# OCT; Comparative Imaging Results with IVUS, VH and Angioscopy

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# Comparison among coronary imaging techniques


| | OCT | IVUS | MRI | CAG | Angioscopy |
|---|---|---|---|---|---|
| **Resolution** | 10 – 15 | 80 – 120 | 80 – 300 | 100-200 | <200 |
| **Probe Size** | 140 | 700 | 1000 | N/A | 800 |
| **Contact** | No | Yes | No | No | No |
| **Ionizing Radiation** | No | No | No | Yes | No |
| **Other** | **Tissue Characterization** | N/A | N/A | Flow Only | Surface Only |

**Advantages of OCT are its high resolution and accuracy of tissue characterization.**

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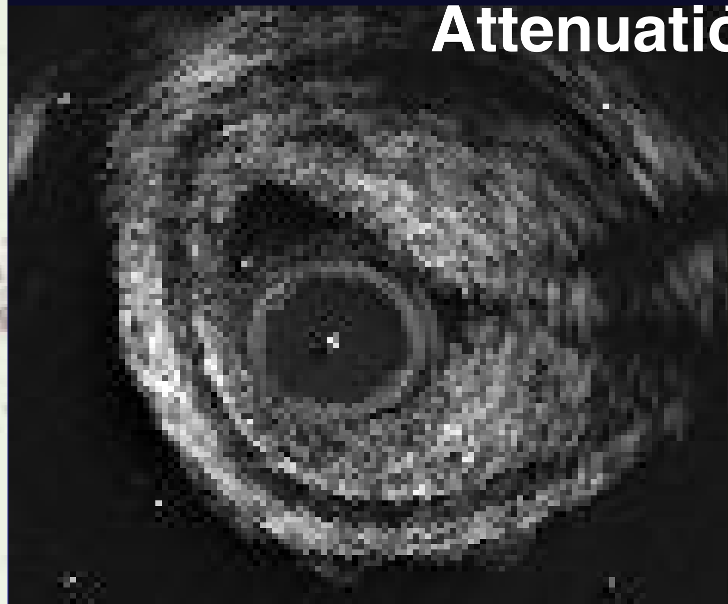
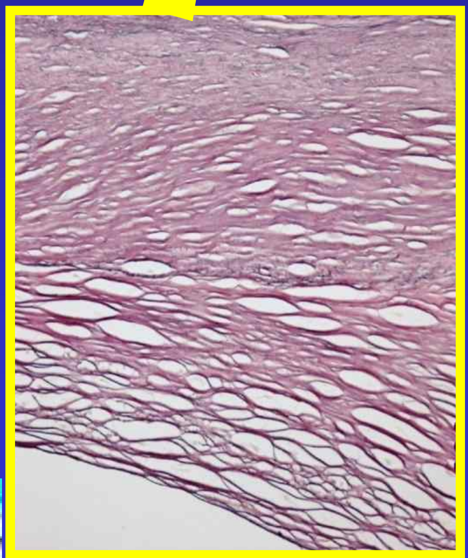
# Intracoronary Imaging
# Comparison among OCT, IVUS, VH & Angioscopy

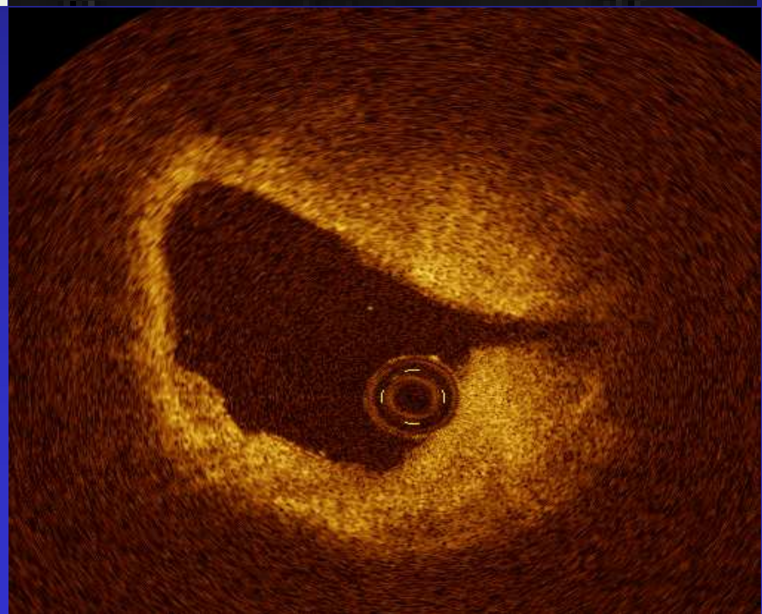
- Tissue characterization: comparison with histology
- Vulnerable plaque identification
- Stent follow-up

