



HARVARD MEDICAL SCHOOL
TEACHING HOSPITAL

Plaque Erosion : A New in vivo Diagnosis

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Background and Aims

- Three most common underlying mechanisms include plaque rupture, plaque erosion, and calcified nodule. Plaque rupture is well characterized. However, in vivo studies on plaque erosion and calcified nodule are limited.
- To evaluate the prevalence and morphological characteristics of erosion and calcified nodule by OCT in the patients with ACS.

Histology studies

1. van der Wal *et al* reported that the prevalence of plaque rupture and **erosion** was 60% and **40%**, respectively.
2. Farb *et al* studied 50 sudden death cases and found ruptures in 28 (56%) patients and **erosions** in 22 (**44%**).
3. Hisaki *et al* reported 70 (56.4%) plaque ruptures and 54 (**43.5%**) **erosions** in 124 lesions.

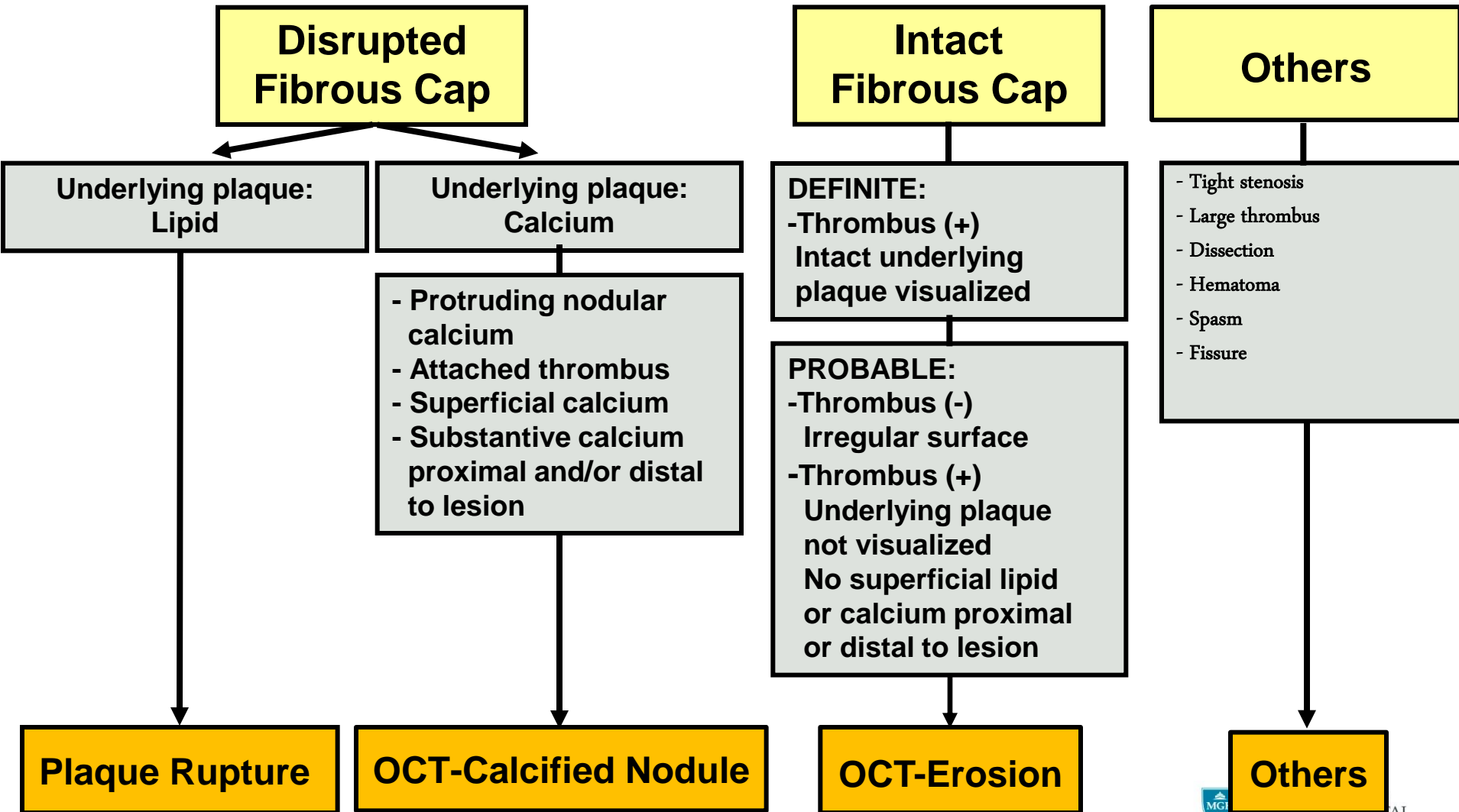




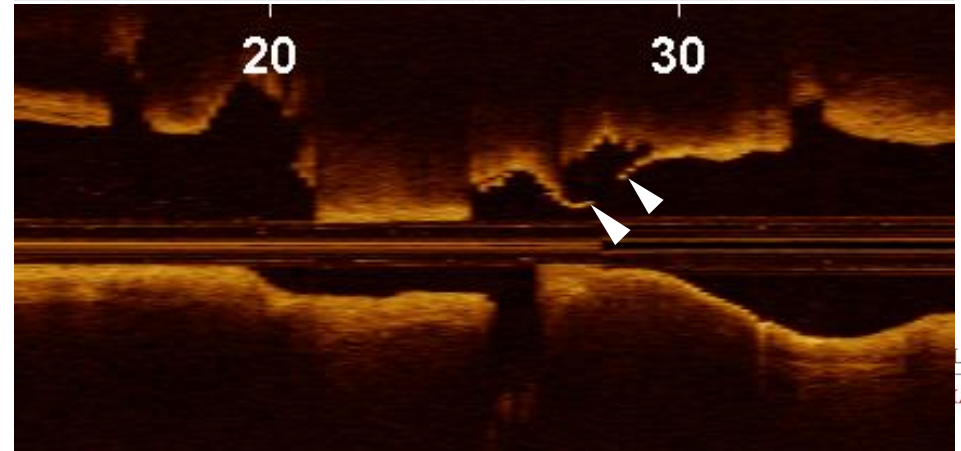
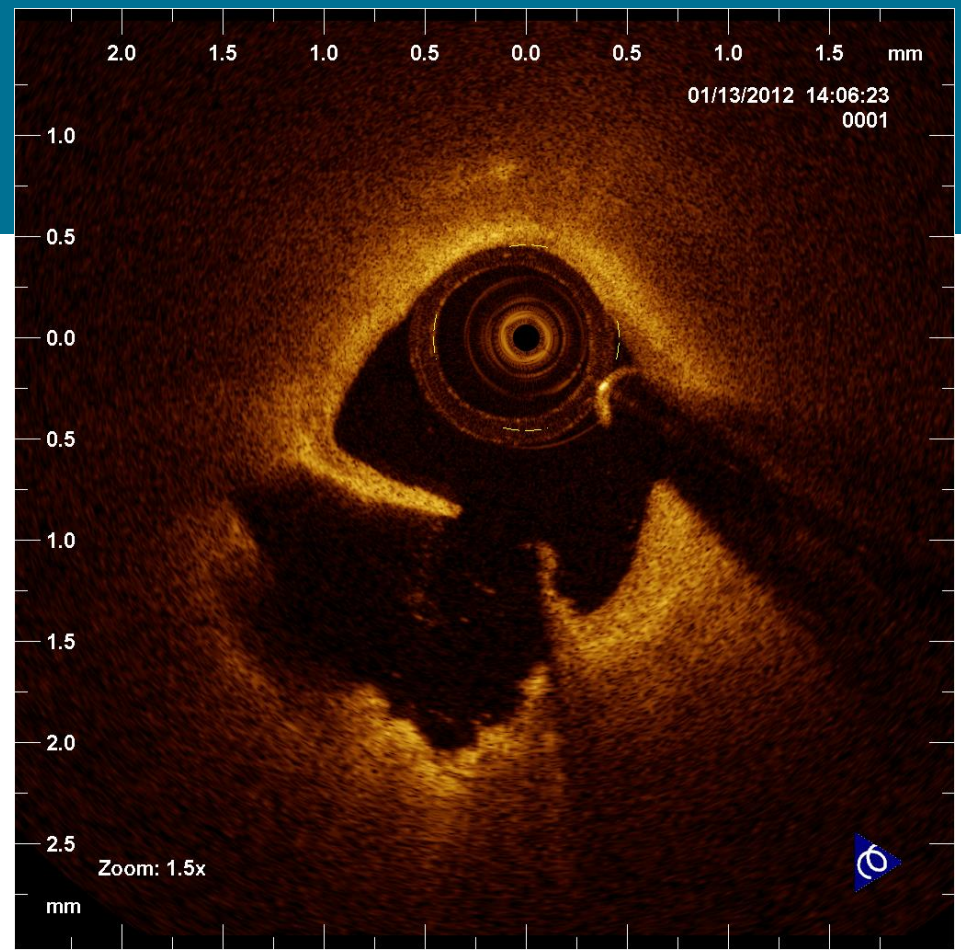
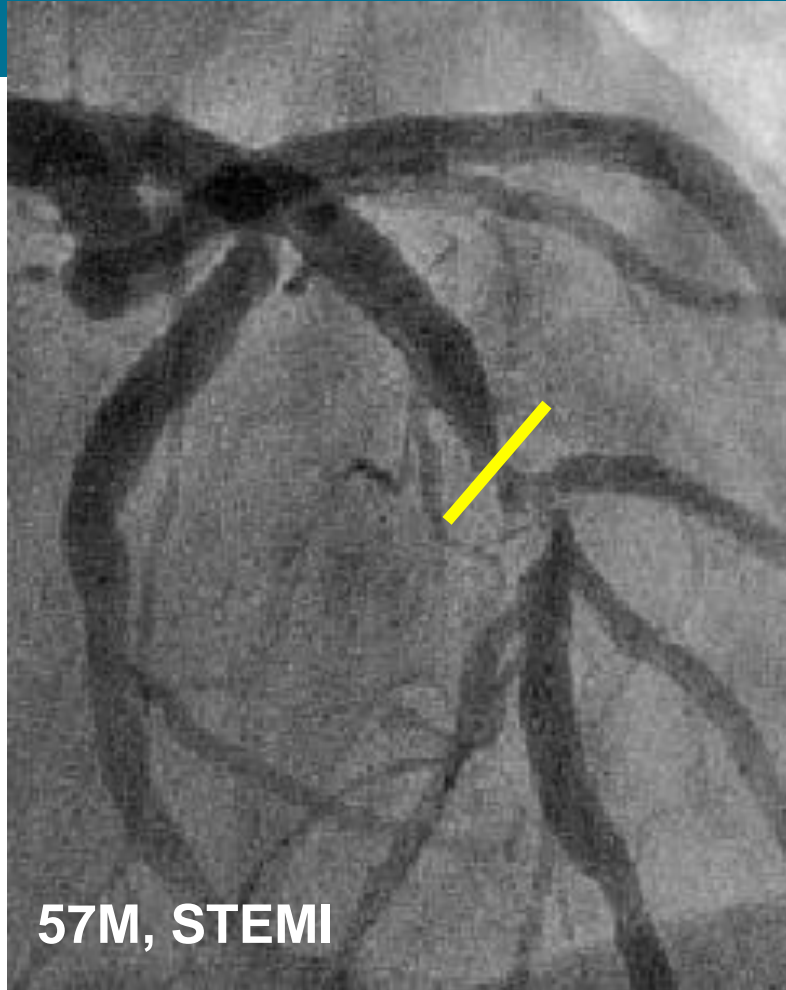
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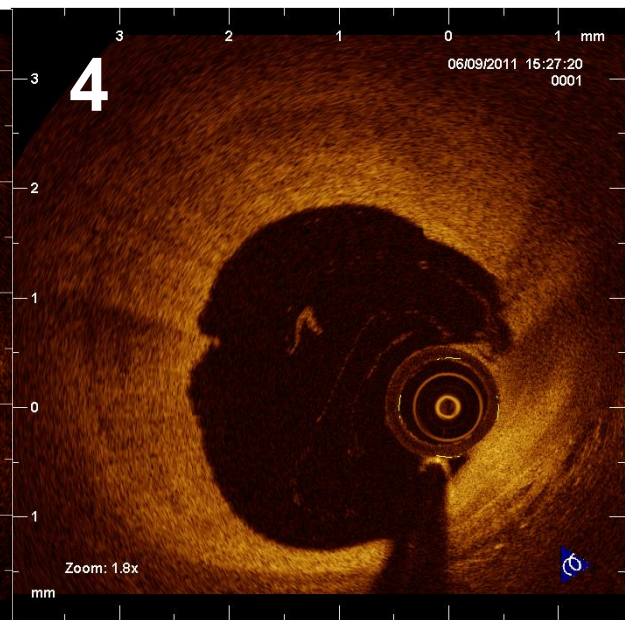
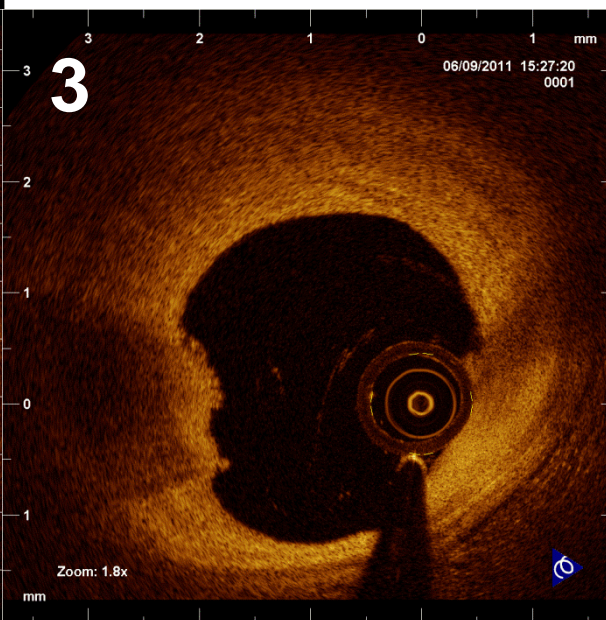
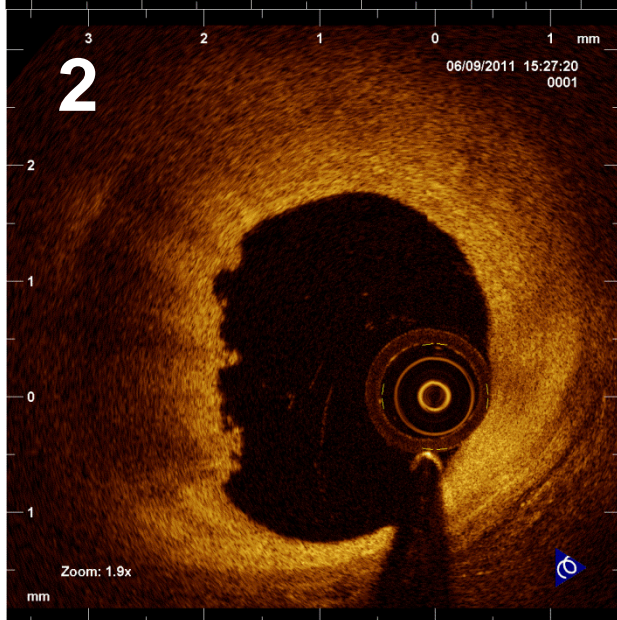
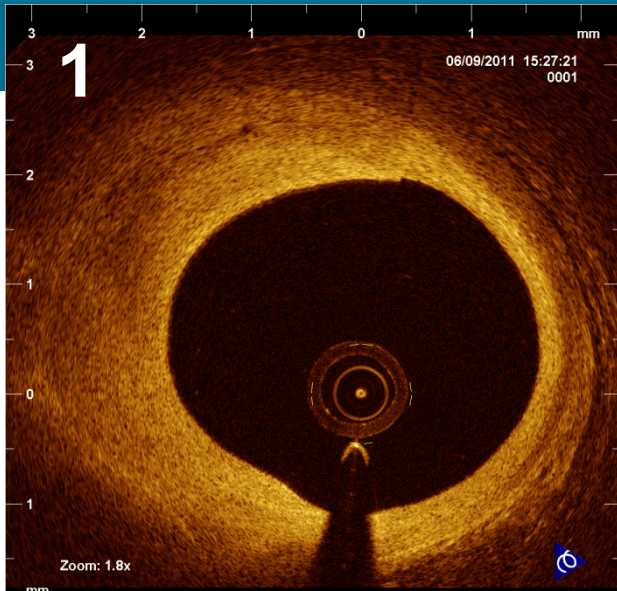
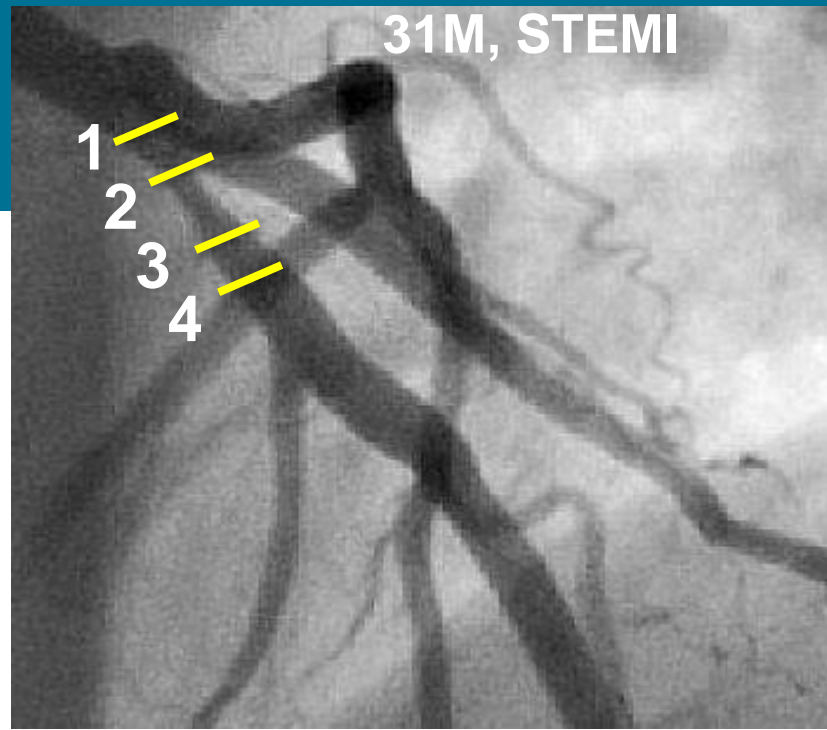
OCT Plaque Classification

