Supplementary data

Supplementary Table 1. Procedural information of index PCI.

Variable	n = 105
Stent	
1st generation DES	27 (25.7%)
2nd generation DES	73 (69.5%)
Bare metal stent	5 (4.8%)
Duration between index PCI to follow-up	1.2 (0.6-3.2)
Atherectomy	
Rotational atherectomy	8/66 (12.1)
Scoring balloon	9/66 (13.6)

Values are n (%) or median (first, third quartile). DES denotes drug-eluting stent.

Supplementary Table 2. Comparison of primary causes between with versus without predilatation.

	Lesions without pre-dilatation (n=98)	All lesions (n=139)	p-value
Biological cause	51 (52.0)	74 (53.2)	0.89
Neointimal hyperplasia	27 (27.6)	35 (25.2)	0.76
Neoatherosclerosis	16 (16.3)	30 (21.6)	0.40
Uncovered ostium	8 (8.2)	9 (6.5)	0.62
Mechanical cause	47 (48.0)	65 (46.8)	0.89
Stent fracture	25 (25.5)	35 (25.2)	0.99
Underexpansion	10 (10.2)	15 (10.8)	0.99
Protruding calcified nodule	12 (12.2)	15 (10.8)	0.84

Values are n (%)

Supplementary Table 3. Angiographic findings for lesions with and without stent fracture.

Variable	Lesions with fracture (n=71)	Lesions without fracture (n=68)	p-value
Multi-vessel disease*	55 (77.5)	56 (82.4)	0.53
Calcification of ascending aorta	25 (35.2)	17 (25.0)	0.20
Target lesion calcification			
Moderate	24 (33.8)	19 (27.9)	0.47
Severe	16 (22.5)	18 (26.5)	0.69
Radiolucent mass	6 (8.5)	8 (11.8)	0.58
In stent restenosis pattern			0.51
Focal			
Proximal stent edge	52 (73.2)	48 (70.6)	
Multi focal	11 (15.5)	9 (13.2)	
Diffuse			
Intra-stent	2 (2.8)	6 (8.8)	
Proliferative	1 (1.4)	0	
Total occlusion	5 (7.0)	5 (7.4)	
Quantitative coronary angiography			
Lesion length (mm)	6.5 (5.4, 10.3)	7.1 (4.9, 12.4)	0.81
Reference vessel diameter (mm)	2.8 (2.6, 3.1)	2.8 (2.5, 3.1)	0.83
Minimum lumen diameter (mm)			
Pre-PCI	1.0 (0.75, 1.3)	1.2 (0.8, 1.5)	0.32
Post-PCI	2.7 (2.3, 3.0)	2.7 (2.4, 3.0)	0.49
Diameter stenosis (%)			
Pre-PCI	64.3 (50.8, 71.5)	56.7 (48.3, 71.8)	0.32
Post-PCI	13.9 (8.4, 24.8)	12.2 (7.7, 17.5)	0.35

