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Functional Angioplasty
Integrated Use of FFR & IVUS

Clinical Implication of Neointimal Characteristics After Stent in OCT

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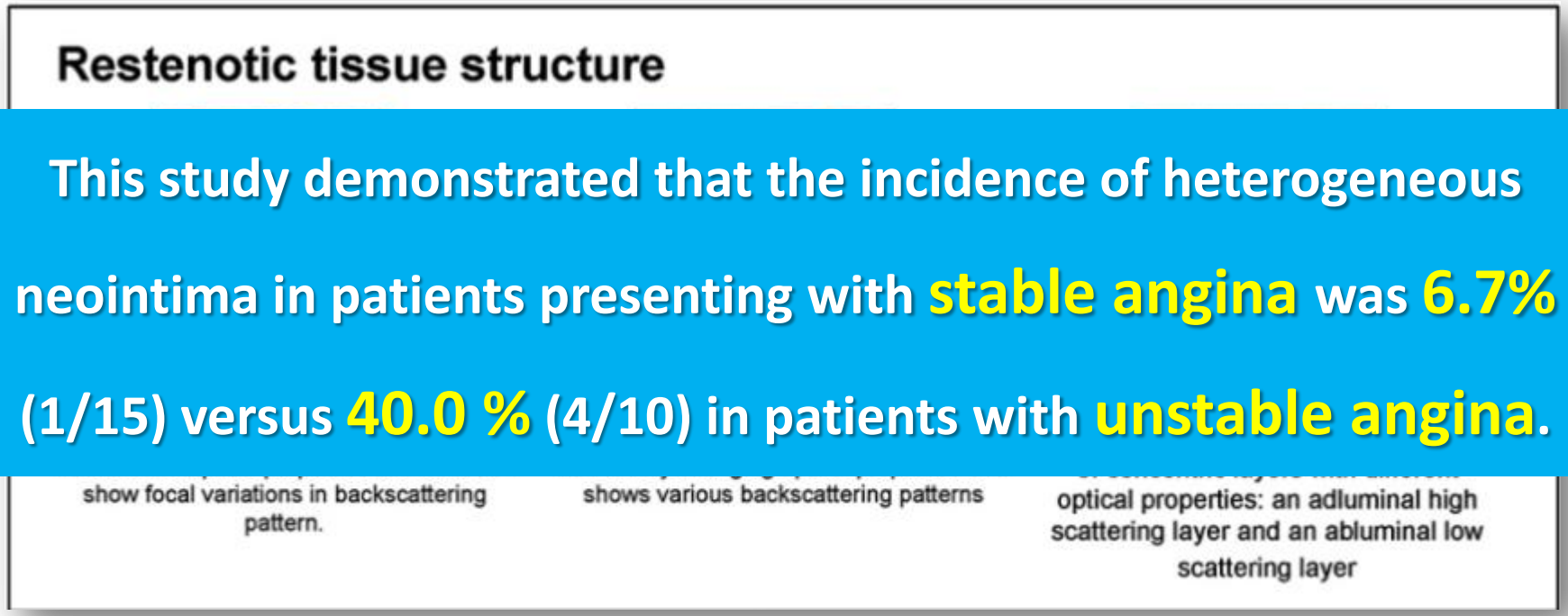
Neointimal tissue of In-stent Restenosis

