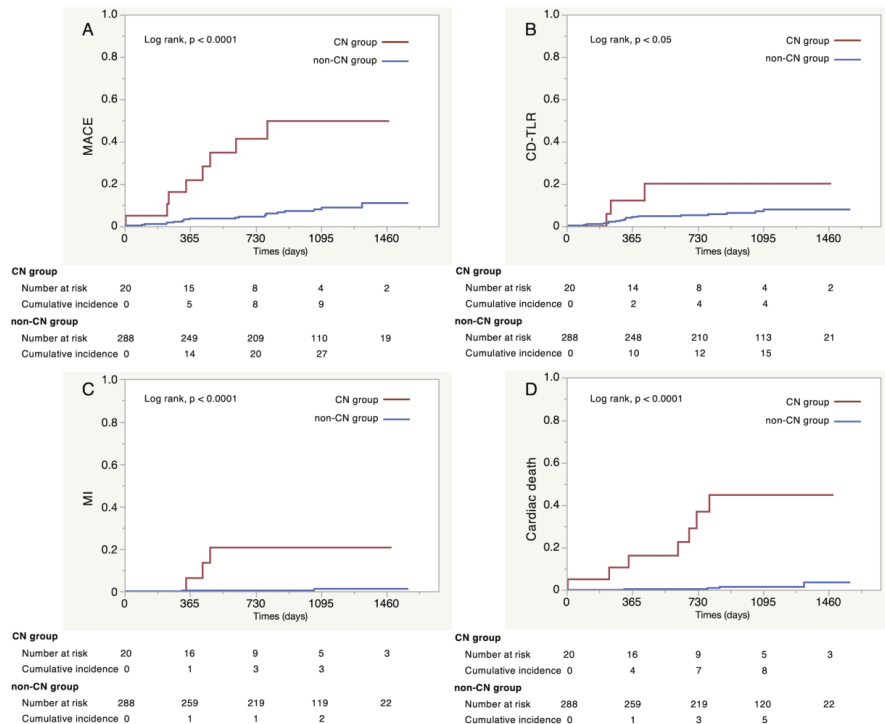


Figure 2. Kaplan-Meier curves for clinical outcomes in the groups with (CN) and without (non-CN) calcified nodules in the culprit lesion: (A) major adverse cardiovascular events (MACE); (B) clinically driven target lesion revascularization (CD-TLR); (C) myocardial infarction (MI); and (D) cardiac death.

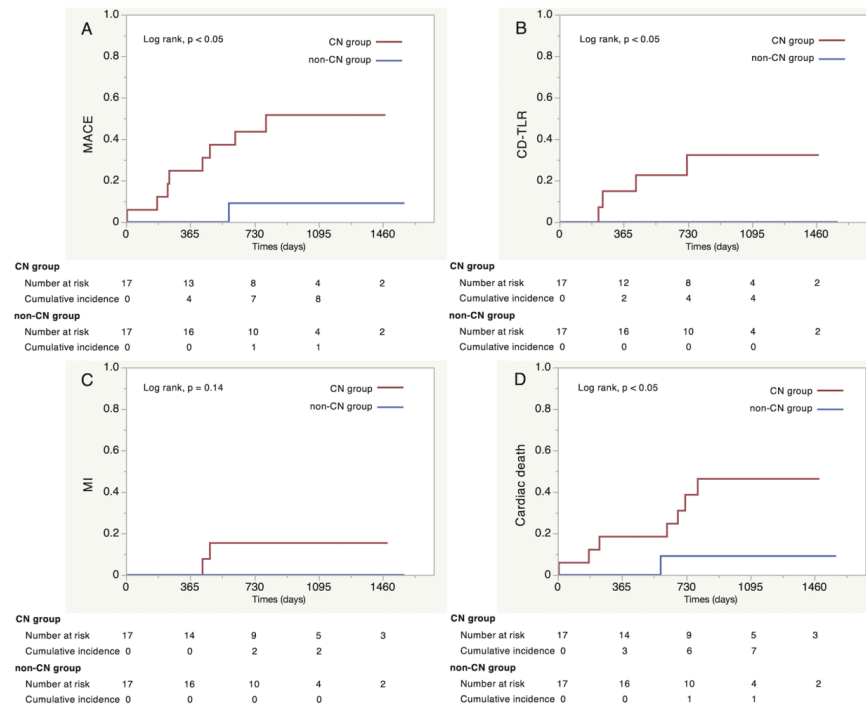


Figure 3. Kaplan-Meier curves of clinical outcomes in the groups with (CN) and without (non-CN) calcified nodules in the culprit lesion after propensity score matching: (A) major adverse cardiovascular events (MACE); (B) clinically driven target lesion revascularization (CD-TLR); (C) myocardial infarction (MI); and (D) cardiac death.

The risk of stent under-expansion due to non-deformable CNs

Distinct immediate treatment responses between eruptive and non-eruptive CNs and their paradoxical long-term outcomes

The risk of early CN re-protrusion through stent struts, potentially leading to in-stent restenosis

The risk of stent fracture caused by hinge motion, given the frequent anatomical location of CNs

The presence of heavily calcified sheets adjacent to CNs, often resulting in a minimal stent area (MSA) outside the site of the CN



WHAT WE KNOW

Eruptive-CN's are associated with more ACS events and higher TLF events

There is a significant difference in stent expansion rate between CN's of different types (Eruptive vs Non Eruptive)

WHAT WE DON'T KNOW

Do specific debulking strategies (balloons / ROTA / ORBITAL / IVL / ELCA) or any of the combination improve PCI-CN outcomes?

DES PCI or DCB PCI?





Antonio Canova
Teseo in lotta col minotauro, 1781,
Gesso
Gypsotheca, Ala ottocentesca



Paolo Canova
How should I treat: Noduli calcifici
Place 2026, Rome