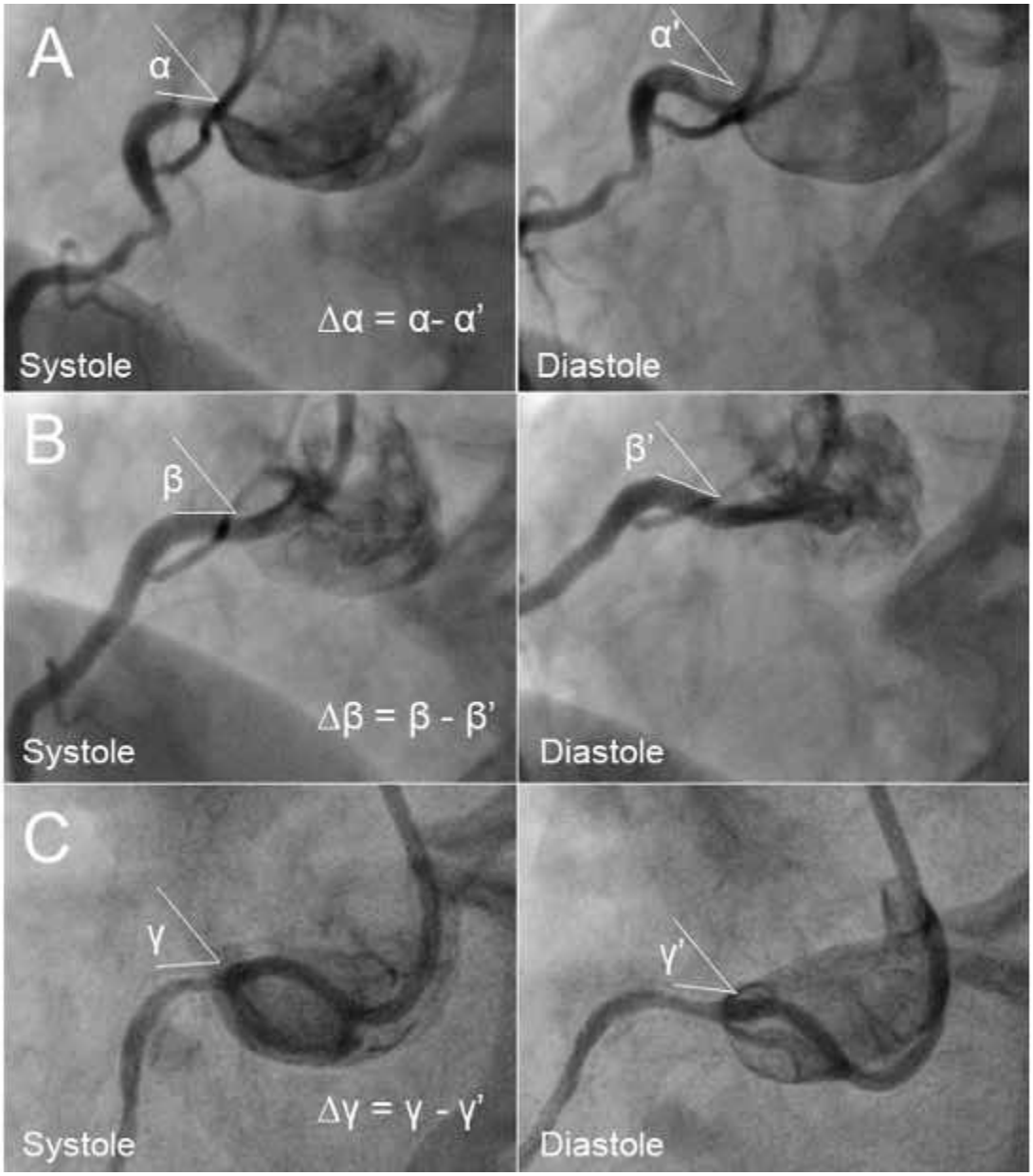
Values are n (%) or median (first, third quartile). *defined as the presence of >50% luminal diameter stenosis in two or more major epicardial arteries. PCI denotes percutaneous coronary intervention

Supplementary Table 4. Comparison of clinical and angiographical characteristics with versus without a new stent implantation for the treatment of in-stent restenosis due to a mechanical cause.

	New stent (+) n=32	New stent (-) n=33	P value
Clinical characteristics			
Age (years)	72 (67, 80)	72 (66, 75)	0.35
Women	15 (46.9)	13 (39.4)	0.62
Hypertension	32 (100)	33 (100)	-
Dyslipidemia	32 (100)	33 (100)	-
Diabetes mellitus	17 (53.1)	17 (51.5)	0.99
Insulin-treated	5 (15.6)	5 (15.2)	0.99
Chronic kidney disease*	12 (37.5)	14 (42.4)	0.80
Dialysis	0 (0)	4 (12.1)	0.11
Peripheral artery disease	6 (18.8)	5 (15.2)	0.75
Prior myocardial infarction	6 (18.8)	9 (27.3)	0.56
Prior coronary artery bypass grafting	8 (25.0)	7 (21.2)	0.77
Prior or current moderate or severe aortic stenosis	5 (15.6)	4 (12.1)	0.73
Duration from prior stent implantation (years)	0.8 (0.3,2.0)	1.9 (0.7, 3.4)	0.17
Clinical presentation at the time of ISR			
Non-ST elevation myocardial infarction	3 (9.4)	4 (12.1)	0.99
Unstable angina	8 (25.0)	21 (63.6)	0.003
Stable coronary artery disease	21 (65.6)	8 (24.2)	0.001
Angiographical characteristics			
Multi-vessel disease	27 (84.4)	26 (78.8)	0.75
Calcification of ascending aorta	9 (28.1)	13 (39.4)	0.43
Target lesion calcification			
Moderate	10 (31.3)	12 (36.4)	0.79
Severe	10 (31.3)	9 (27.3)	0.79
Radiolucent mass	3 (9.4)	7 (21.2)	0.30
In stent restenosis pattern			
Focal	27 (84.4)	32 (96.8)	0.10
Proximal stent edge	24 (75.0)	28 (84.9)	0.37