# Fibrous plaque

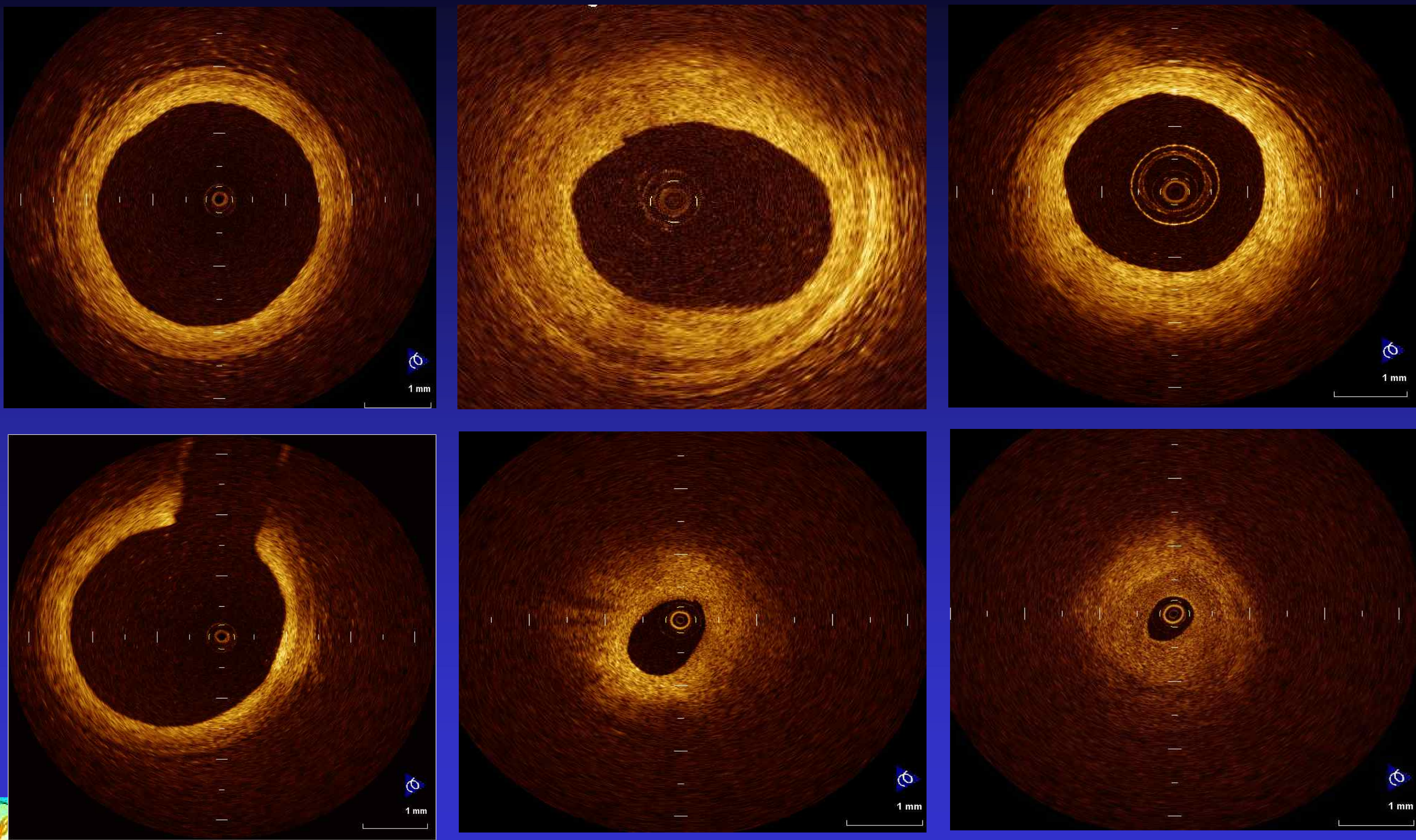
Attenuation



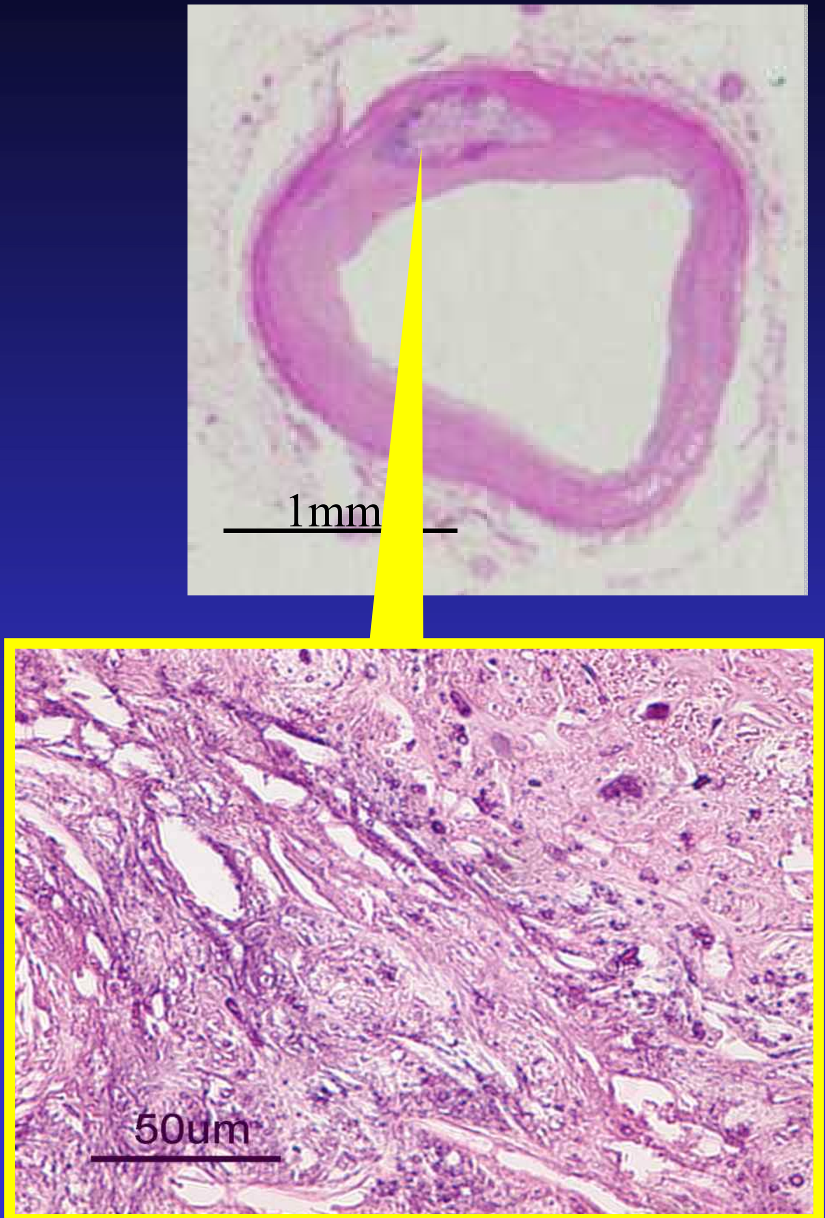


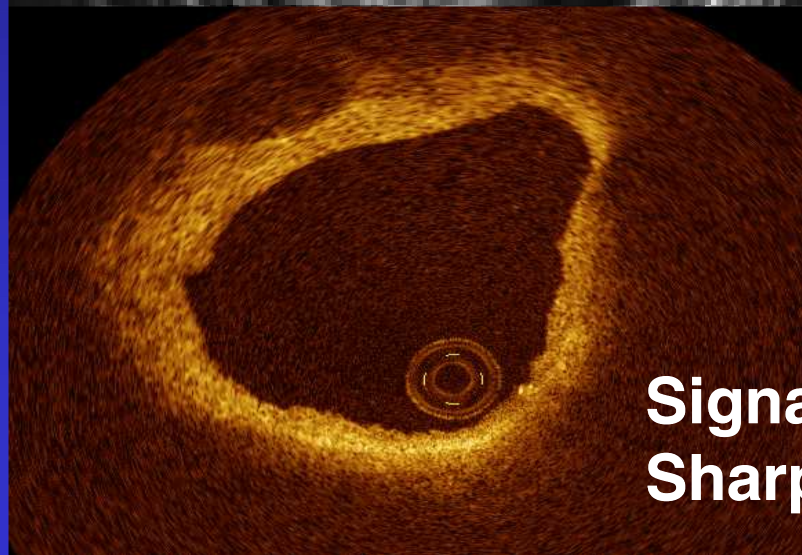
Signal rich
Diffuse border

# Fibrous plaque



# Fibrocalcific plaque



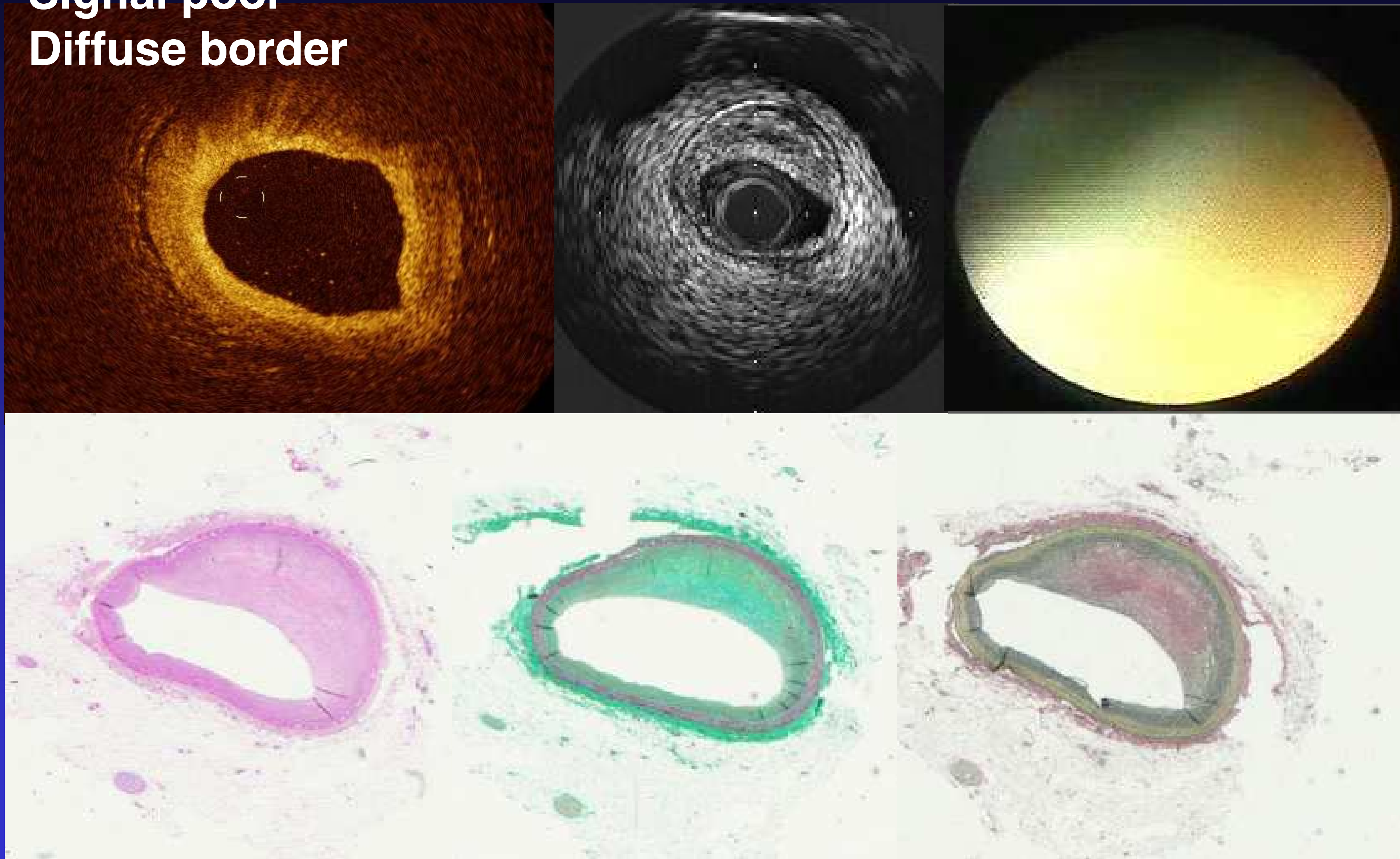



Signal poor
Sharp border

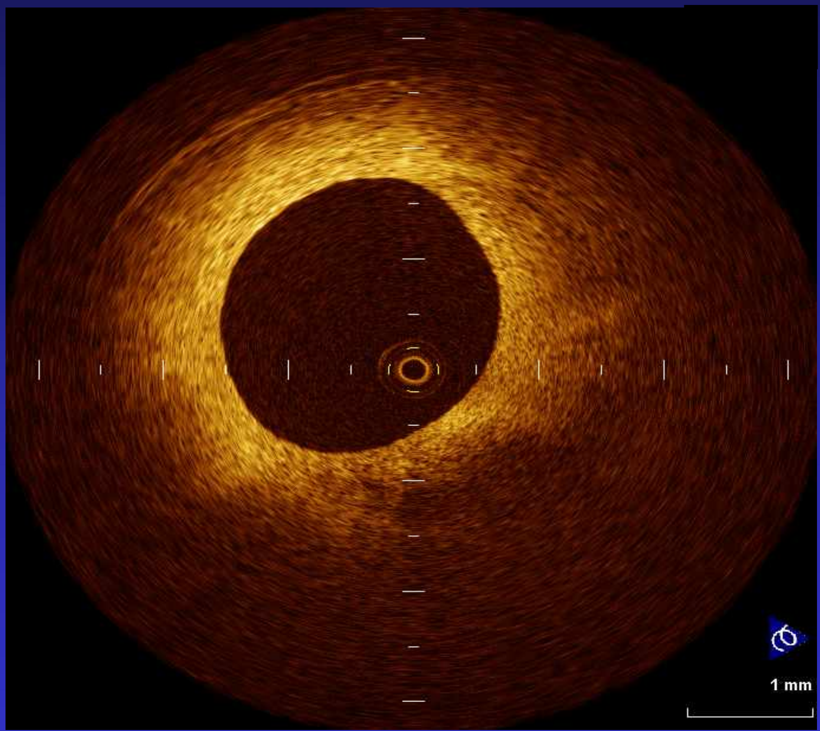
# Calcified plaque

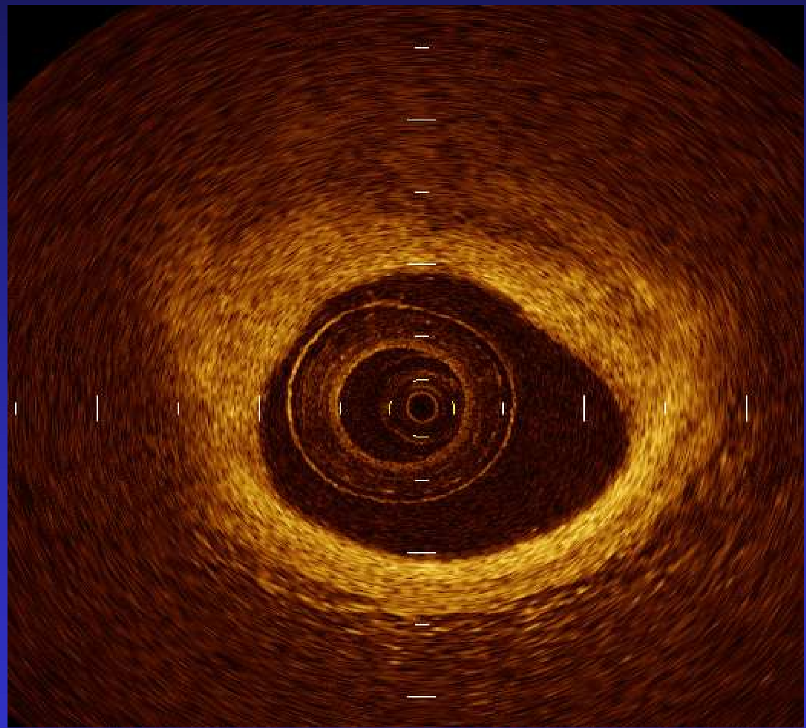
## Superficial calcified nodule

# Fibro-lipidic plaque

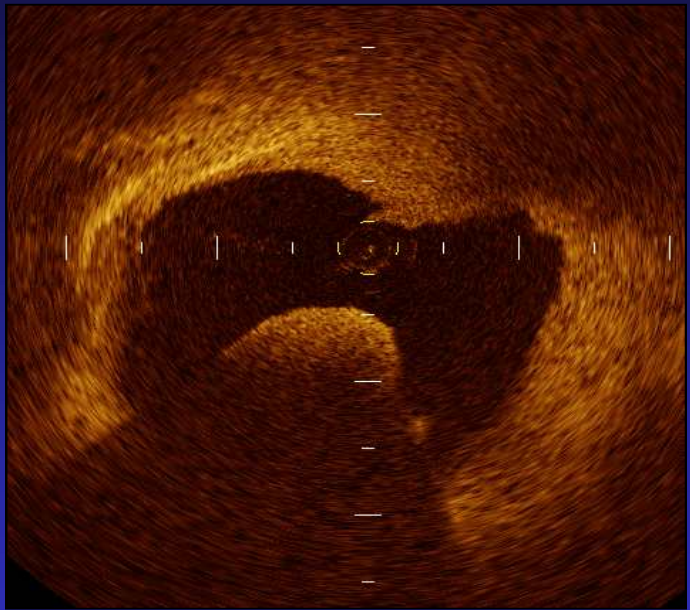


# Fibrofatty plaque



# Red & white thrombus

| Red thrombus | White thrombus | Mixed thrombus |
| --- | --- | --- |
|  |  |  |
| Protrusion mass with shadow | Protrusion mass without shadow | Protrusion mass with & without shadow |

Kume T, Akasaka T, et al ( Am J Cardiol 97:1713-1717 , 2006 )
Kubo T, Akasaka T, et al. ( J Am Coll Cardiol 50:933-939,2007)

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# Thrombus


OCT CAS IVUS

# *Accuracy of intra-coronary OCT for differentiation between red and white thrombus*

| | | Angioscopy | |