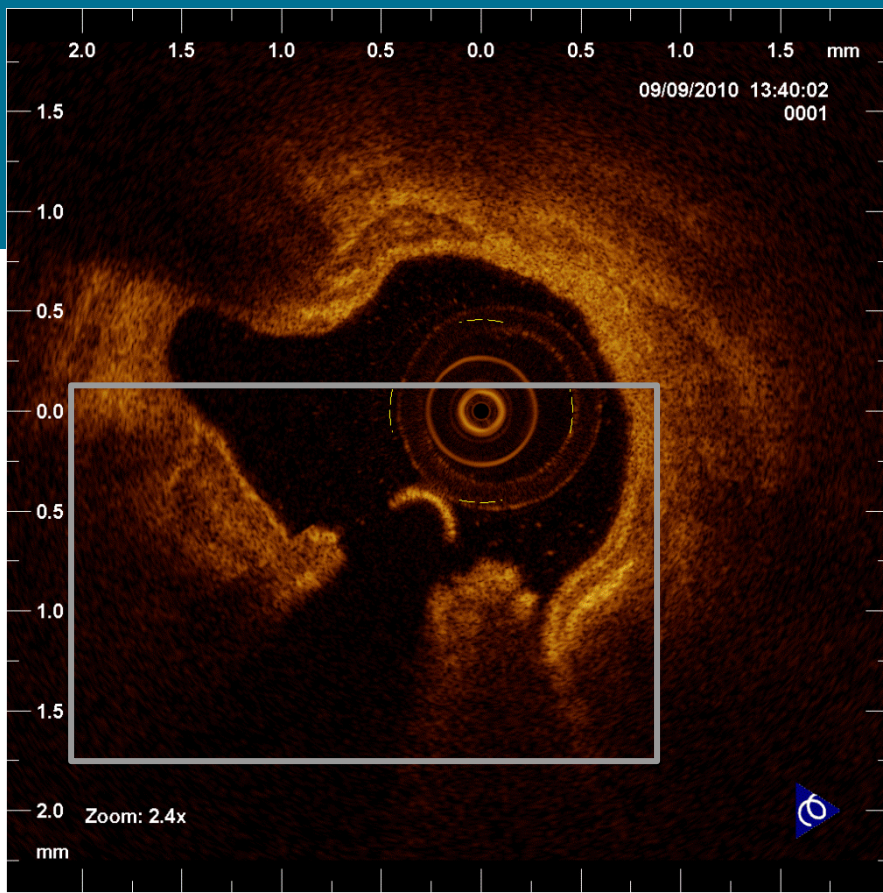


Plaque Rupture

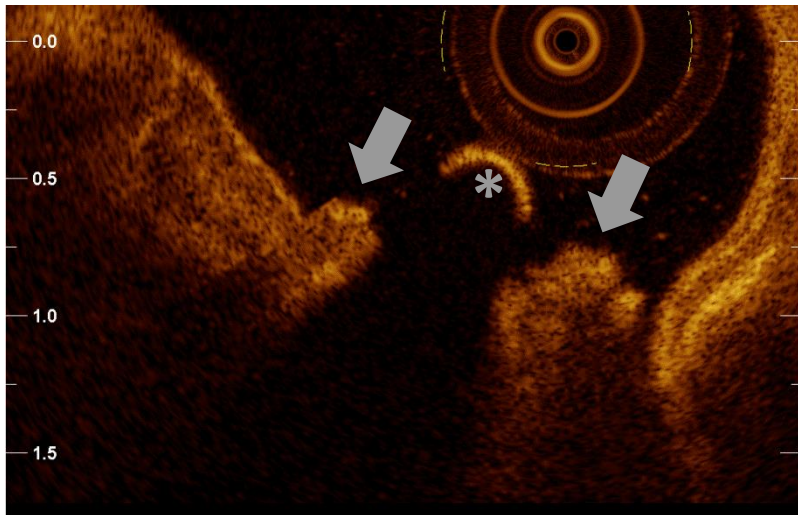
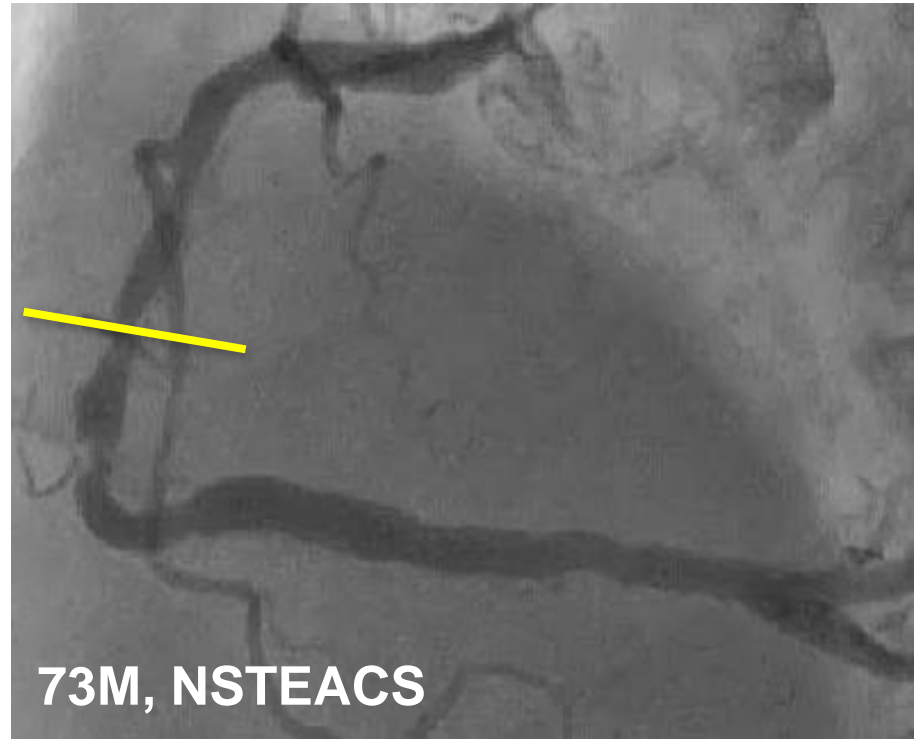