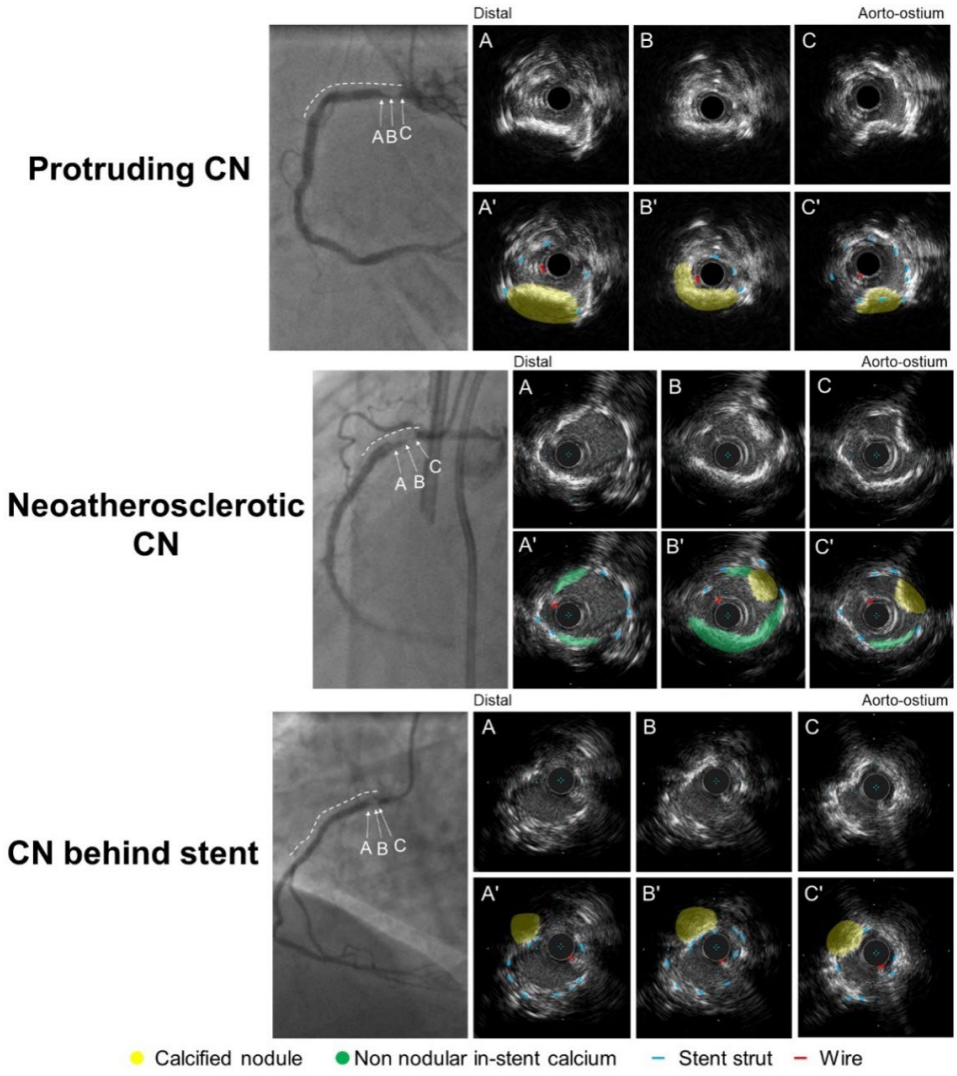
Multi focal	3 (9.4)	4 (12.1)	0.99
Diffuse	2 (6.3)	1 (3.0)	0.61
Proliferative	0 (0)	0 (0)	-
Total occlusion	3 (9.4)	0 (0)	0.11
Lesion length (mm)	6.4 (5.3, 8.9)	6.3 (5.1, 9.4)	0.95
Reference vessel diameter (mm)	2.8 (2.6, 3.0)	2.8 (2.4, 3.2)	0.76
Minimum lumen diameter (mm)			
Pre-PCI	1.0 (0.8, 1.3)	1.1 (0.7, 1.5)	0.40
Post-PCI	2.7 (2.4, 3.0)	2.3 (2.2, 2.6)	0.01
Diameter stenosis (%)			
Pre-PCI	64.3 (51.4, 71.3)	60.3 (50.2)	0.45
Post-PCI	11.3 (8.2, 20.4)	21.0 (10.0, 30.3)	0.03

Values are n (%) or median (first, third quartile). *Defined as estimated glomerular filtration rate <60 mL/min/1.73 m^2 calculated using the Modification of Diet in Renal Disease equation. ISR denotes in-stent restenosis; PCI, percutaneous coronary intervention.