|---|---|---|---|
| | | Red thrombus | White thrombus |
| OCT | Intensity half distance ＜250μm | 18 | 3 |
| | Intensity half distance ≧250μm | 1 | 21 |

*Sensitivity = 95%*

*Specificity = 88%*

*Positive predictive value = 86%*

*Negative predictive value =95%*

# Intracoronary Imaging
# Comparison among OCT, IVUS & Angioscopy

- Tissue characterization: comparison with histology
- Vulnerable plaque identification
- Stent follow-up

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# Study Design

Oral aspirin (162 mg) and intravenous heparin (100 U/kg) were administered before PCI.

Cardiac catheterization was performed by the femoral approach, using a 7F sheath and catheters.

- **Thrombectomy** ***(Export catheter ® Medtronic Japan)***

  ↓ **TIMI grade III**

- **IVUS** ***(Atlantis SR Pro® 2.5F, 40-MHz; Boston Scientific, Natick, MA, USA)***

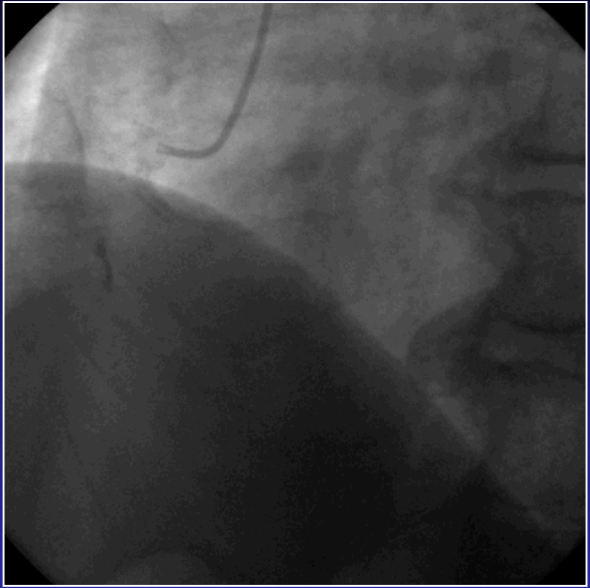
  ↓

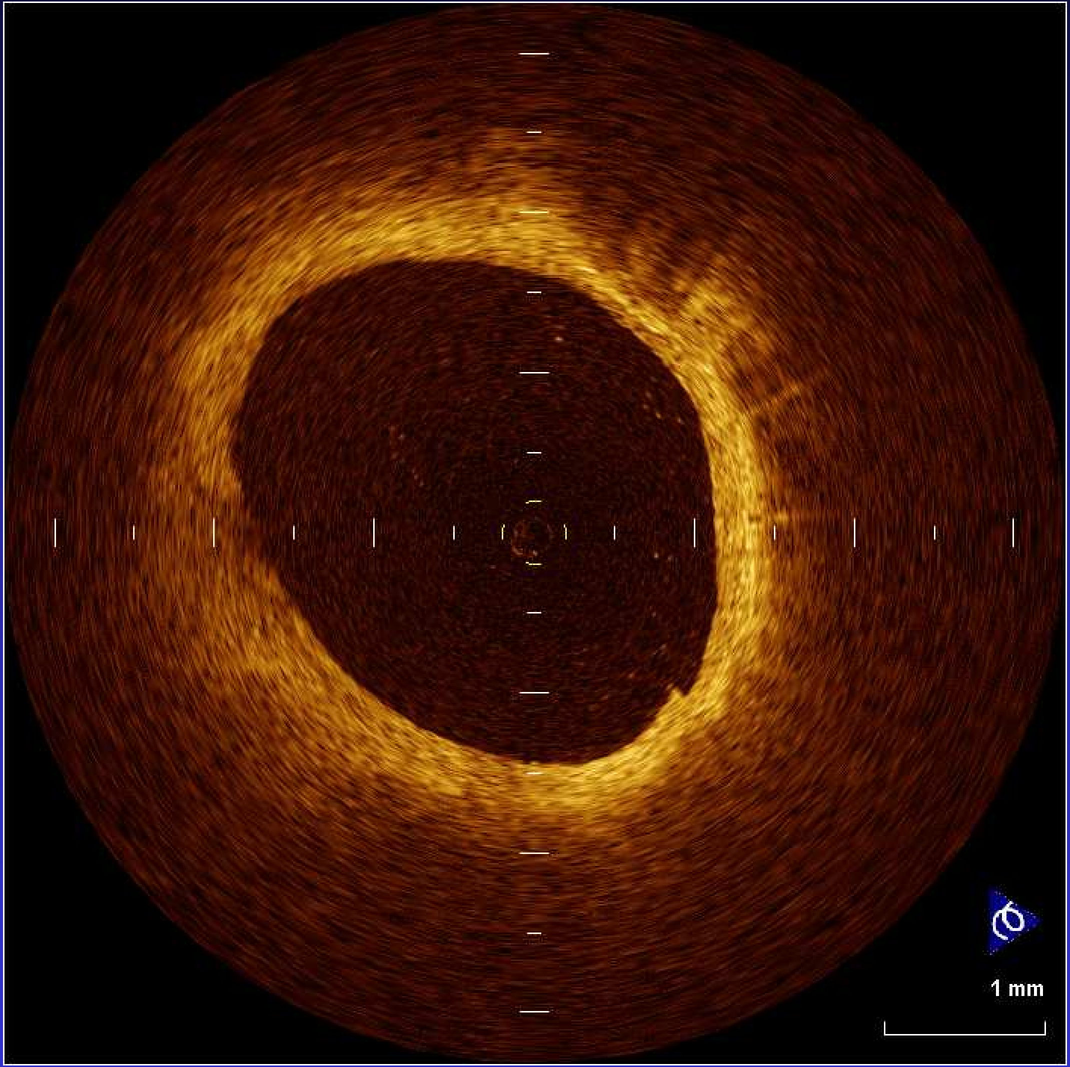
- **CAS** ***(Angioscope MC-800E and the optic fiber AS-003, Nihon Kohden)***