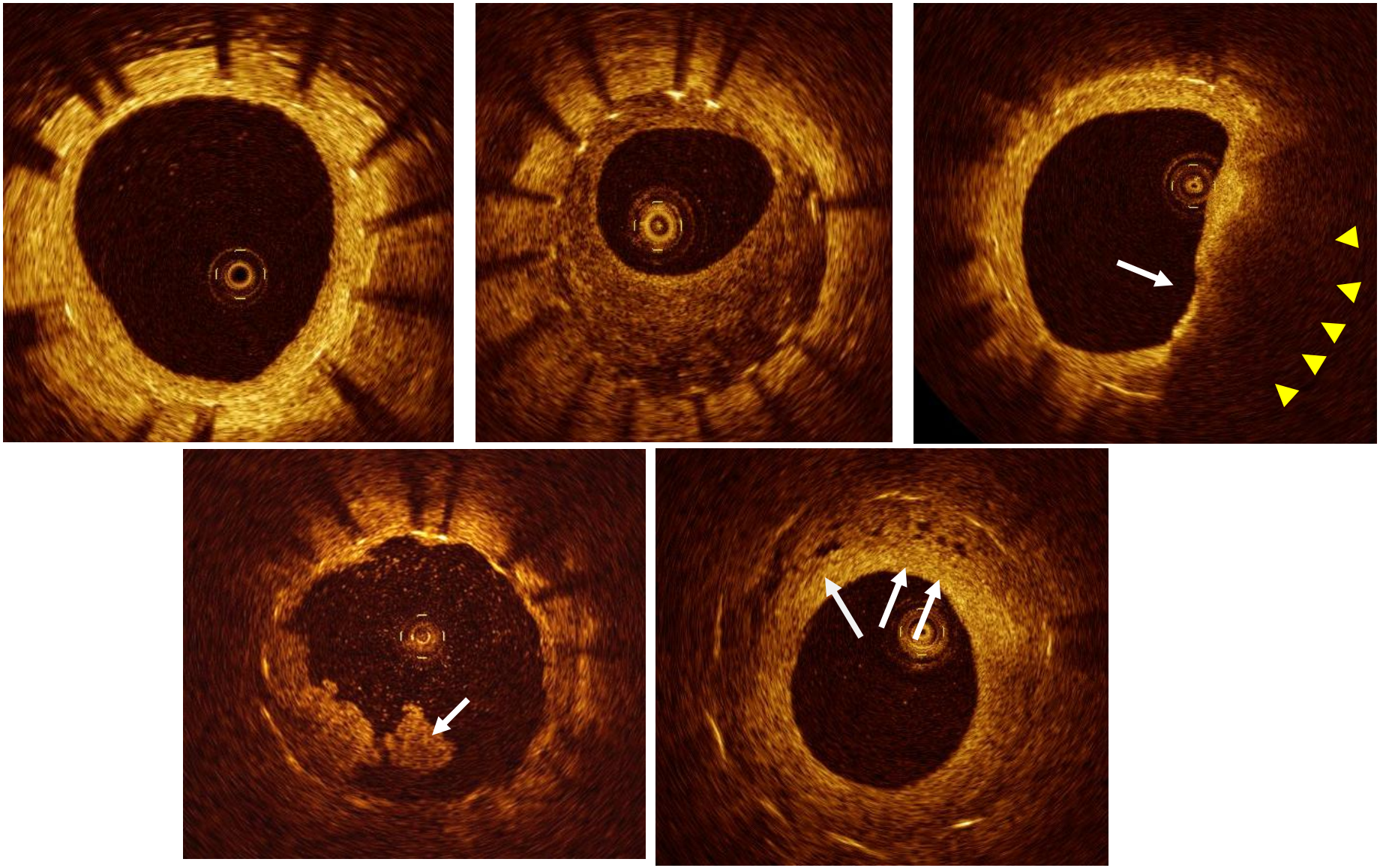


This study demonstrated that the incidence of heterogeneous neointima in patients presenting with stable angina was 6.7% (1/15) versus 40.0 % (4/10) in patients with unstable angina.