Plaque Erosion

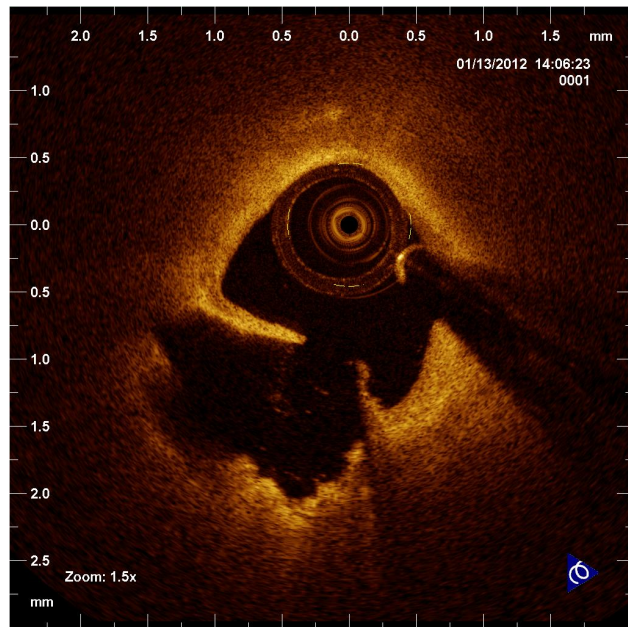




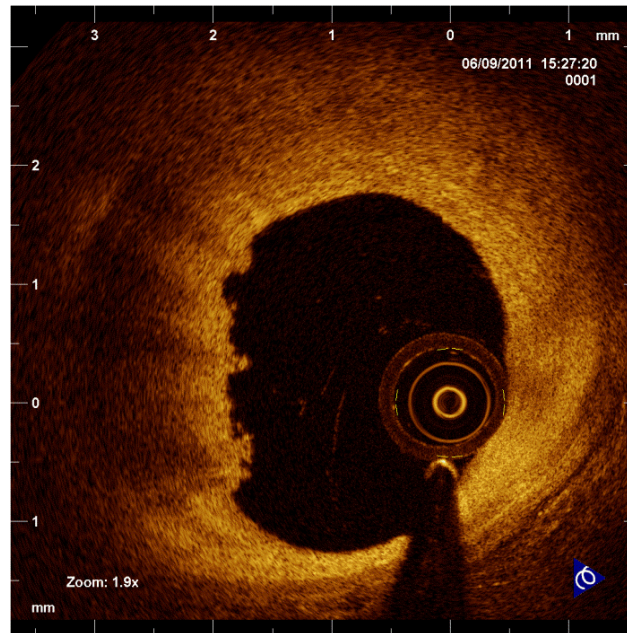
Calcified Nodule



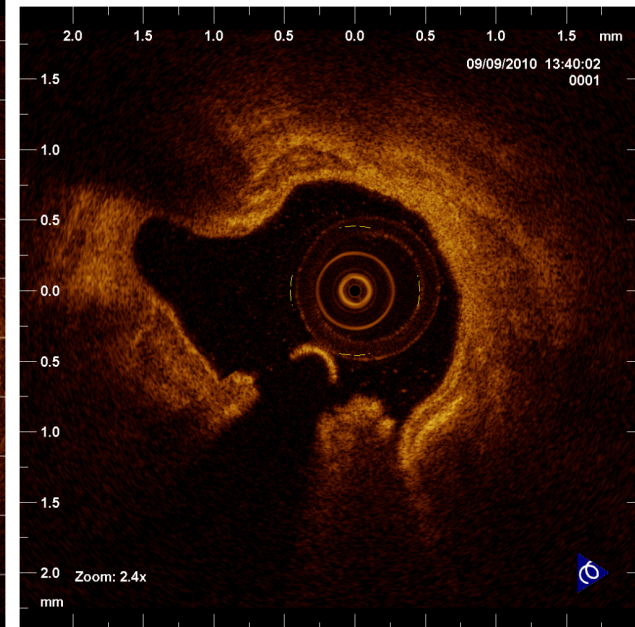
Rupture



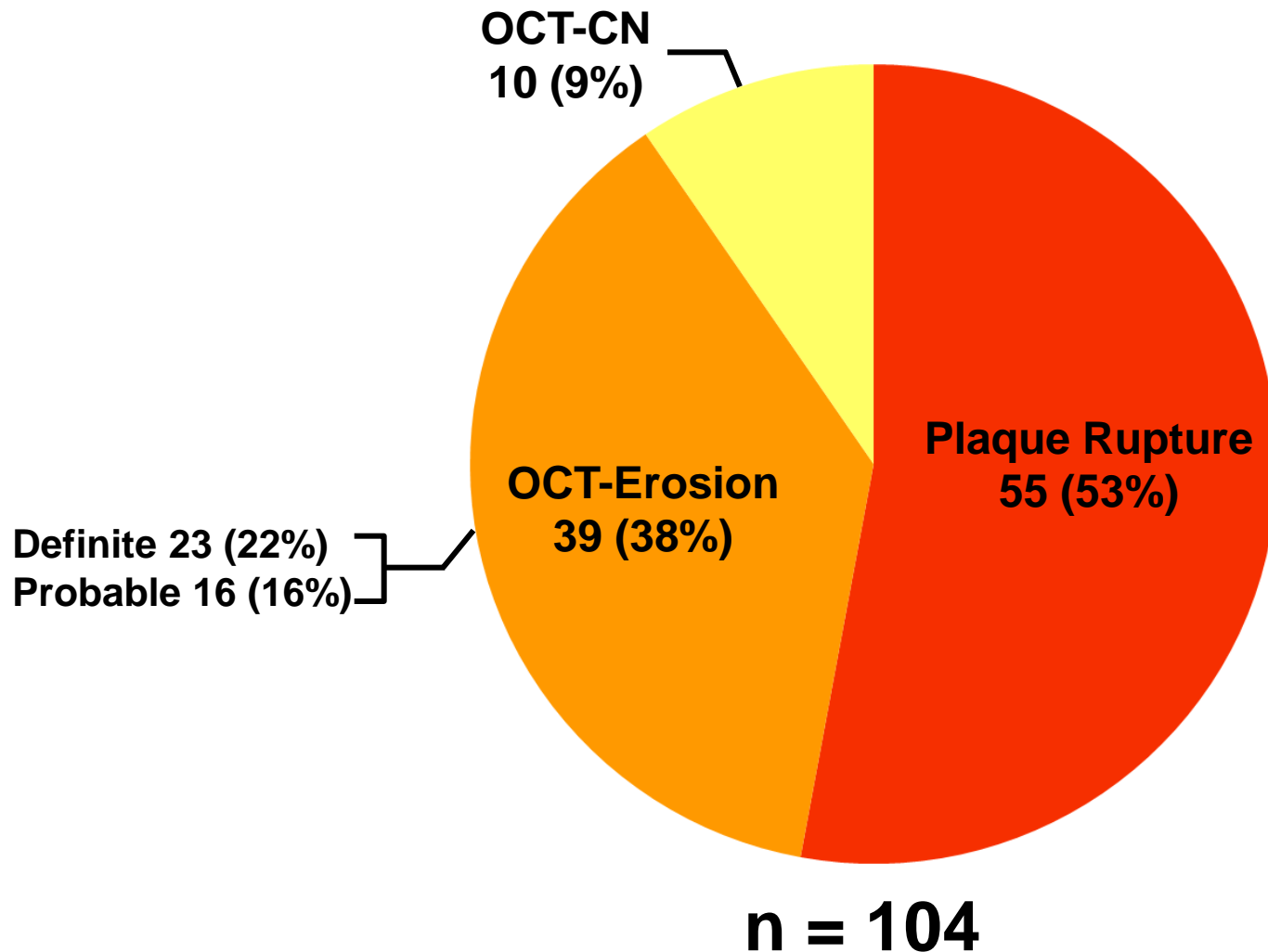
Erosion



Ca Nodule



Incidence of Rupture, Erosion, and Calcified nodule



JACC 2013

Conclusions

- (1) OCT is able to define plaque erosion and calcified nodules in addition to rupture *in vivo*;
- (2) More than one third of ACS cases caused by erosion;
- (3) In erosion, vascular integrity is better preserved with larger lumen and platelet rich thrombus is more frequently observed;



Relationship Between Underlying Plaque Morphologies and Residual Thrombus Pattern in Patients with STEMI after Thrombolytic Therapy : an In Vivo OCT Study

In collaboration with Prof. C. Stefanadis,
Greece

JACC 2014

Sining Hu, MD

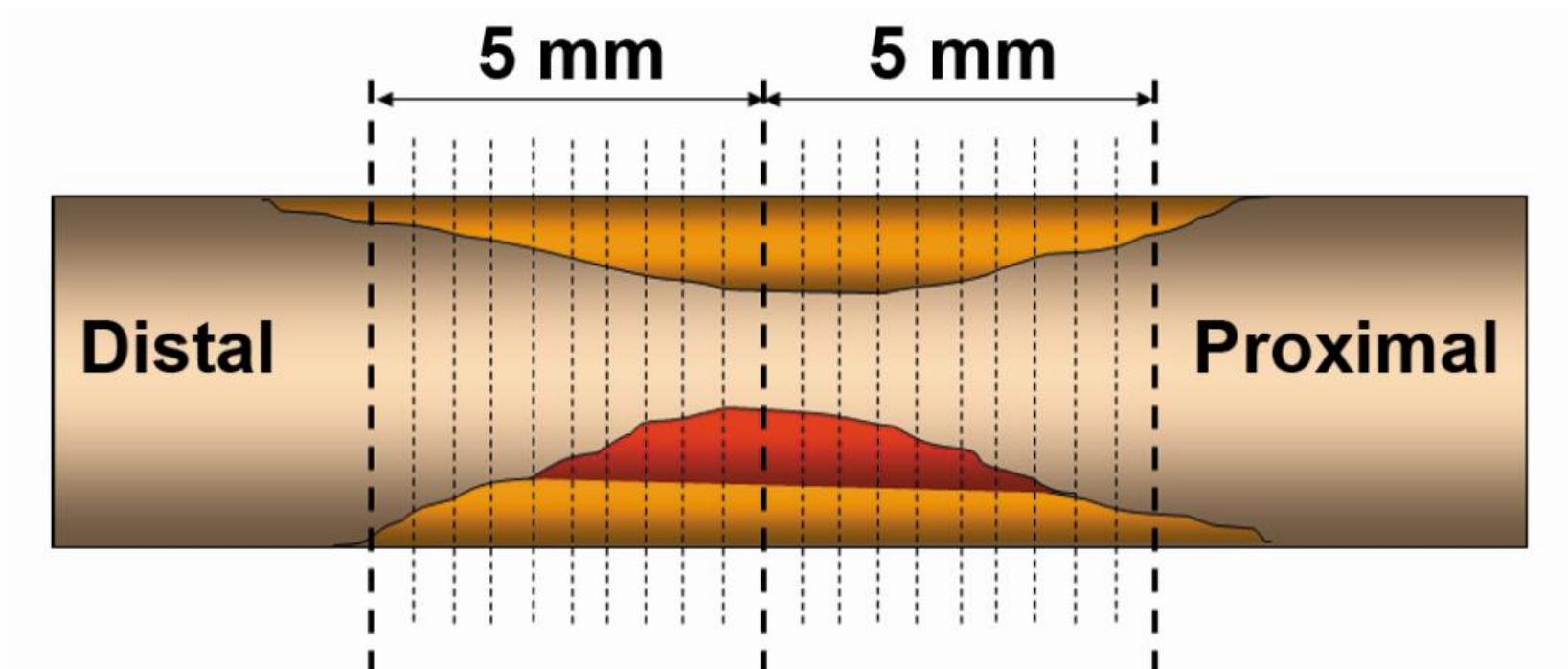


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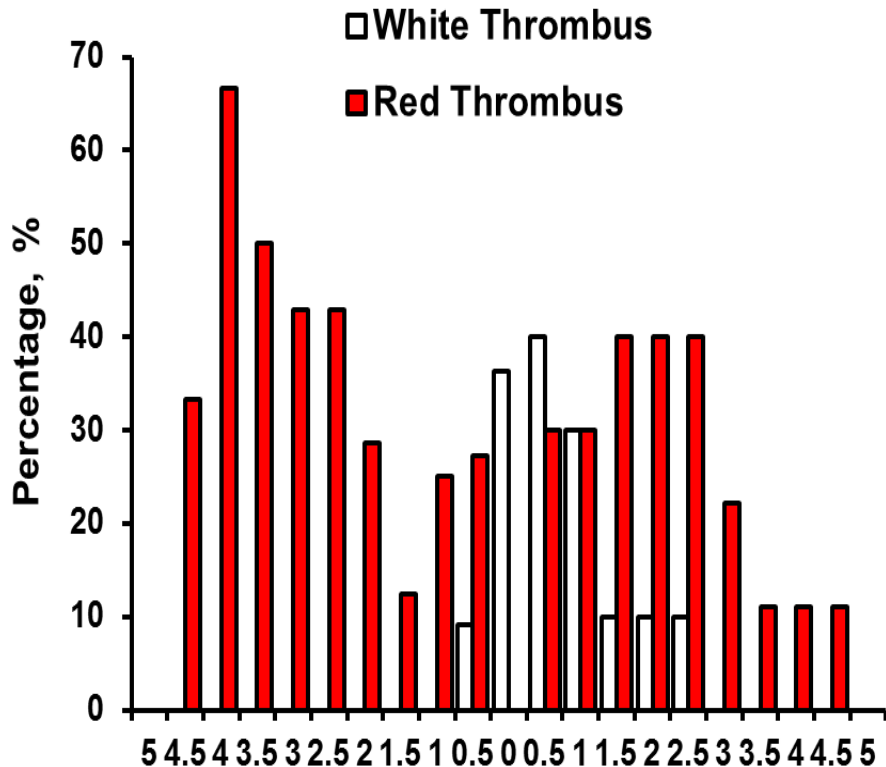
Background and Objective

- The role of underlying plaque morphologies in determining the patterns and distribution of coronary thrombus is unknown.
- To evaluate the relationship between the underlying plaque morphologies and residual thrombus patterns and distribution in culprit lesions of patients with STEMI by OCT after thrombolytic therapy.