Supplementary Figure 1. Analysis of the angle between the proximal segment of the RCA and the ascending aorta.

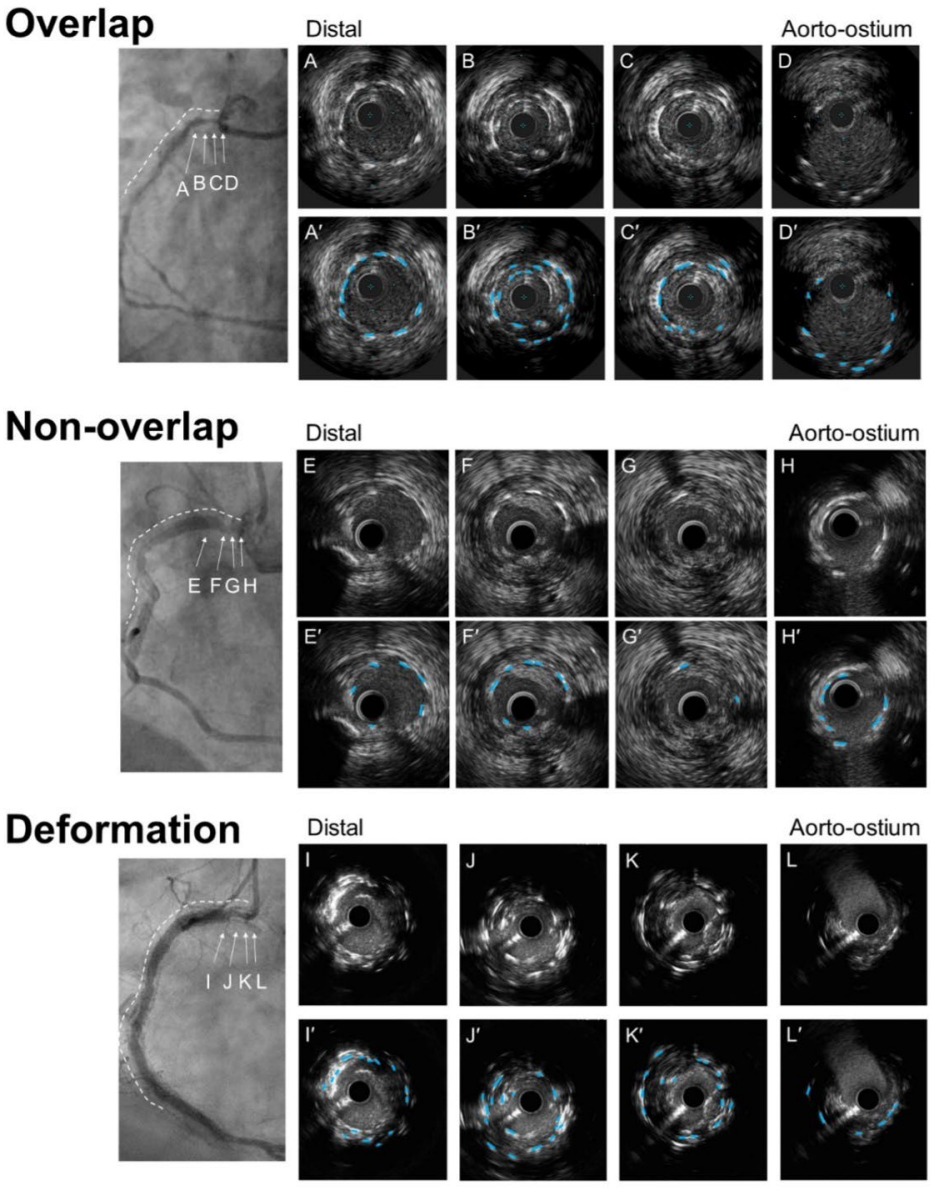
Angle was measured during systole (α) and diastole (α') and the change (Δα = α - α') was calculated. Panel A showed pre-intervention and Panel B showed post-intervention at index procedure. Panel C showed restenosis including ostium of RCA before repeat revascularization. RCA denotes right coronary artery.



Supplementary Figure 2. Representative cases of protruding CN, neoatherosclerotic CN, and CN behind the stent.