  ↓

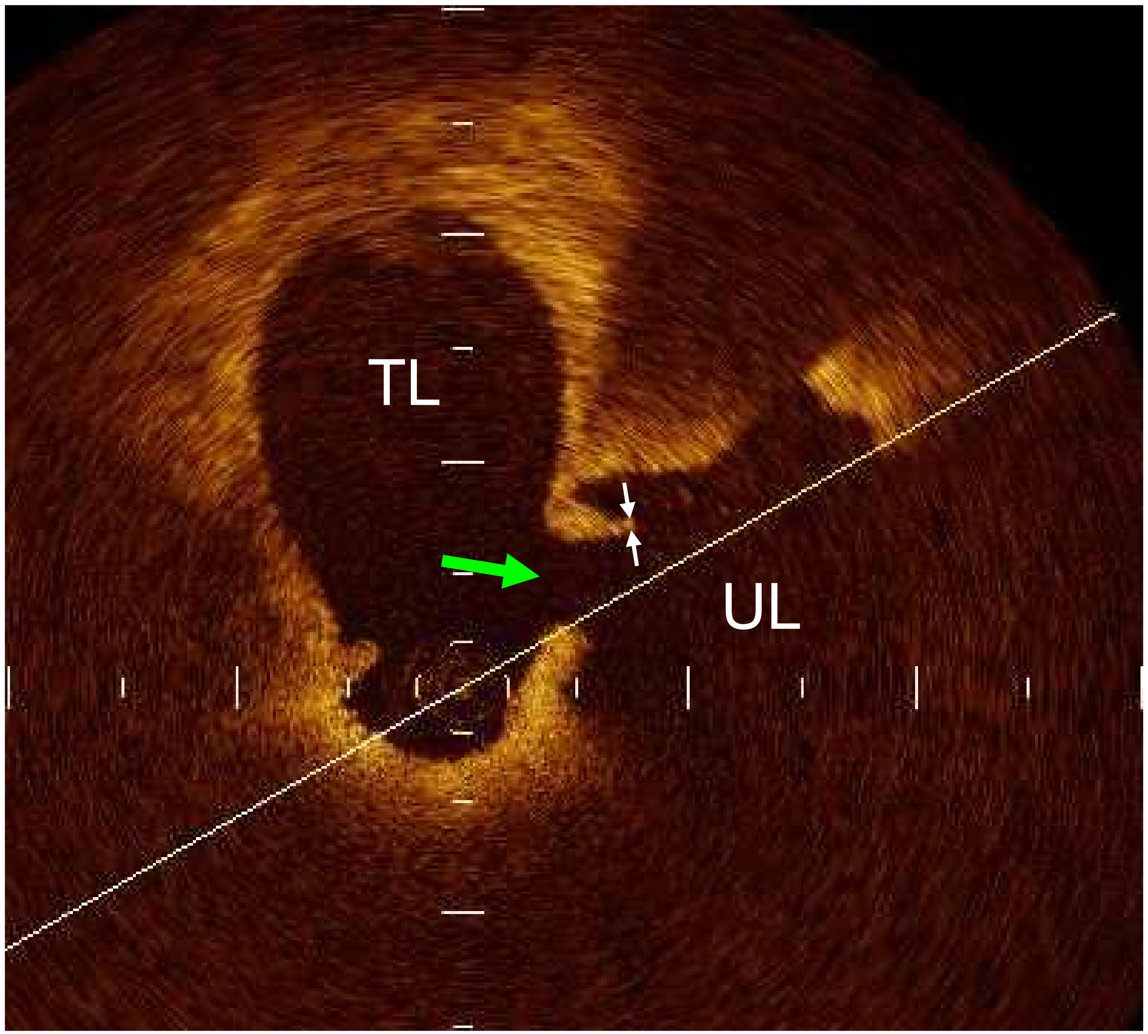
- **OCT** ***(ImageWire®; LightLab Imaging, Westford, MA, USA)***