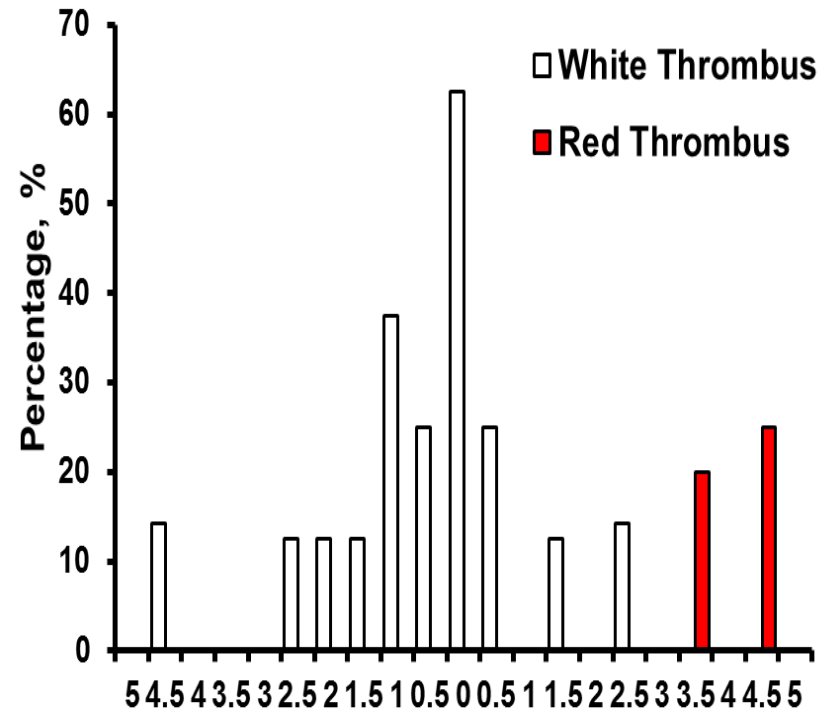
Analysis



Post-lysis Residual Thrombus



Rupture



Erosion

Plaque Rupture, Plaque Erosion and Calcified Nodule in Patients with STEMI: A Combined OCT and IVUS Study

JACC Interv. 2015

Takumi Higuma, MD, PhD



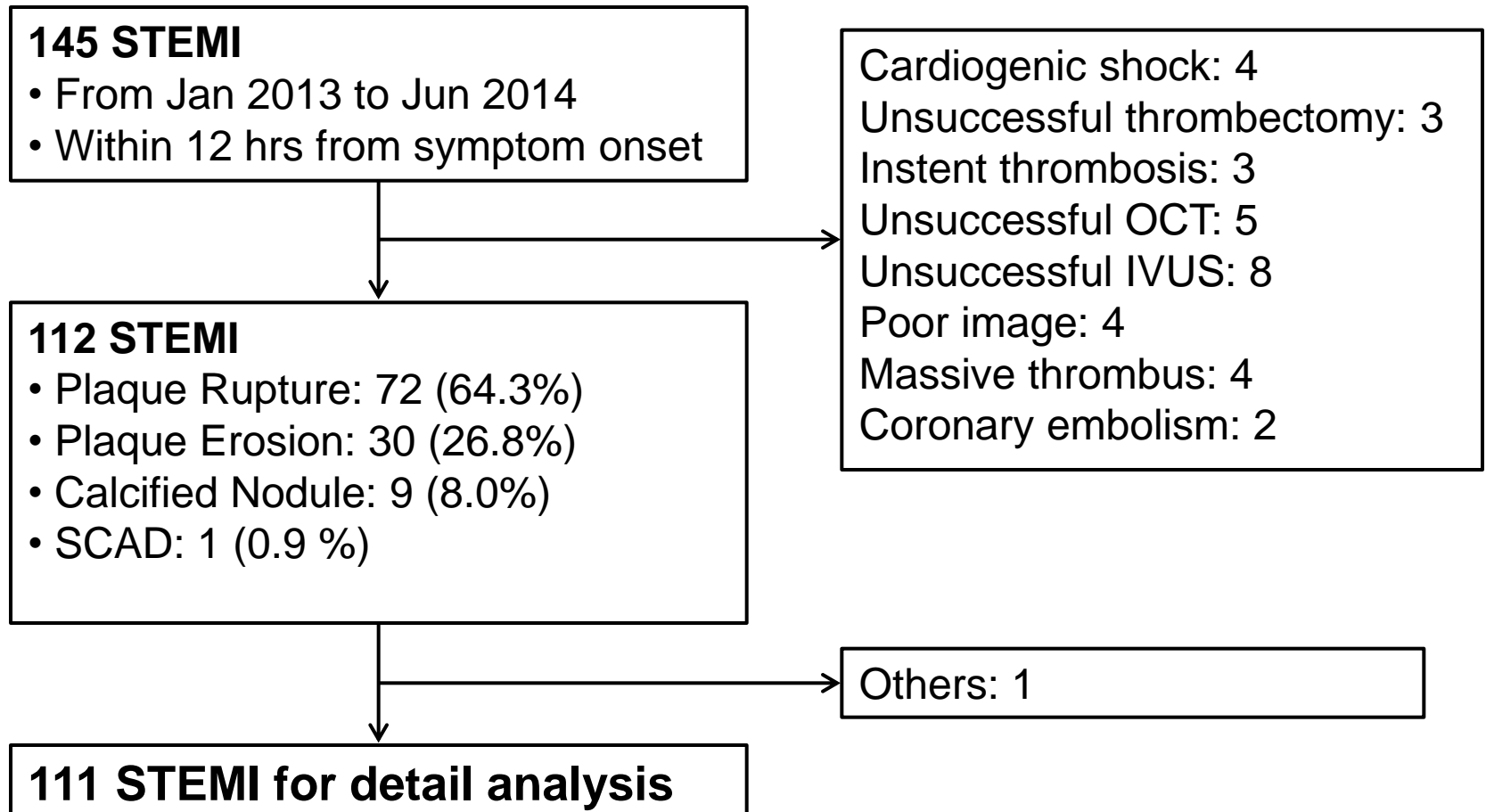
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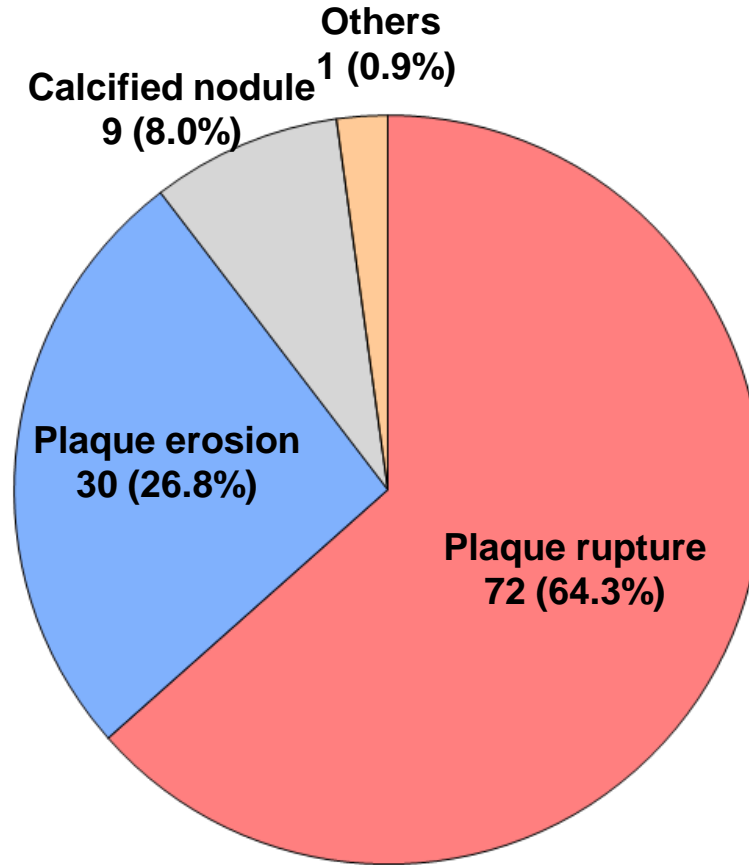
Objects

1. To evaluate the incidence of PR, PE, and CN in STEMI
2. To study the detailed plaque morphology in these 3 groups using OCT and IVUS
3. To evaluate the correlation between acute outcome (TIMI grade, myocardial blush grade, max CK) and plaque morphology