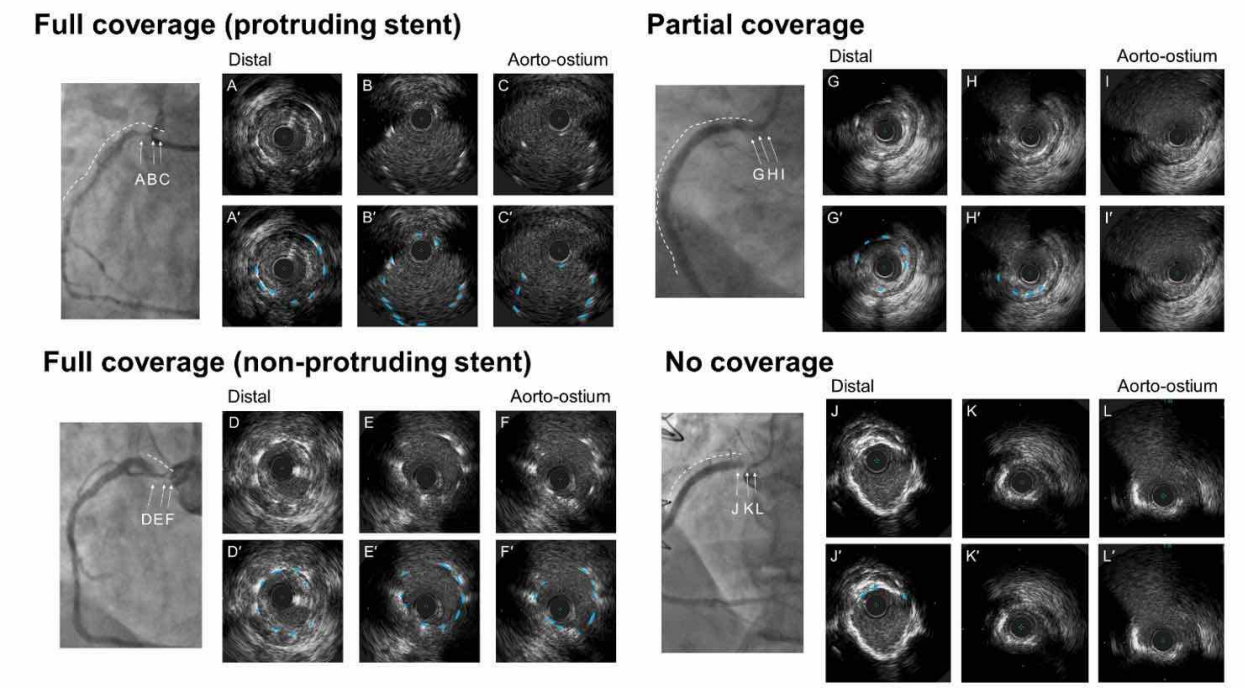
Yellow area indicate CN and green area indicates neoatherosclerotic calcium. Top panel: There is no adjacent neointimal hyperplasia to the CN indicating protruding calcium through the stent struts. Middle panel: There is an adjacent neoatherosclerotic calcium (green area) indicating CN developed as a part of neoatherosclerosis. Bottom panel: There is a CN behind stent struts (blue dotted line) without neointimal hyperplasia or neoatherosclerosis within the stent. The

differentiation of these images requires checking proximal or distal to the current region of interest frame. CN denotes calcified nodule.



Supplementary Figure 3. Representative cases of stent fracture or deformation.