# Inferior AMI (71y.o. Male)



# Inferior-AMI（71y.o., M） Plaque Rupture

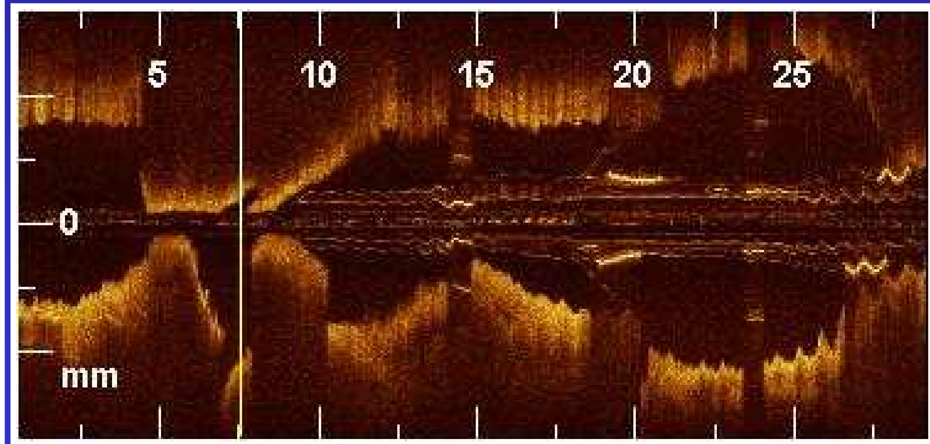



Ruptured Fibrous Cap

Fibrous Cap Thickness = 40μm

TL : True Lumen

UL : Ulceration

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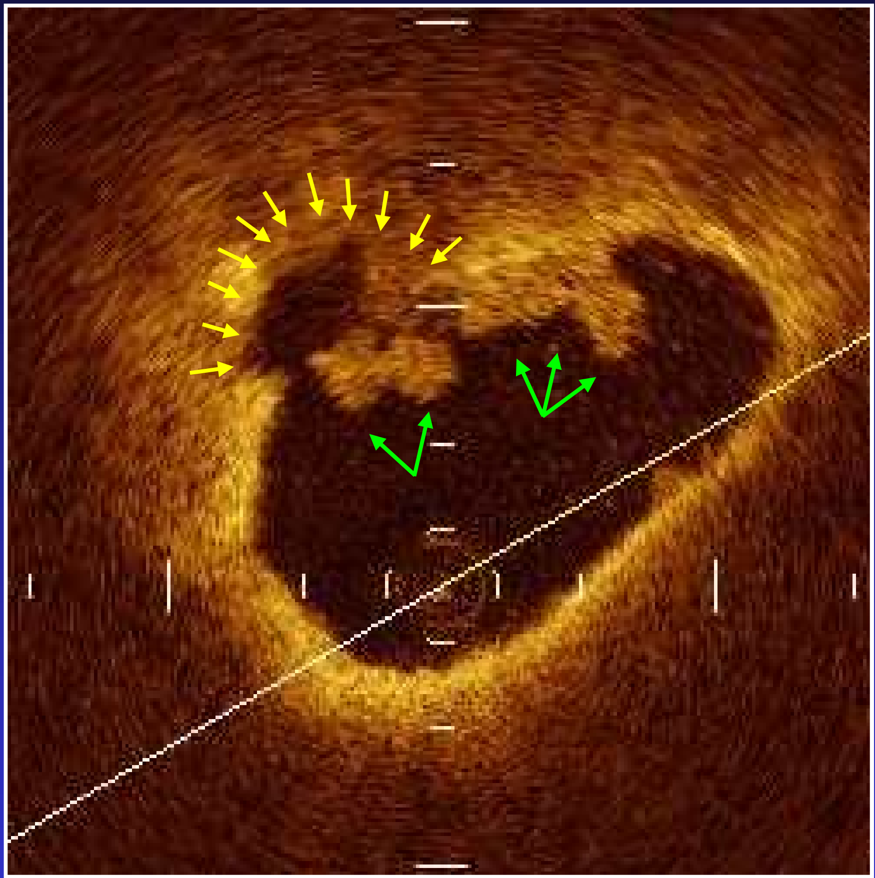
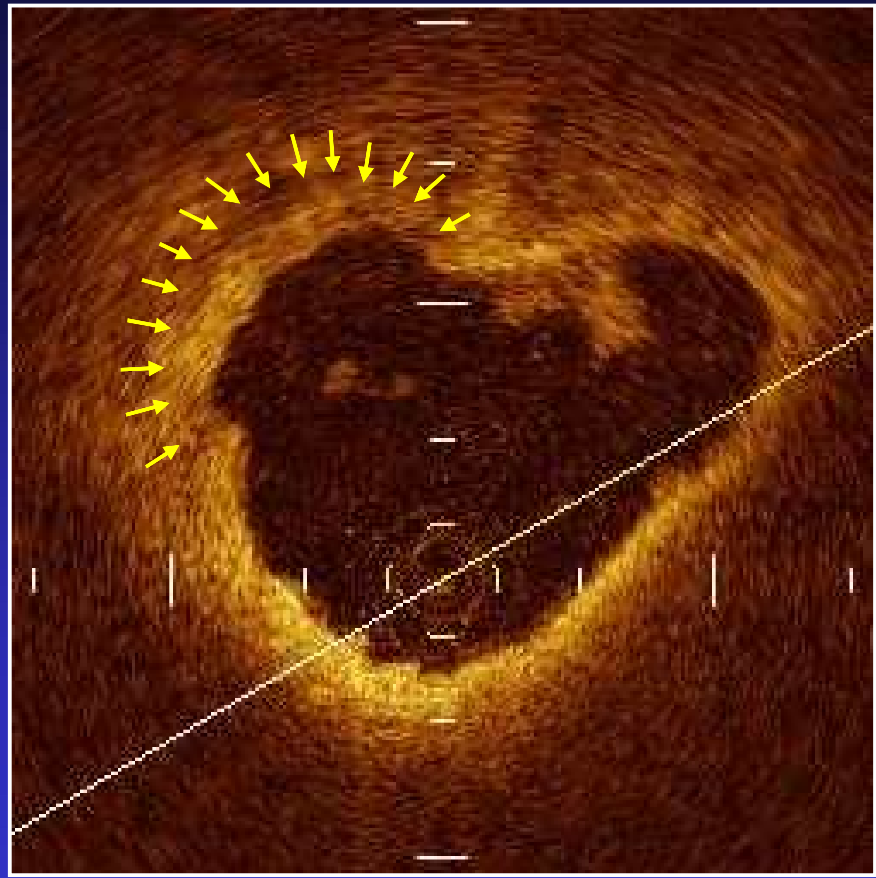
# Anteroseptal AMI （80y.o., M）





**Erosion (Ulceration)**

**Thrombus**

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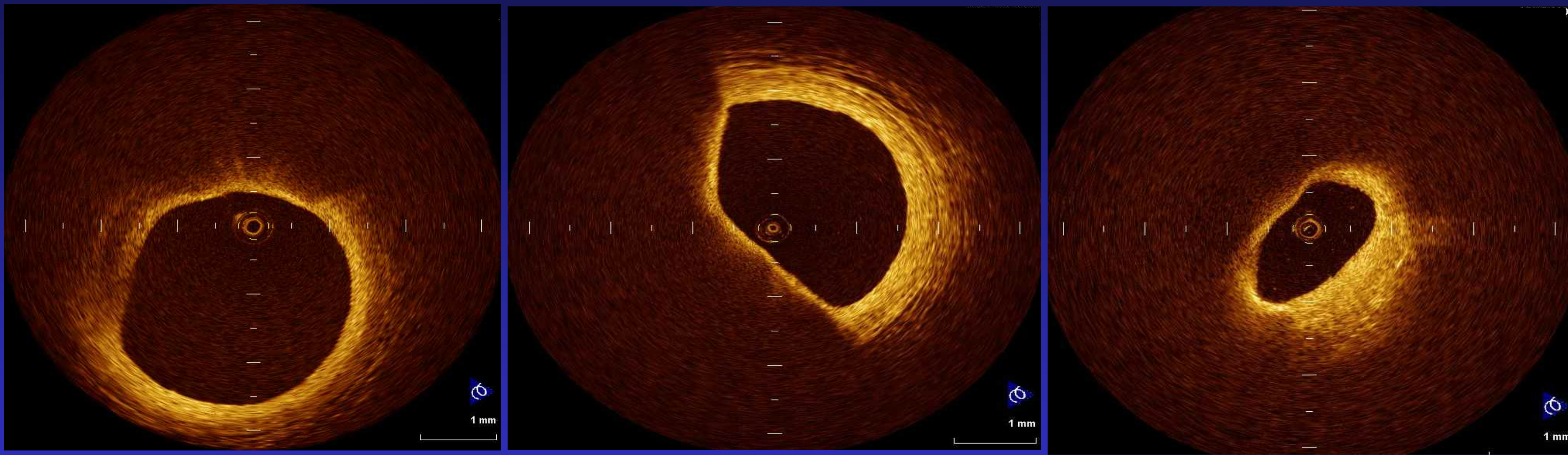
# Comparison of plaque Images in AMI (OCT vs. CAS vs. IVUS) n=30

（Kubo T, Akasaka T, et al. J Am Coll Cardiol in press）

| | OCT | *CAS | **IVUS | **p* | ***p* |
|---|---|---|---|---|---|
| Plaque Rupture (%) | 73 | 47 | 40 | 0.035 | 0.009 |
| Ulceration (erosion) (%) | 23 | 3 | 0 | 0.022 | 0.005 |
| Thrombus (%) | 100 | 100 | 33 | 1.000 | <0.001 |
| Red thrombus (%) | 100 | 90 | - | 0.076 | - |
| White thrombus (%) | 100 | 93 | - | 0.150 | - |
| TCFA（≦65μm） (%) | 83 | - | - | - | - |
| Fibrous cap thickness (μm) | 49±21 | - | - | - | - |
| LRP (Lipid Arch＞180° ) (%) | 83 | - | 67 | - | NS |

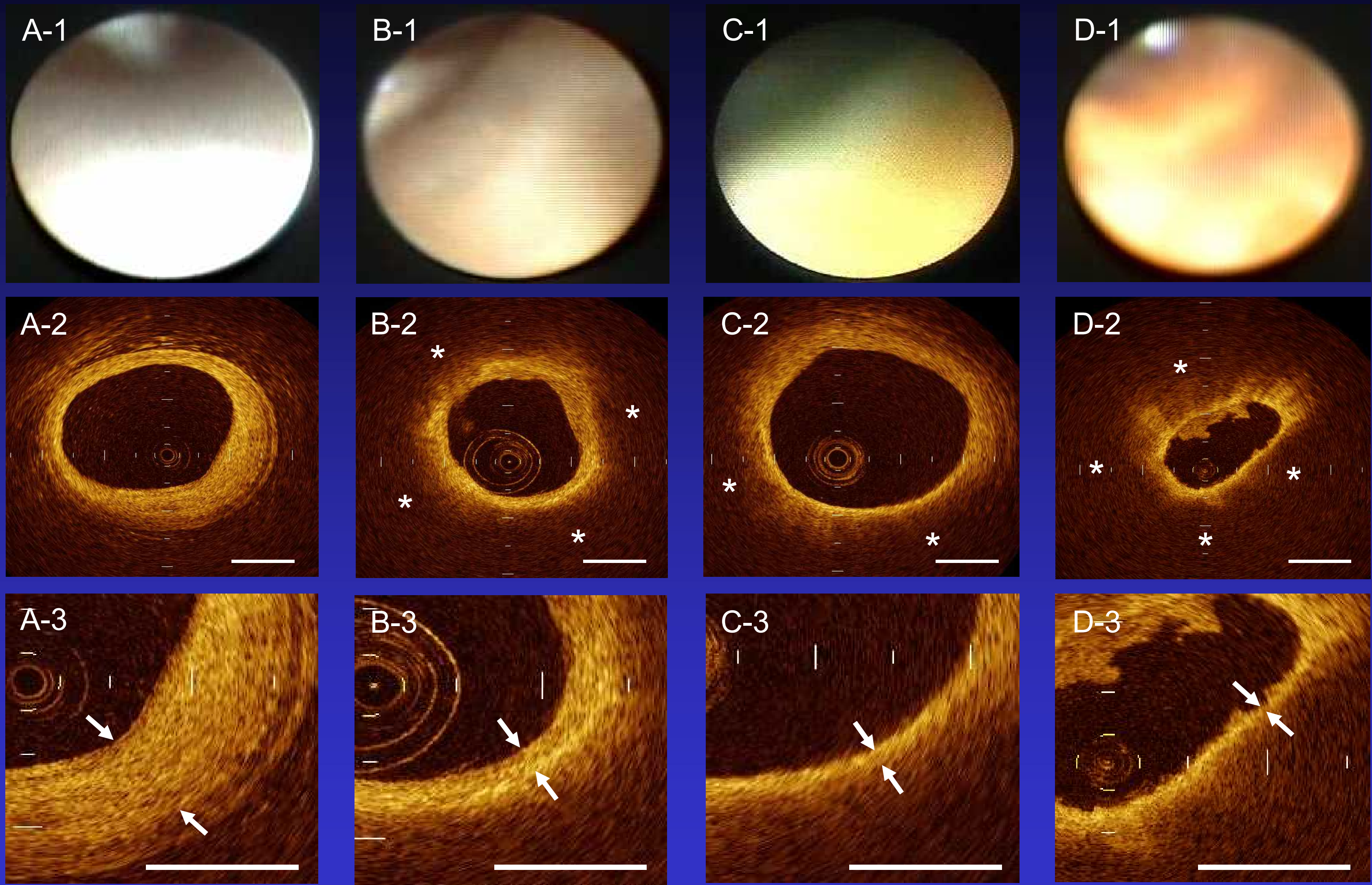
TCFA; Thin Cap Fibro-Atheroma, LRP; Lipid Rich Plaque