Study Flow Chart



Underlying Mechanisms of STEMI



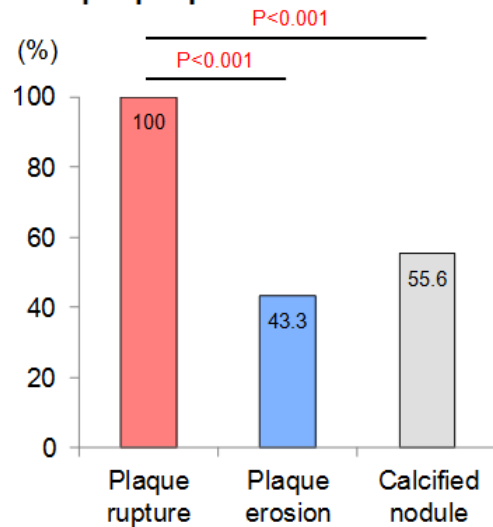
Intra-observer's reliability 0.85

Inter-observer's reliability 0.87

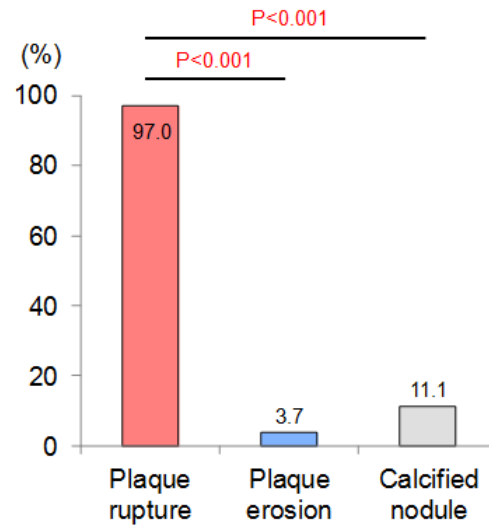
Total 112 STEMI

OCT Findings

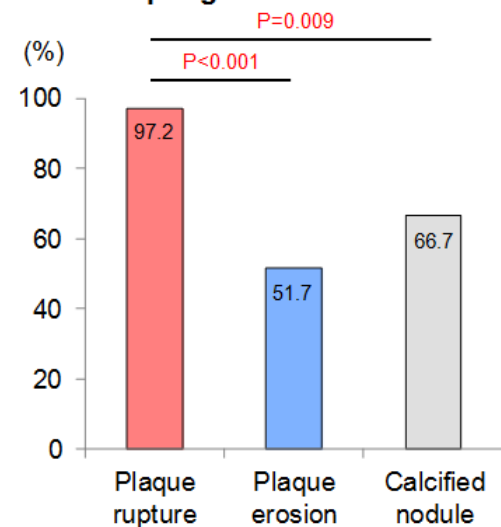
A. Lipid plaque



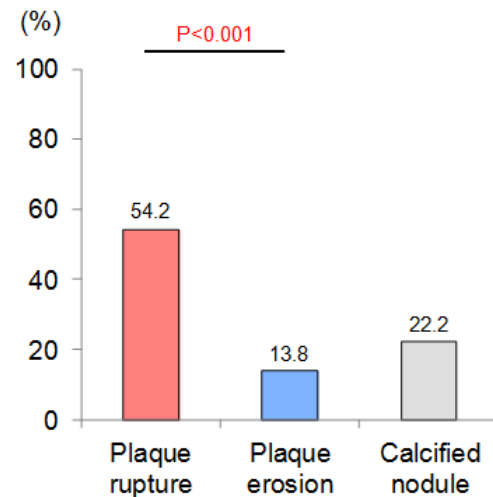
B. TCFA



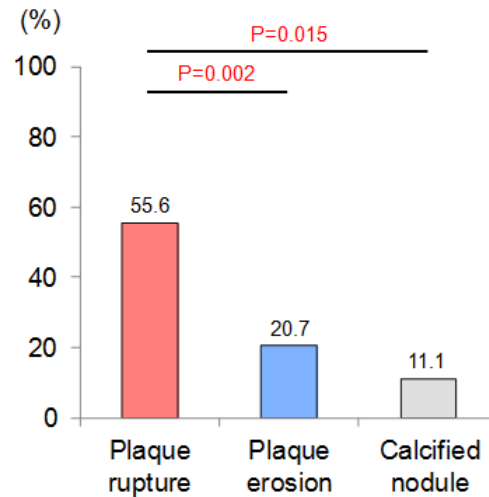
C. Macrophage



D. Microchannel

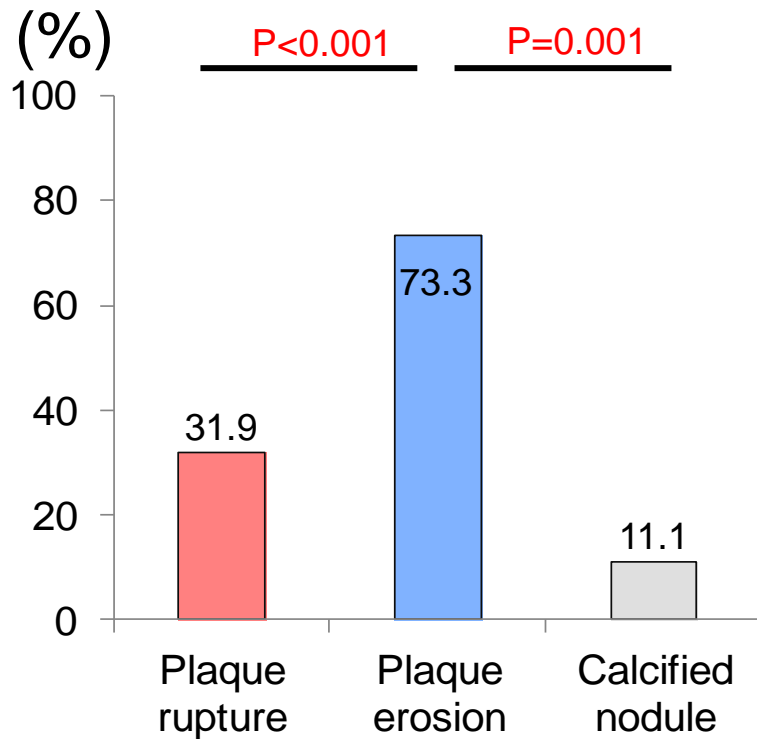


E. Cholesterol crystal

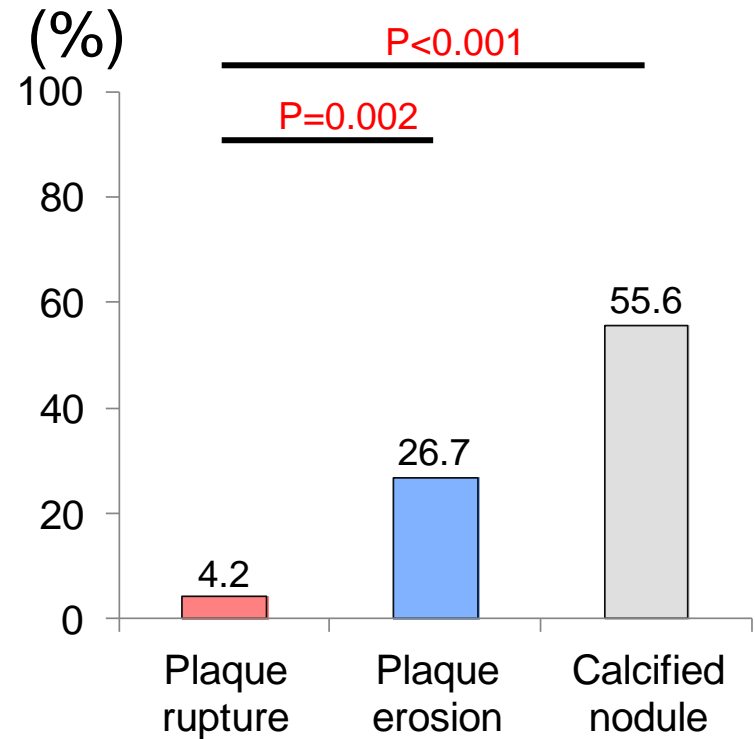


IVUS Findings

Eccentric plaque

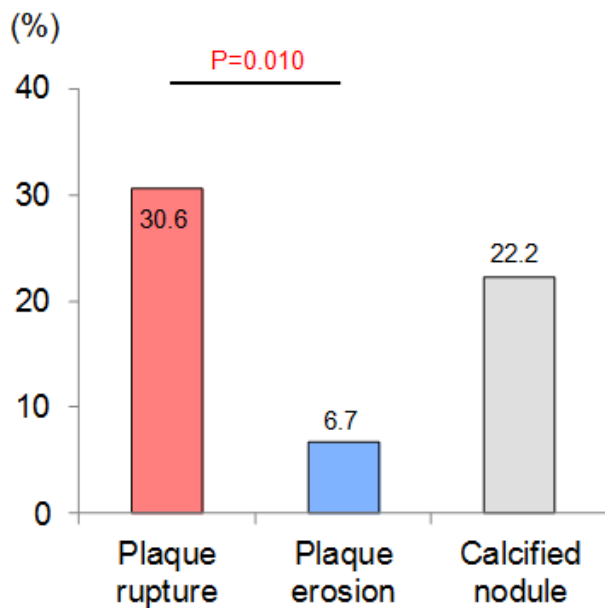


Constrictive remodeling

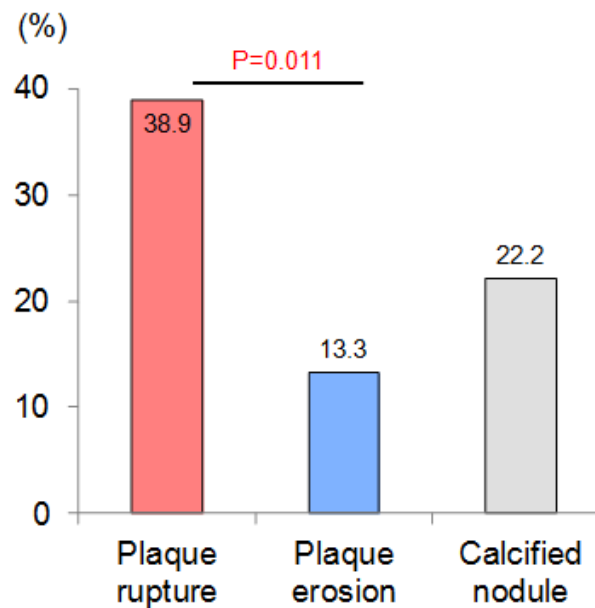


Acute outcomes after PCI

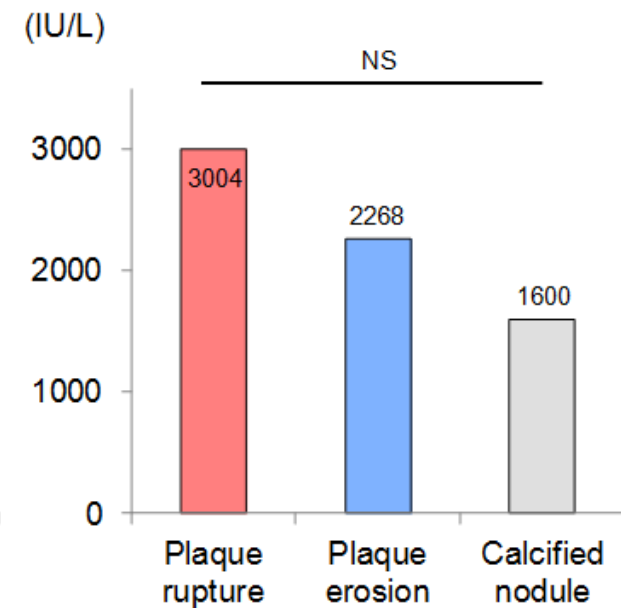
A. Myocardial brush grade ≤ 1



B. No reflow



C. Peak CK



Summary

1. The incidence of erosion was 26.8% in STEMI.
2. Erosion had lower prevalence of TCFA and other features of plaque vulnerability.
3. Erosion had more eccentric plaques with more constrictive remodeling.
4. Erosion had better outcome after PCI in patients with STEMI.

Morphologic Characteristics of Eroded Coronary Plaques: A Combined Angiographic, OCT, and IVUS Study

Int J Cardiol 2014

Jinwei Tian, MD, PhD

Background

- Plaque erosion accounts for 1/4 -1/3 of STEMI and acute coronary syndrome (ACS).
- Systemic milieu such as thrombogenic status and/or endothelial dysfunction may be an essential precondition for the occurrence of plaque erosion.
- However, ACS patients frequently have multiple lesions and not all plaques develop erosion resulting in occlusive thrombus formation.



Hypothesis

- Since the systemic milieu is the same, we hypothesized that plaque morphological features would be different between eroded culprit plaques (ECP) and non-eroded, non-culprit plaques (NENCP).

Angiographic findings

	ECP (n=26)	NENCP (n=43)	<i>P</i>
MLD, mm	1.42 ± 0.70	2.23 ± 0.67	<0.001
RD, mm	3.32 ± 0.76	3.43 ± 0.64	0.530
DS, %	59.7 ± 12.2	35.6 ± 14.7	<0.001
Location			
LAD	14(54)	10(23)	0.041
RCA	8(31)	22(51)	0.341
LCX	4(15)	11(26)	0.157



OCT findings