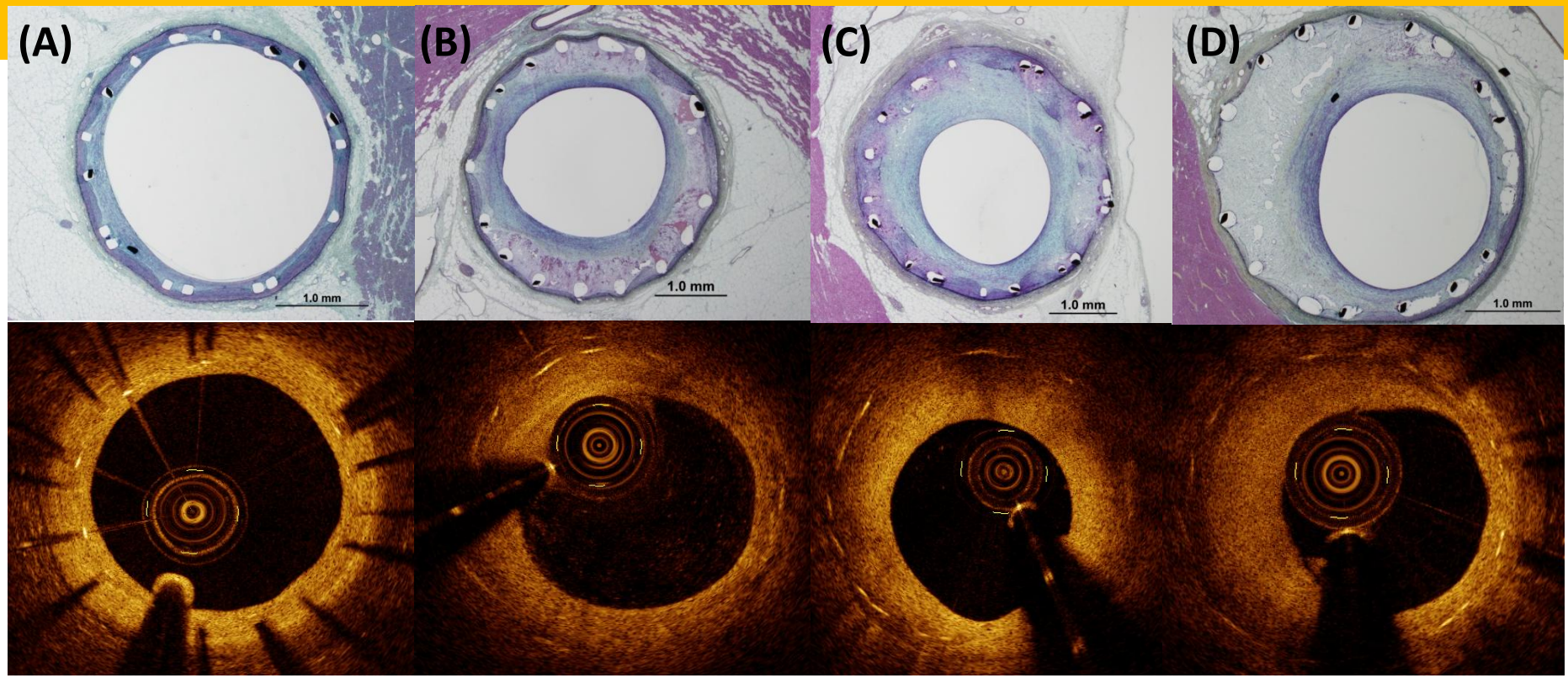
	Angiographic classification			
	Diffuse (n = 9)	Focal (n = 11)	Margin (n = 5)	p
Layered	7 (77.8%)	5 (45.5%)	1 (20%)	0.005
Homogeneous	2 (22.2%)	1 (9.1%)	4 (80%)	
Heterogeneous	0	5 (45.5%)	0	

Gonzalo N, et al. Am Heart J 2009;158:284-93

Pattern of Restenotic Tissue



Kim JS, Hong MK , et al. J Am Coll Cardiol Img 2012



Representative images of OCT and histologic sections.

(A) **Homogeneous** neointimal pattern in OCT has a collagen rich neointima (bluish color) (B) **heterogeneous** neointimal pattern shows lots of loose connective tissue (grey color) and fibrin (pink color) (C) **layered neointimal** pattern shows thick neointima, external elastic laminal rupture and peristrut inflammation (D) **neovascularization** is shown in the middle of neointima.