# Thin-cap fibroatheroma (TCFA)




**Possibility to identify TCFA has been demonstrated by several pilot studies.**

# Corresponding Images of OCT and Angioscopy

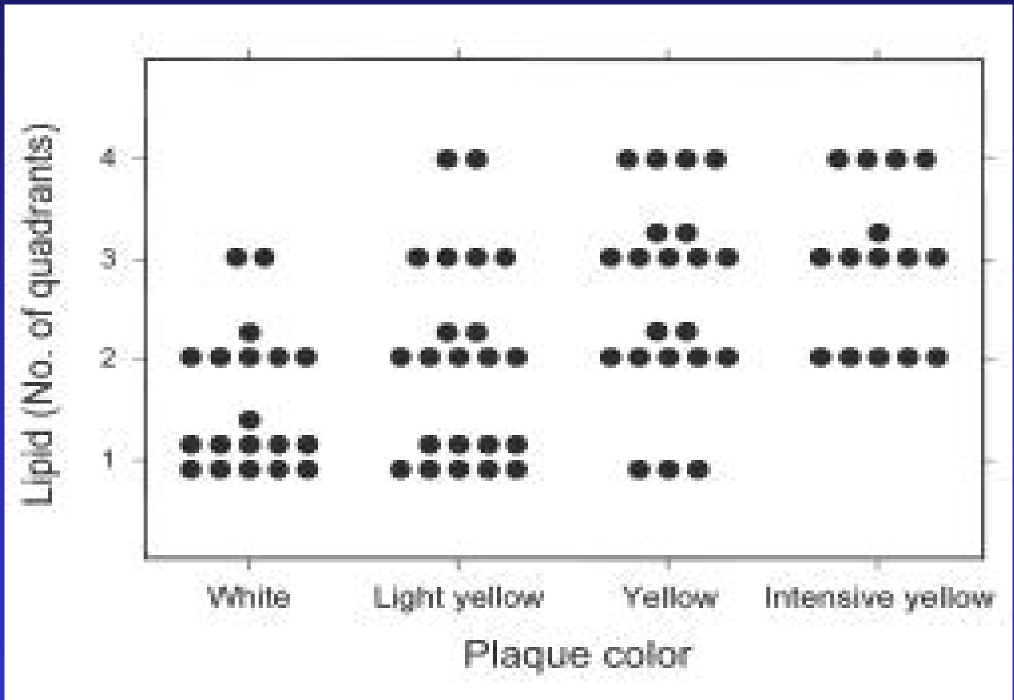



（Kubo T, et al. J Am Coll Cardiol Intv 1:74-80,2008）

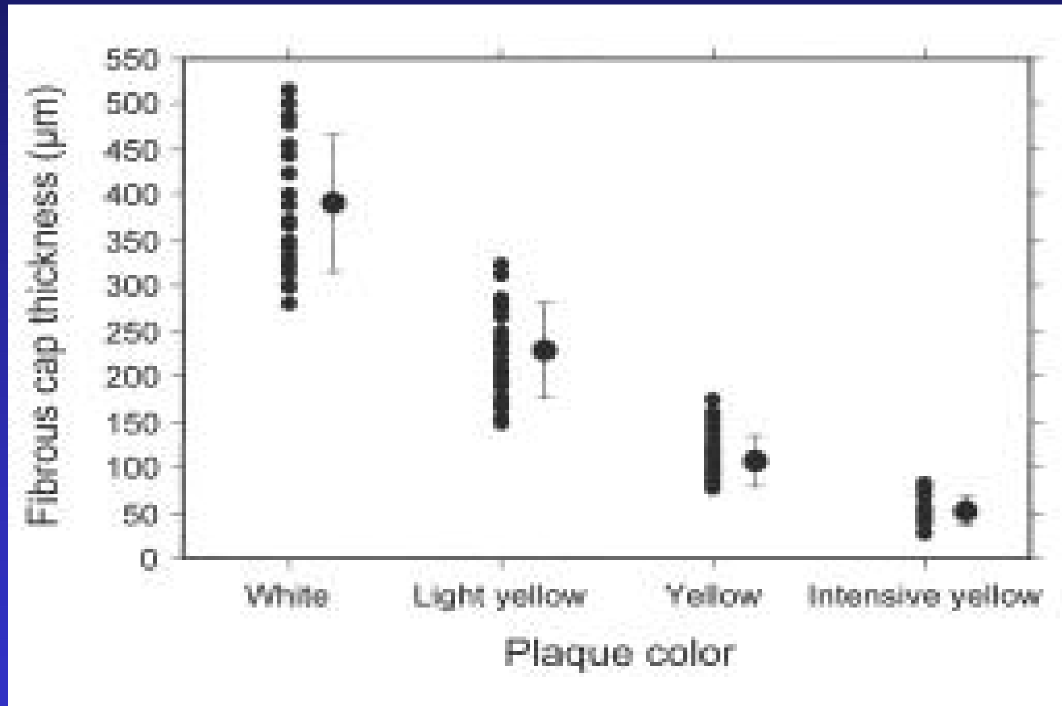
Figure. 1

# Angioscopy vs OCT

## Plaque color vs lipid size




## Plaque color vs fibrous cap thickness




（Kubo T, et al. J Am Coll Cardiol Intv 1:74-80,2008）

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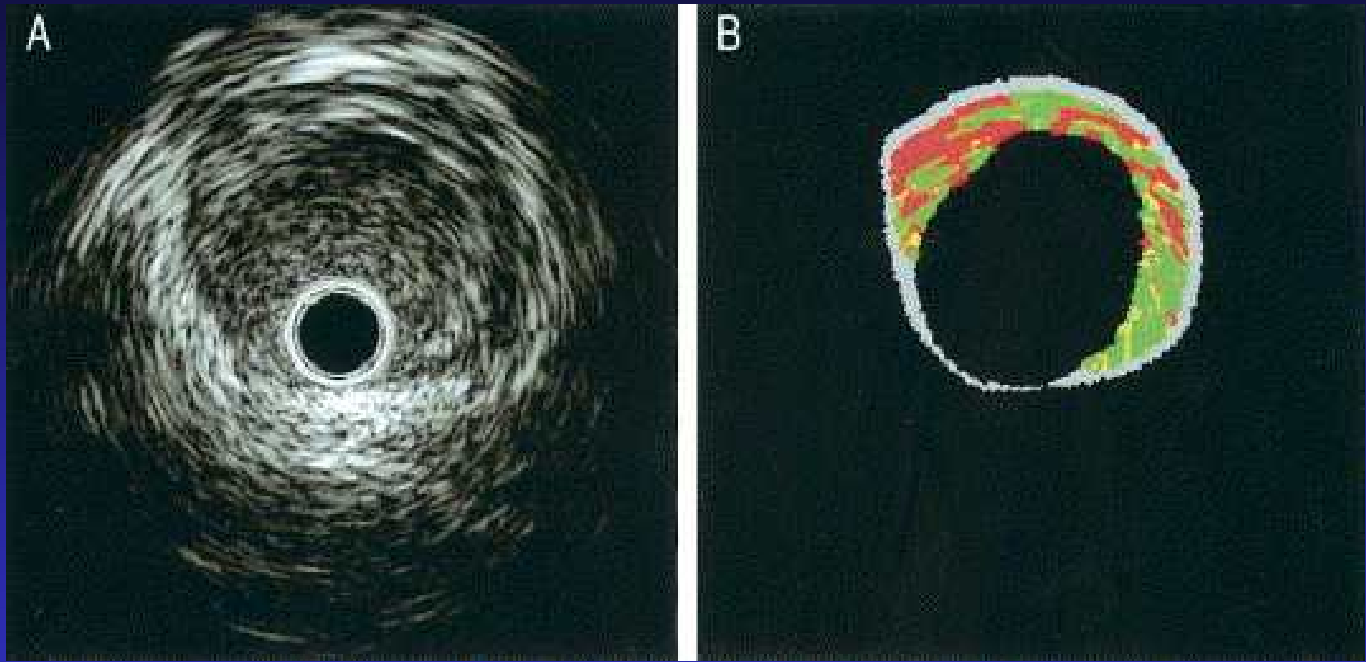
# IVUS-derived TCFA

( Rodriguez-Granillo GA, et al. J Am Coll Cardiol 46:2038-2042, 2005 )