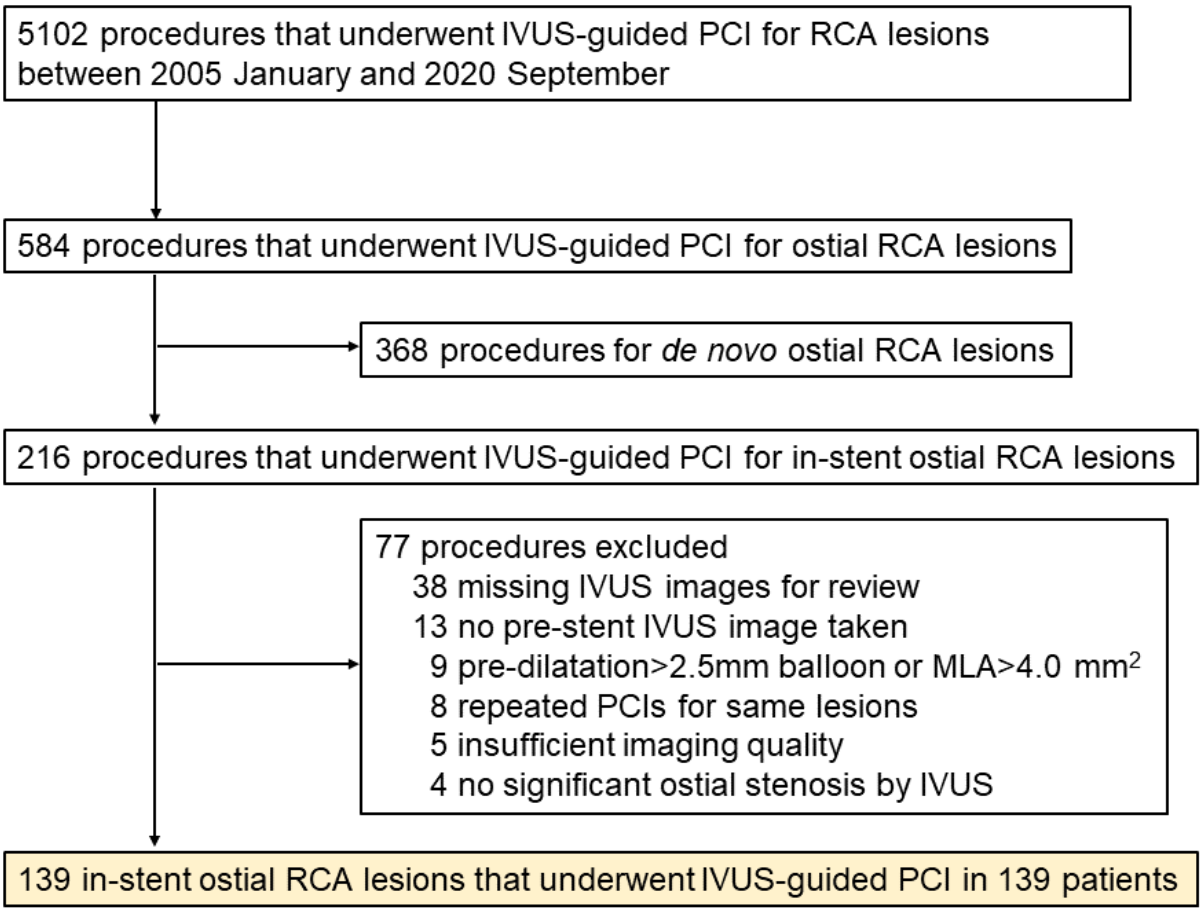
Top panel: There are double layers appearance of stent struts (blue dotted line in B and C) with preserved 3-dimentional stent integrity indicating overlapped type of stent fracture. Middle panel: There was no struts in G except one strut at 3 and 12 o'clock indicating partial stent fracture (non-overlap type). Bottom panel: There are multiple layers of stent struts with loss of 3-dimentional stent integrity indicating stent deformation.



Supplementary Figure 4. Representative cases of full coverage (protruding stent), full coverage (non-protruding stent), partial coverage, or no coverage.