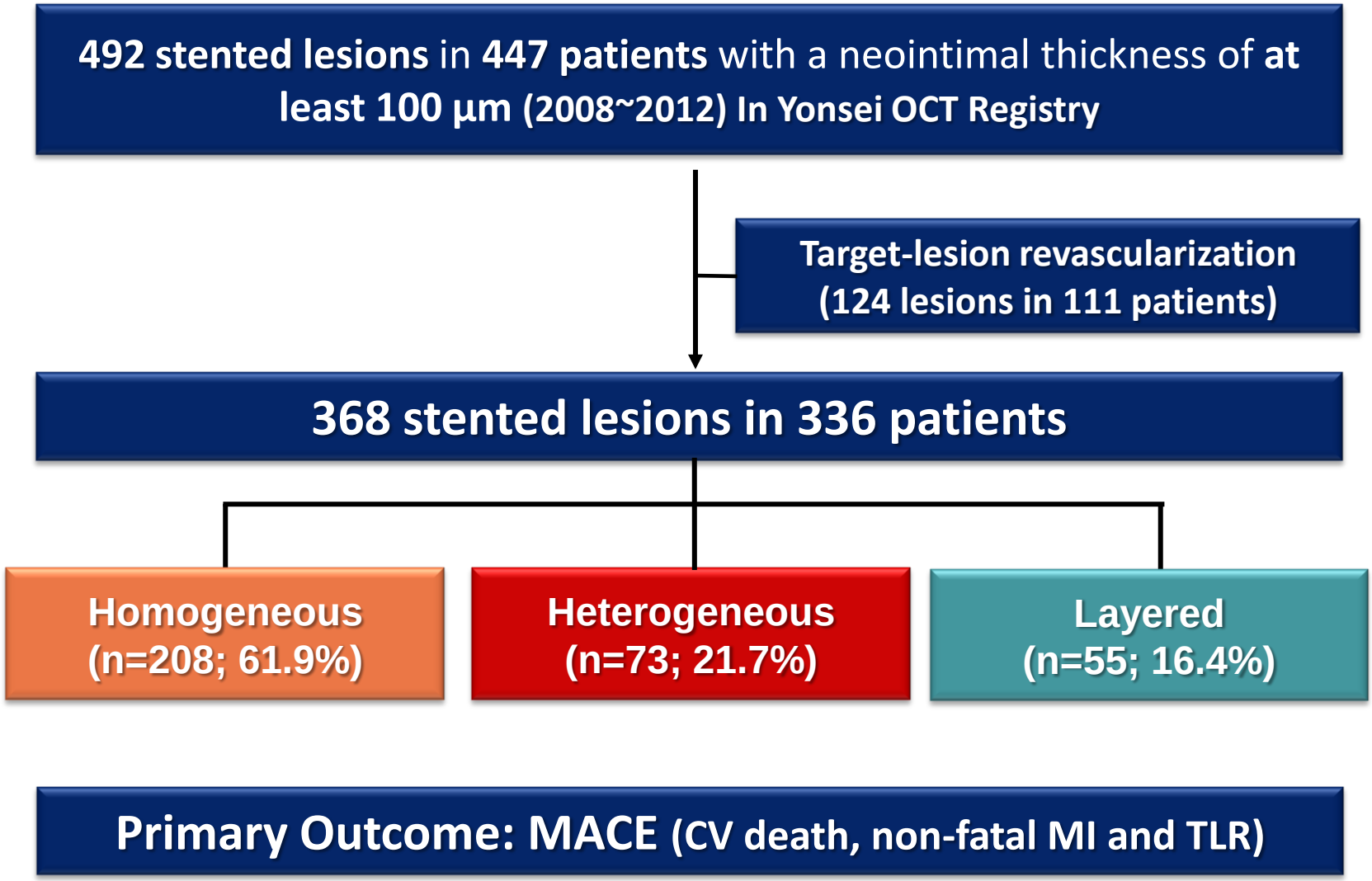
Kim JS, Granada JF, et al. Eur Heart J Cardiovasc Imaging 2013

Background

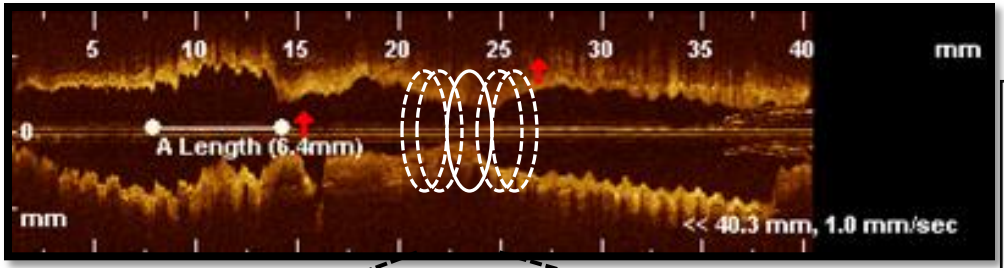
- However, the relationship between different OCT-based neointimal characteristics and clinical outcomes has not been investigated.

- Therefore, the aim of this study was to find out the correlation between in-stent neointimal characteristics as assessed by OCT and clinical outcomes.