	ECP (n=26)	NENCP (n=43)	<i>P</i>
Fibrous Plaque	9(35)	13(30)	0.689
Lipid rich plaque	15(58)	23(54)	0.705
TCFA	2(8)	7(16)	0.065
FCT, μm	142 \pm 56	125 \pm 73	0.281
Maximum lipid arc, °	227 \pm 61	204 \pm 71	0.096
Lipid length, mm	9.4 \pm 6.1	9.2 \pm 4.7	0.830
Plaque rupture	0(0)	3(7)	0.285
Thrombus	22(85)	3(7)	<0.001
Calcification	10(39)	10(23)	0.165
Cholesterol crystal	10(39)	8(19)	0.045
Macrophage	18(69)	15(35)	0.009
Microvessel	17(65)	8(19)	<0.001

IVUS findings

	ECP (n=26)	NENCP (n=43)	P
Lesion segment			
Plaque burden	75.5 ± 12.1	61.5 ± 11.5	<0.001
Remodeling index	1.04 ± 0.15	0.99 ± 0.13	0.127
EEM CSA, mm²	13.0 ± 4.3	13.3 ± 5.4	0.920
Lumen CSA, mm²	2.9 ± 1.7	5.4 ± 2.8	<0.001
Max intima thickness	1.84 ± 0.59	1.35 ± 0.46	0.002
Min intima thickness	0.40 ± 0.37	0.28 ± 0.17	0.141
Plaque eccentricity	0.78 ± 0.21	0.77 ± 0.16	0.949
Proximal reference segment			
EEM CSA, mm²	13.6 ± 4.34	14.5 ± 5.49	0.654
Lumen CSA, mm²	7.03 ± 2.78	8.21 ± 3.76	0.342
Distal reference segment			
EEM CSA, mm²	11.3 ± 4.01	13.4 ± 5.29	0.246
Lumen CSA, mm²	6.35 ± 2.72	7.41 ± 3.26	0.396

	Univariate regression			Multivariable regression		
	OR	95%CI	<i>P</i>	OR	95%	<i>P</i>
LAD	3.85	1.35-10.9	0.012	5.33	1.10-25.9	0.038
Plaque burden	7.13	2.39-21.3	<0.001	14.9	2.02-110	0.008
MaxIT	2.62	0.96-7.20	0.061			
Lumen area	6.22	2.07-18.8	0.001	1.41	0.26-7.69	0.689
Microvessel	8.26	2.71-25.2	<0.001	13.4	2.42-74.2	0.003
Cholesterol crystal	2.73	0.91-8.23	0.074			
Macrophage	4.20	1.48-11.9	0.007	4.38	0.90-21.4	0.068

Conclusion

- Unlike rupture, plaque types, fibrous cap thickness, lipid content, and remodeling index did not appear to be important for plaque erosion.
- Interestingly, the location of a plaque in the LAD, microvessels, and greater plaque burden were independently related to plaque erosion.
- Our findings showed that local morphological characteristics are also important in addition to systemic biomarkers such as myeloperoxidase levels to predict the risk of plaque erosion.

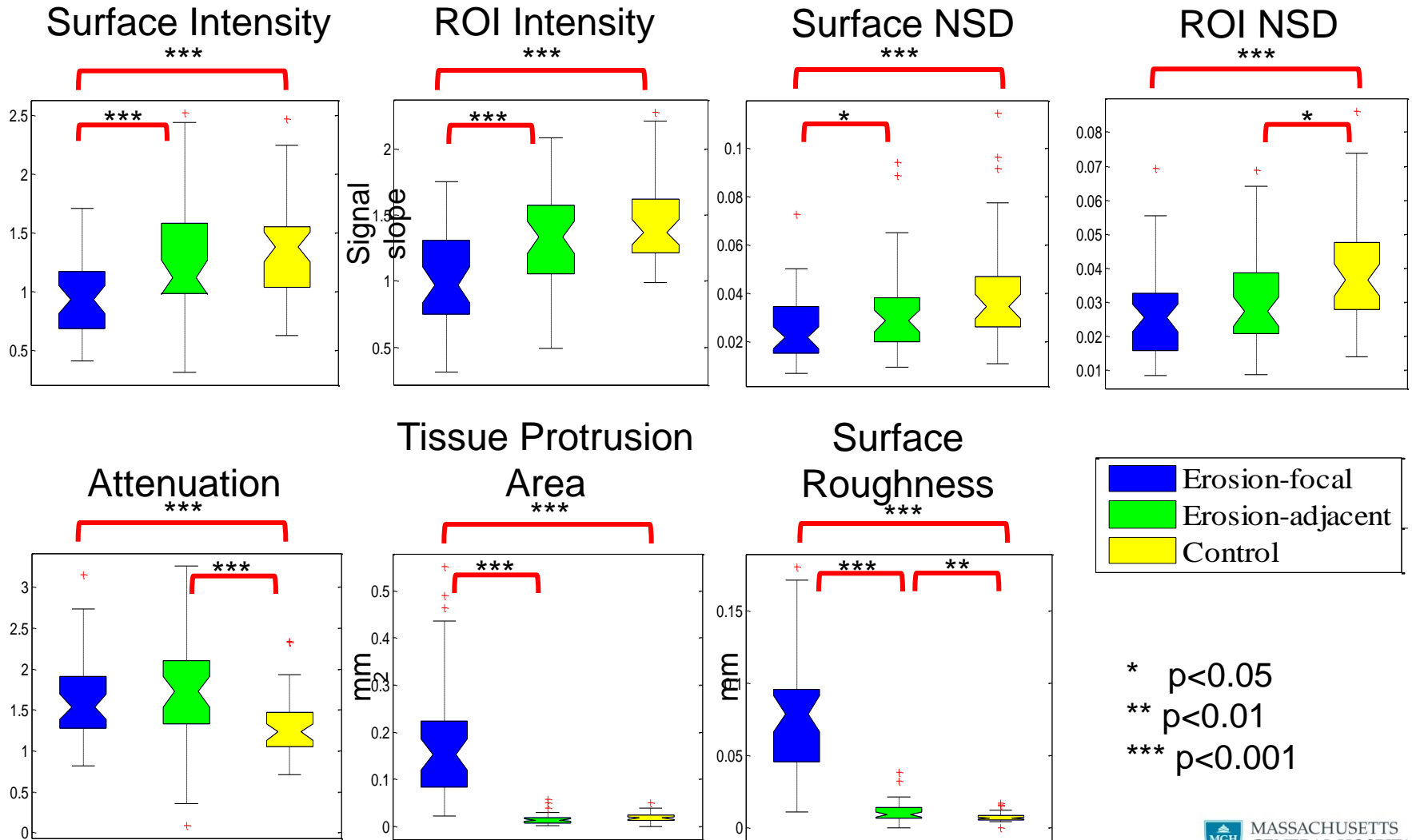


Computer Aided Imaging Analysis Algorithm to Enhance In Vivo Diagnosis of Plaque Erosion