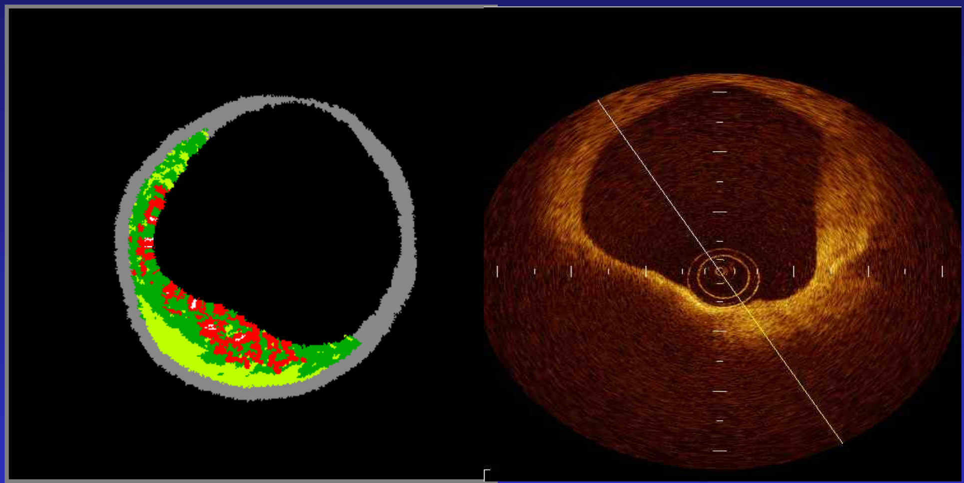



- Percent atheroma volume = (EEM area – Lumen area)/EEM area x100≧40%
- Nectrotic core≧10%
- Without evident overlying fibrous tissue

# VH-IVUS vs OCT

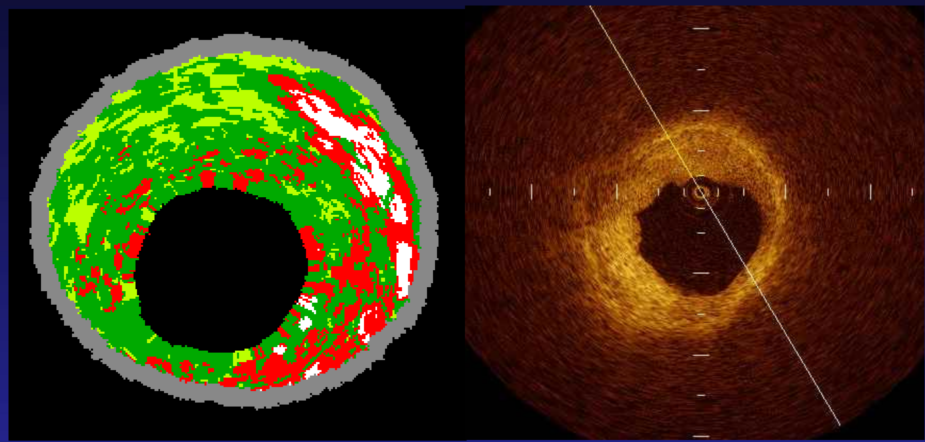
Figure 2

## Concordant

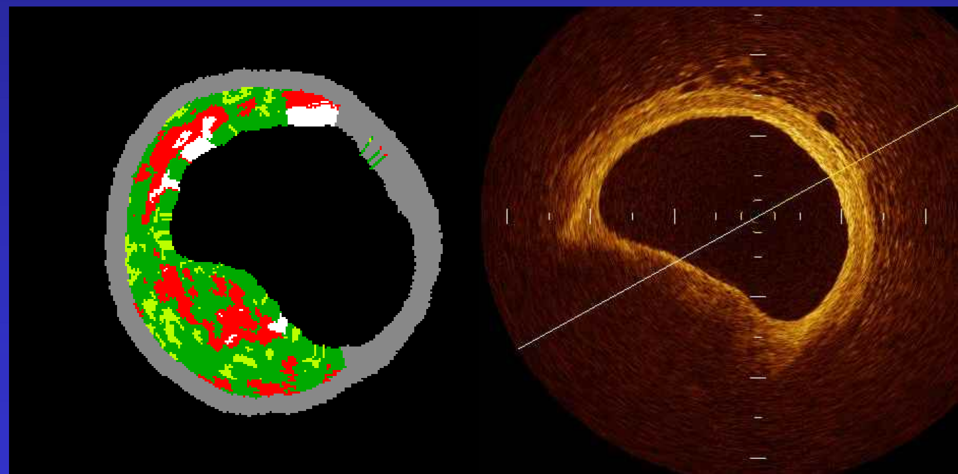


**Without evident overlying fibrous tissue**

## Discordant



**Without evident overlying fibrous tissue**



**With evident overlying fibrous tissue**

# Concordance & discordance between VH-IVUS and OCT in the assessment of TCFA

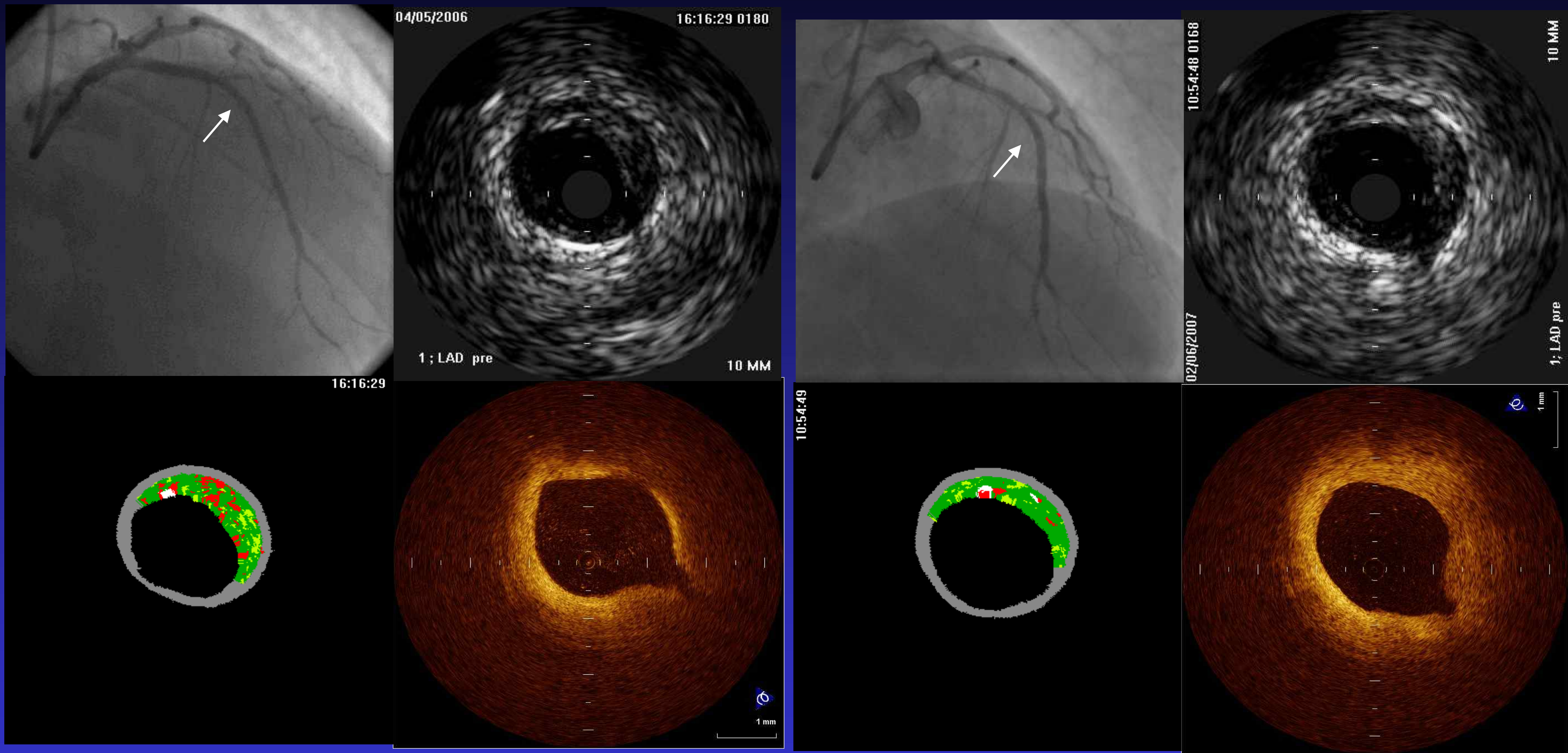
Table 4

| IVUS-VH Diagnosis \ OCT Diagnosis | TCFA (n=11) | Not TCFA (n=36) |
|---|---|---|
| VH-TCFA (n=31) | 9 | 22 |
| Not VH-TCFA (n=16) | 2 | 14 |

Discordance between VH-IVUS & OCT has been described by Sawada T, et al. (Eur Heart J 29:1136-1146, 2008)

# *OCT assessment of non-culprit lesion (47y.o. male)*

## Baseline | 9 month later




| | Baseline | | 9 month later | |
|---|---|---|---|---|
| Lumen Area | 6.1 $mm^2$ | | 8.0 $mm^2$ | |
| EEL Area | 12.3 $mm^2$ | | 14.4 $mm^2$ | |
| Plaque Area | 6.2 $mm^2$ | | 6.4 $mm^2$ | |
| %plaque burden | 50% | | 44% | |
| FI Green Area | 2.1 $mm^2$ | 68% | 2.5 $mm^2$ | 84% |
| FF Light green Area | 0.4 $mm^2$ | 12% | 0.3 $mm^2$ | 9% |
| DC White Area | 0.1 $mm^2$ | 2% | 0.1 $mm^2$ | 3% |
| NC Red area | 0.6 $mm^2$ | 18% | 0.1 $mm^2$ | 4% |