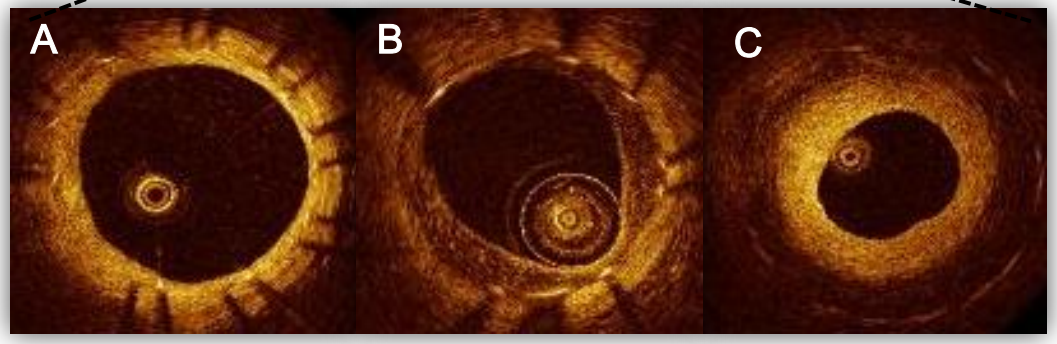
Methods


492 stented lesions in 447 patients with a neointimal thickness of at least 100 µm (2008~2012) In Yonsei OCT Registry
Target-lesion revascularization (124 lesions in 111 patients)
368 stented lesions in 336 patients
Homogeneous (n=208; 61.9%)
Heterogeneous (n=73; 21.7%)
Layered (n=55; 16.4%)
Primary Outcome: MACE (CV death, non-fatal MI and TLR)

Methods



368 stented lesions with a neointimal thickness of **at least 100 μm in 5 consecutive CS** around MLA were assessed.



(A) Homogeneous pattern : an uniform signal-rich band without focal variation or attenuation.

(B) Heterogeneous pattern : focally changing optical properties and various backscattering patterns.

(C) Layered pattern : layers with different optical properties, namely an adluminal high scattering layer and abluminal low scattering layer.

Baseline characteristics

	Homogeneous (n=208)	Heterogeneous (n=73)	Layered (n=55)	p
Age (years)	60.8 ± 9.6	64.0 ± 7.9	63.5 ± 7.9	0.014
Male, n (%)	134 (64.4)	52 (71.2)	39 (70.9)	0.450
Diabetes mellitus, n (%)	58 (27.9)	24 (32.9)	22 (40.0)	0.207
Hypertension, n (%)	125 (60.1)	40 (54.8)	36 (65.5)	0.472
Dyslipidemia, n (%)	95 (45.7)	25 (34.2)	25 (45.5)	0.221
Current smoker, n (%)	39 (18.8)	19 (26.0)	15 (27.3)	0.238
Chronic renal failure, n (%)	3 (1.4)	1 (1.4)	0 (0.0)	0.672
Clinical presentation, n (%)				0.096
Stable angina	117 (56.3)	31 (42.5)	32 (58.2)	
Acute coronary syndrome	91 (43.8)	42 (57.5)	23 (41.8)	

Angiographic characteristics

	Homogeneous (n=227)	Heterogeneous (n=79)	Layered (n=62)	p
Target coronary artery				0.033
Left anterior descending	117 (51.5)	46 (58.2)	28 (45.2)	
Left circumflex	58 (25.6)	14 (17.7)	9 (14.5)	
Right	52 (22.9)	19 (24.1)	25 (40.3)	
Stent types, n (%)				
Bare-metal stent	0 (0.0)	3 (3.8)	0 (0.0)	0.004
Drug-eluting stent	227 (100.0)	76 (96.2)	289 (100.0)	
1st generation DES	74 (32.6)	27 (35.5)	21 (33.9)	0.893
Stent diameter (mm)	3.0 ± 0.3	3.1 ± 0.4	3.0 ± 0.4	0.125
Total stent length (mm)	24.1 ± 6.2	21.4 ± 6.4	23.6 ± 6.6	0.006