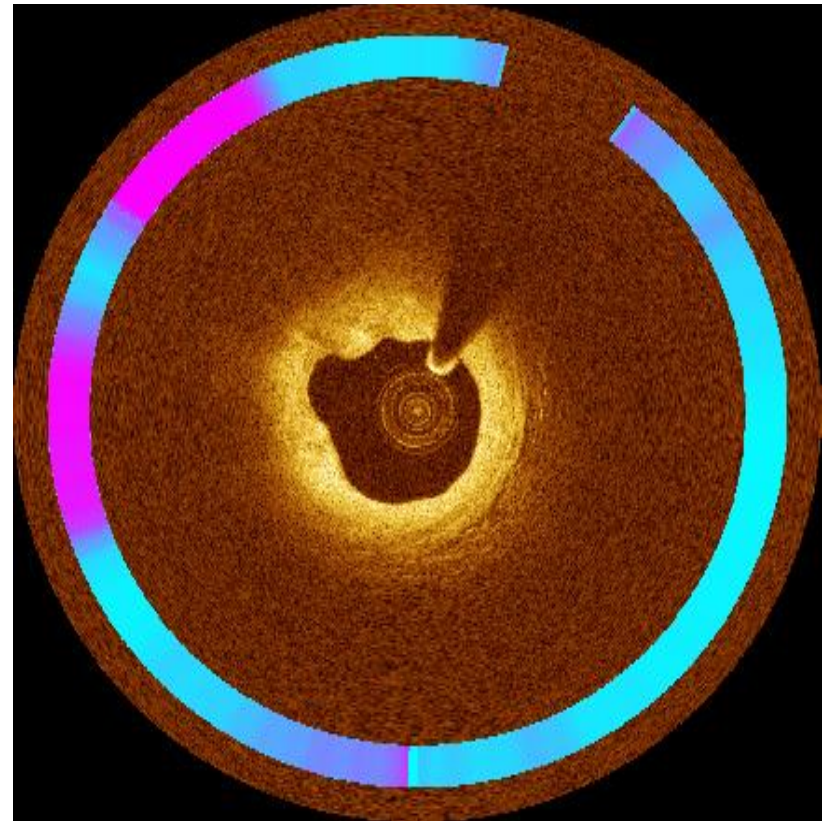
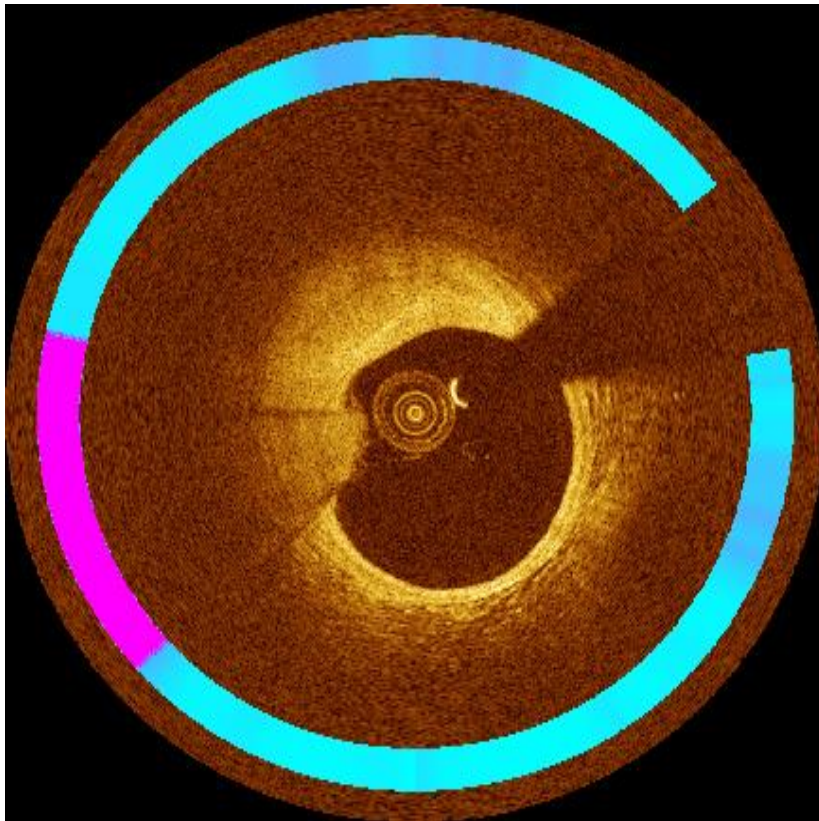
In collaboration with Prof. J. Fujimoto, MIT

Circulation CV Imag 2014

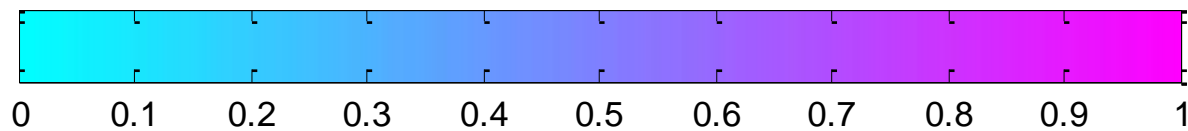
Zhao Wang, PhD



Computer Aided Diagnosis of Plaque Erosion



Likelihood
of Plaque
Erosion



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Erosion: Facts

1. Incidence *in vivo*: 27- 38%
2. Vascular integrity: better preserved
3. Lumen: larger
4. Better response to antithrombotic therapy
5. Less inflammation
6. Eccentric plaque and constrictive remodeling
7. Better outcome after PCI
8. Diagnosis became easier

Implication

1. Incidence: 27-38%

Clinically important

Implication

1. Incidence: 27-38%.
2. Vascular integrity: better preserved
3. Lumen: larger
4. Better response to antithrombotic therapy
5. Less inflammation.
6. **Pharmacologic therapy**
7. Better outcome after PCI.
8. Detection became easier.

Implication

1. Incidence: 27-38%.

2. Vascular integrity: better preserved.

PCI may be treatment of choice.

3. Lumen: larger.

4. Better response to pharmacologic

5. Less inflammation

6. Eccentric and constrictive remodeling

7. Better outcome after PCI

8. Diagnosis became easier

Implication

Optimal Treatment

Unknown

Collaborators

Registry

20 sites

MGH

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Takumi Higuma, MD, PhD

Lei Xing, MD, PhD

Erika Yamamoto, MD, PhD

Jiannan Dai, MD

Krzysztof Bryniarski, MD

Thomas Zanchin, MD

Paul Lee

Koji Kato, MD

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Sining Hu, MD

Jinwei Tian, MD

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Luigi Biasucci, MD

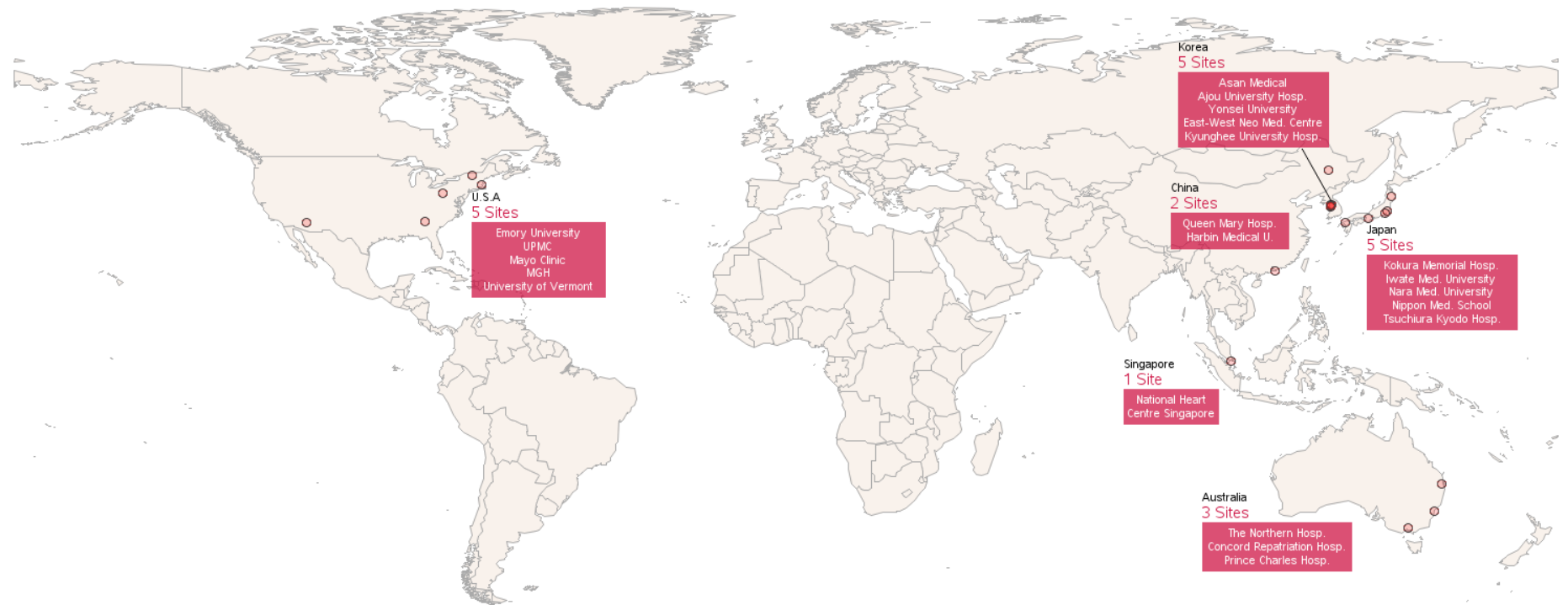


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MGH OCT Registry Sites

MGH OCT Registry Sites



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Thank You