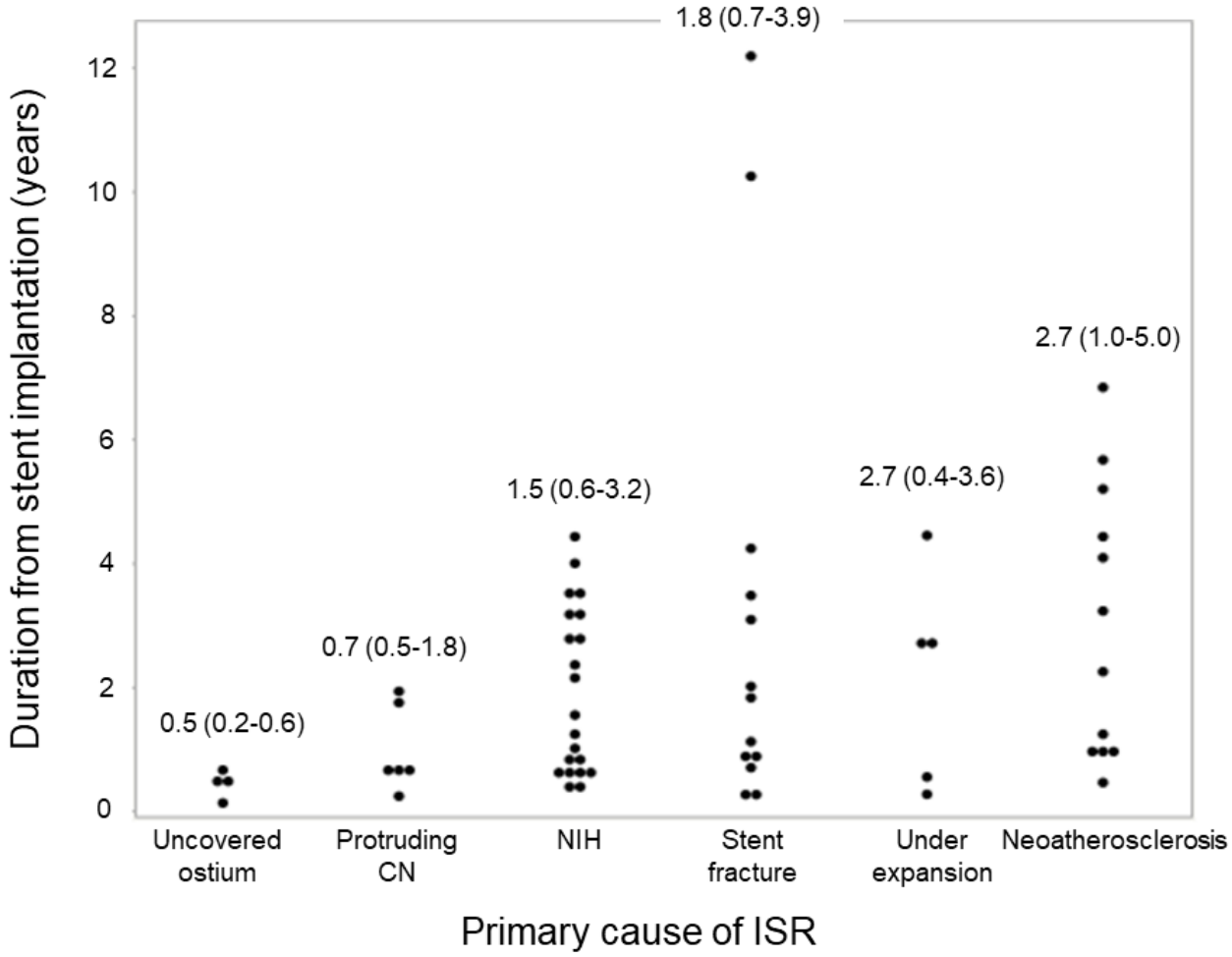
Top left panel: Protruding stent struts were found; thus, the ostium was fully covered. IVUS catheter was outside of stent without deforming the stent integrity (C). Bottom left panel: The

length of protruding struts measured <1mm in length. Top right panel: There is no struts at 9 to 4 o'clock (H) at the ostium indicating partial coverage of ostium. Bottom right panel: There is no strut at all at the ostium indicating no coverage of ostium (K). IVUS denotes intravascular ultrasound.



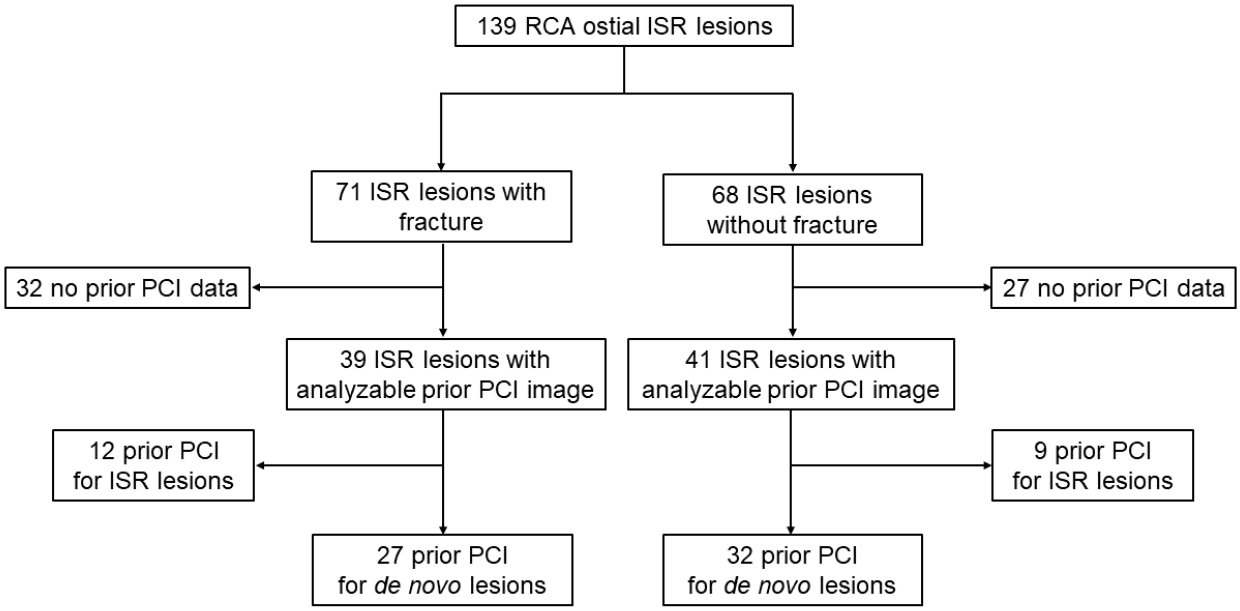
Supplementary Figure 5. Flowchart of exclusion and inclusion of lesions.