OCT analysis

	Homogeneous (n=227)	Heterogeneous (n=79)	Layered (n=62)	p
Total frames	5380	1649	1386	
Median time interval (m), IQR	9.0 (6.0-10.0)	8.0 (5.0-10.0)	9.0 (6.0-11.0)	0.637
Mean stent CSA (mm^2)	7.1 ± 1.9	7.1 ± 2.1	7.3 ± 1.8	0.599
Mean neointimal CSA (mm^2)	1.2 ± 0.7	1.4 ± 0.9	1.9 ± 1.2	<0.001
Mean lumen CSA (mm^2)	5.9 ± 1.7	5.7 ± 1.9	5.5 ± 1.7	0.193
Minimal lumen area (mm^2)	4.5 ± 1.6	4.0 ± 1.9	3.7 ± 1.8	0.001
Mean neointimal thickness (μm)	138 ± 68	168 ± 119	217 ± 133	<0.001
Neointimal CSA (%)	16.5 ± 8.1	20.1 ± 12.9	25.4 ± 13.7	<0.001
Uncovered strut (%)	3.4 ± 5.4	4.7 ± 8.0	4.1 ± 7.3	0.293

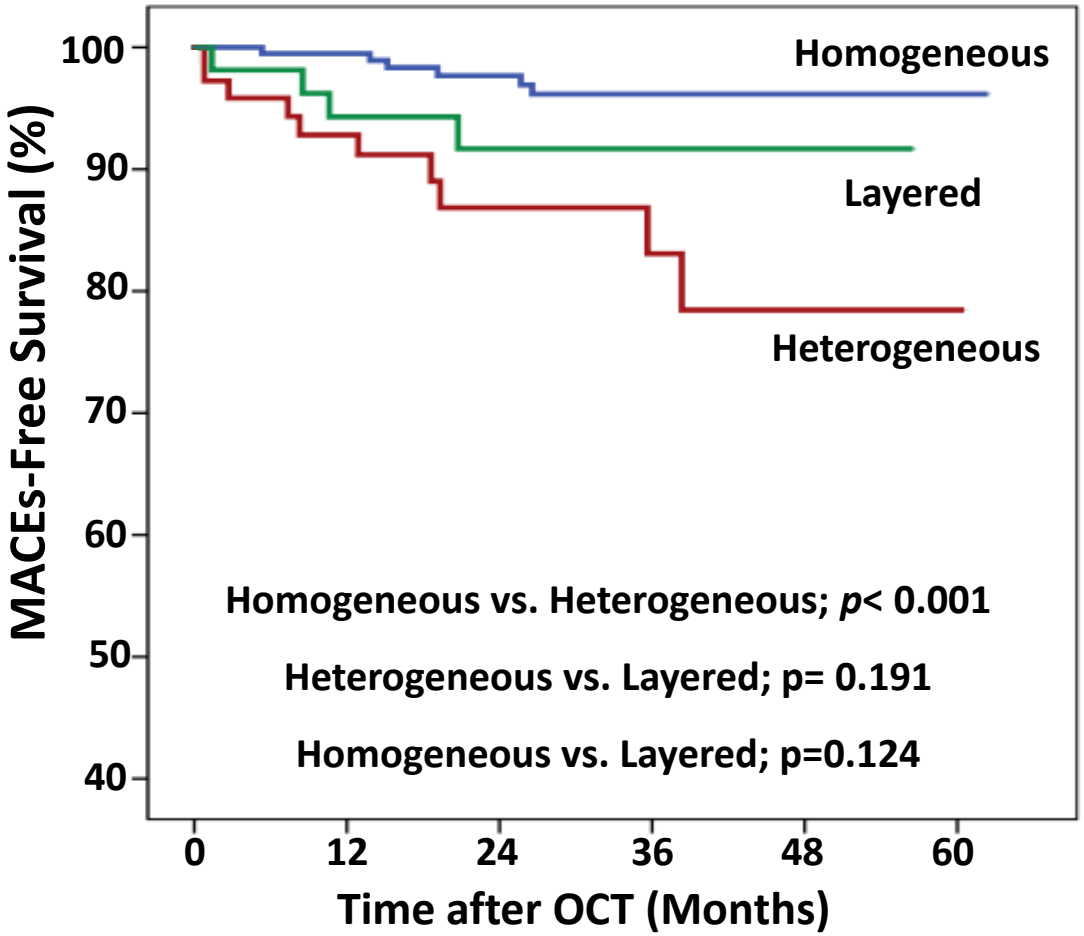
Predictors for Heterogeneous Pattern

	Univariate analysis		Multivariate analysis	
	OR (95% CI)	p	OR (95% CI)	p
Age (per years)	1.032 (1.003-1.062)	0.029	1.039 (1.008-1.070)	0.013
Gender (male)	1.046 (0.616-1.775)	0.868	0.852 (0.484-1.498)	0.578
1st gen. DES	1.125 (0.662-1.912)	0.663		
Initial ACS dx	1.874 (1.130-3.107)	0.015	2.010 (1.182-3.418)	0.010
Diabetes mellitus	1.289 (0.758-2.190)	0.348	1.396 (0.797-2.443)	0.243
Hypertension	0.831 (0.503-1.373)	0.470		
Dyslipidemia	0.662 (0.395-1.109)	0.117	0.723 (0.419-1.248)	0.244
Chronic renal failure	0.913 (0.101-8.290)	0.936		
Time interval to OCT (m)	1.015 (1.002-1.028)	<0.001	1.014 (0.999-1.025)	0.079
Uncovered struts (%)	1.024 (0.989-1.061)	0.179	1.022 (0.986-1.060)	0.230
Stent length (per mm)	0.975 (0.938-1.014)	0.206		

MACE during follow up after OCT

	Homogeneous (n=208)	Heterogeneous (n=73)	Layered (n=55)	p
A composite of cardiac death, non-fatal MI, or TLR	6 (2.9%)	10 (13.7%)	4 (7.3%)	0.001
Cardiac death	1 (0.5%)	0 (0.0%)	0 (0.0%)	0.780
Non-fatal MI	0 (0.0%)	3 (4.1%)	0 (0.0%)	<0.001
TLR	5 (2.4%)	7 (9.6%)	4 (7.3%)	0.020
Stent thrombosis	1 (0.5%)	3 (4.1%)	0 (0.0%)	0.006

Kaplan Meier Curve



Homogeneous (n)	208	187	132	100	49	2
Layered (n)	55	49	33	22	6	0
Hetero (n)	73	59	34	22	8	1

Predictors for MACEs

	Univariate analysis		Multivariate analysis	
	HR (95% CI)	p	HR (95% CI)	p
Age (per years)	1.006 (0.959-1.055)	0.814	0.970 (0.915-1.029)	0.314