Among 5102 procedures that underwent IVUS-guided PCI for RCA lesions, finally 139 RCA ostial in-stent restenotic lesions consist of current cohort. PCI denotes percutaneous coronary intervention.



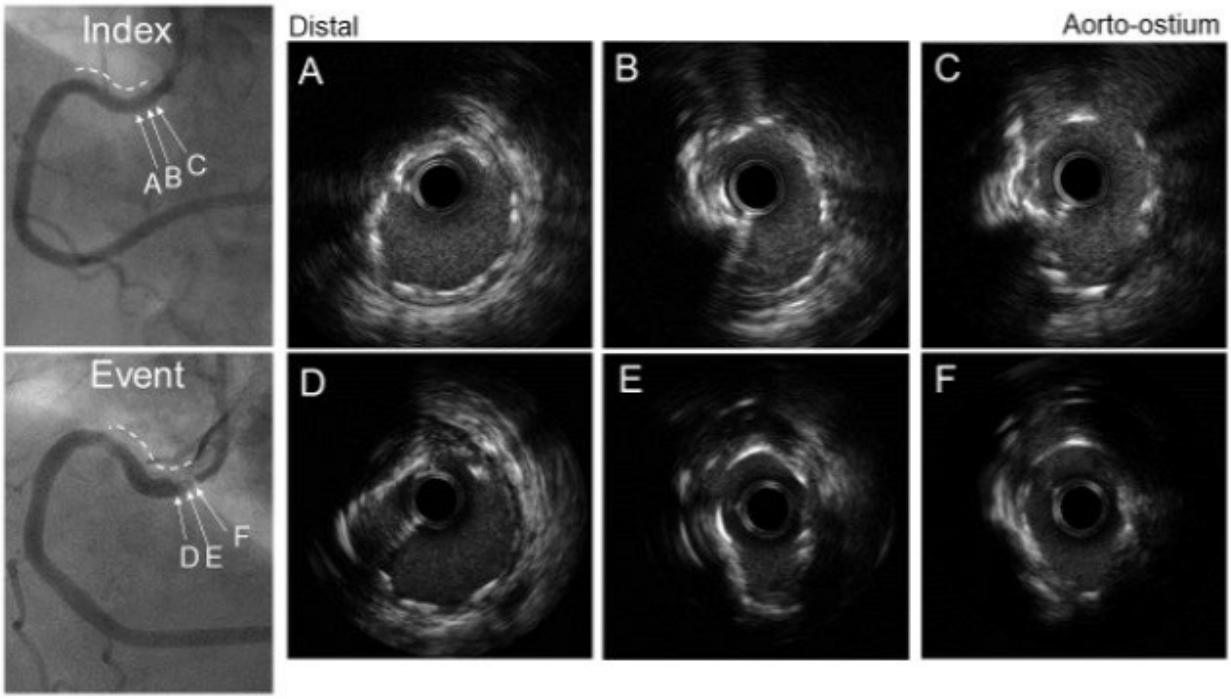
Supplementary Figure 6. Duration from stent implantation (years) stratified by primary cause of in-stent restenosis.

Except ISR lesions with stent fracture which had substantial range of duration, the other ISR occurred at different timing based on the different cause of ISRs. ISR denotes in-stent restenosis.



Supplementary Figure 7. Flowchart of exclusion and inclusion of lesions for angiographic hinge motion analysis at index and follow-up.

Among 139 RCA ostial ISRs, index angiography was available in 57 RCA ostial ISRs.



Supplementary Figure 8. A case example showing stent recoil.

The top panel showed final IVUS images at index procedure and the bottom panel showed IVUS images at the time of in-stent restenosis. Minimum stent area measured 6.4 mm^2 (B) and 5.4 mm^2 (E) indicating stent recoil, respectively.