Gender (male)	0.931 (0.371-2.333)	0.879	0.885 (0.309-2.421)	0.865
Hypertension	0.688 (0.286-1.652)	0.402		
Diabetes mellitus	1.881 (0.779-4.539)	0.160	1.262 (0.479-3.326)	0.638
Initial ACS dx	1.586 (0.648-3.884)	0.312	1.008 (0.384-2.648)	0.987
1st gen. DES	2.440 (0.980-6.075)	0.055	2.447 (0.792-7.560)	0.120
Time interval to OCT (months)	1.018 (1.003-1.033)	0.017	0.988 (0.958-1.020)	0.457
Minimal lumen CSA (per mm^2)	0.319 (0.206-0.495)	<0.001	0.421 (0.267-0.664)	<0.001
Stent length (per mm)	1.024 (0.954-1.098)	0.513		
Heterogeneous pattern*	5.638 (2.044-15.549)	0.001	4.524 (1.293-15.825)	0.018
Layered group*	2.632 (0.743-9.332)	0.134	1.880 (0.478-7.394)	0.366

Limitation

- Only patients with stented lesion ≥100 μm of neointimal thickness were included in this study.
- The neointimal tissue characteristics need to be validated with histology and the current intravascular OCT system may be limited in its ability to properly evaluate the qualitative characteristics of the neointima.
- The interval between stent implantation and OCT examination varied within the study population because of retrospective study.

Conclusion I

- This is the first study to investigate the clinical significance of neointimal tissue patterns.

- The occurrence of heterogeneous neointima was significantly associated with both older age and initial clinical presentation of acute coronary syndrome.

- MACEs occurred more frequently in patients with heterogeneous pattern compared with those with Homogeneous or layered pattern.

Conclusion II

- Heterogeneous pattern of neointima and minimal lumen CSA on follow-up OCT examination were independent risk factor of future MACEs.

- This findings implied that although the quantitative growth of neointimal tissue were important factors for the occurrence of MACEs after stent implantation, the qualitative pattern of neointimal characteristics might be also a possible prognostic parameter.

- These findings strongly suggest the need for large randomized clinical studies to validate the effect of neointimal characteristics by OCT on clinical outcome.