（Takarada S, et al.
Atherosclerosis
202:491-497, 2009）

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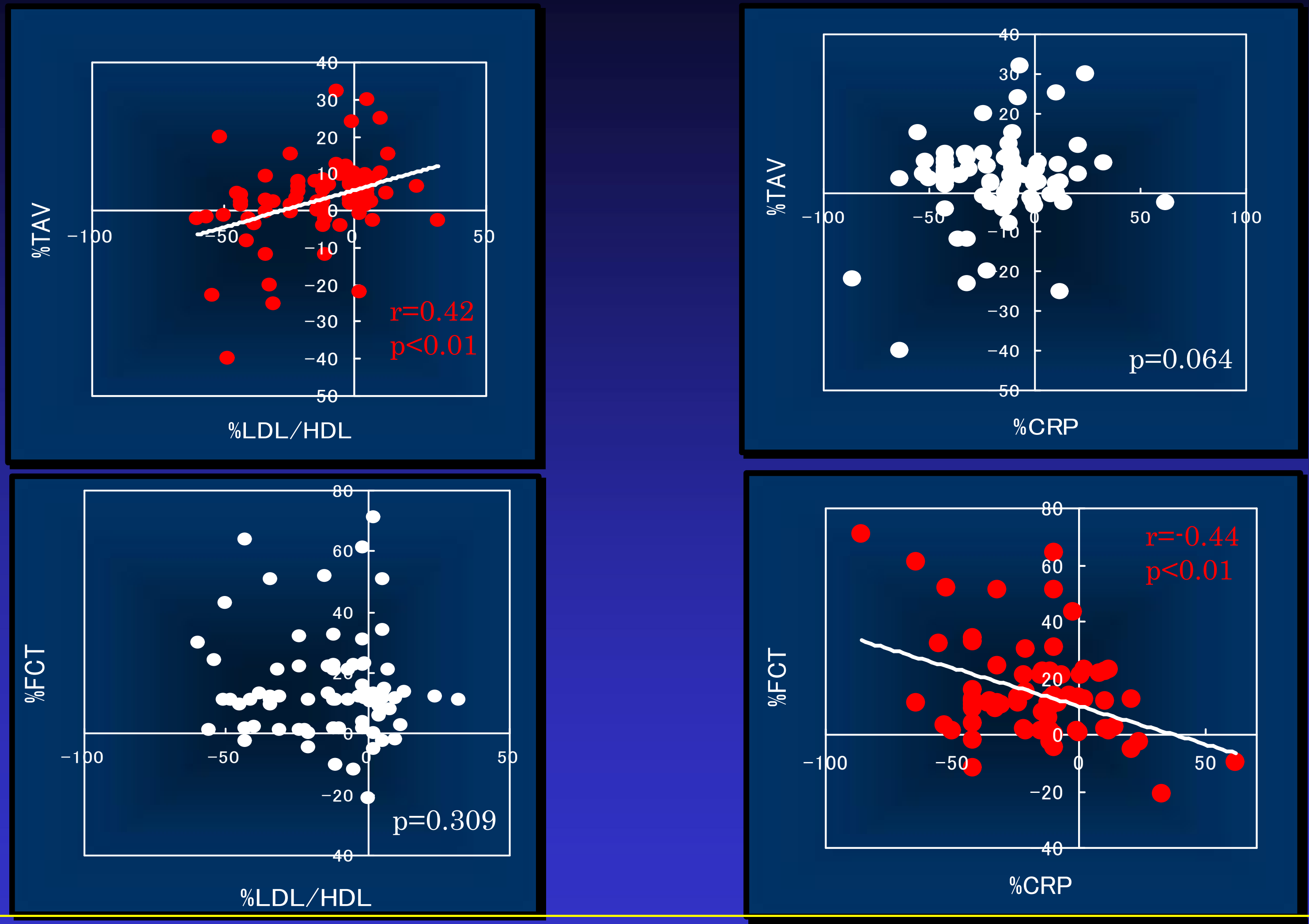
# Changes of plaque characteristics by statin

(Takarada S, et al. Atherosclerosis 202: 491-497, 2009)

| | Baseline | Follow-up | p |
|---|---|---|---|
| **Statin group** | | | |
| Fibrous cap thickness (μm) | 114±83 | 162±75 | <0.01 |
| Lipid arc (degrees) | 132±37 | 116±23 | <0.01 |
| **Non-statin group** | | | |
| Fibrous cap thickness (μm) | 117±78 | 129±54 | ns |
| Lipid arc (degrees) | 129±37 | 128±28 | ns |

# The correlation between the lipid profile and the % change of fibrous-cap thickness (FCT) and total atheroma volume (TAV).




**%TAV and %LDL/HDL were positively correlated (p<0.01, r = 0.42).**
**%FCT and %CRP were inversely correlated (p<0.01, r = -0.44).**

（Takarada S, et al. JACC Interv. 2010, in press ）

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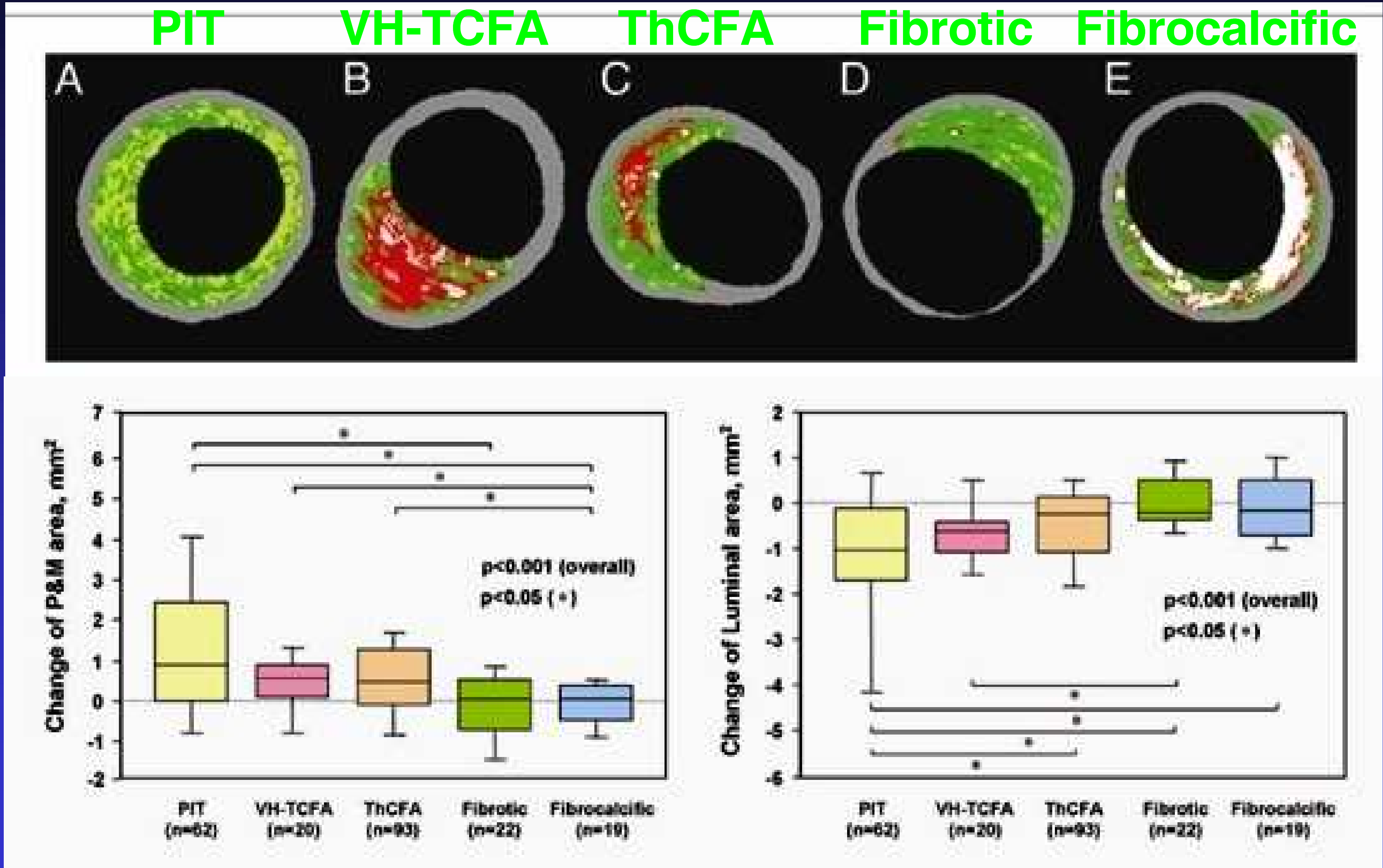
# Changes of plaque, media & lumen area




( Kubo T, et al. J Am Coll Cardiol 55;1590-1597, 2010 )

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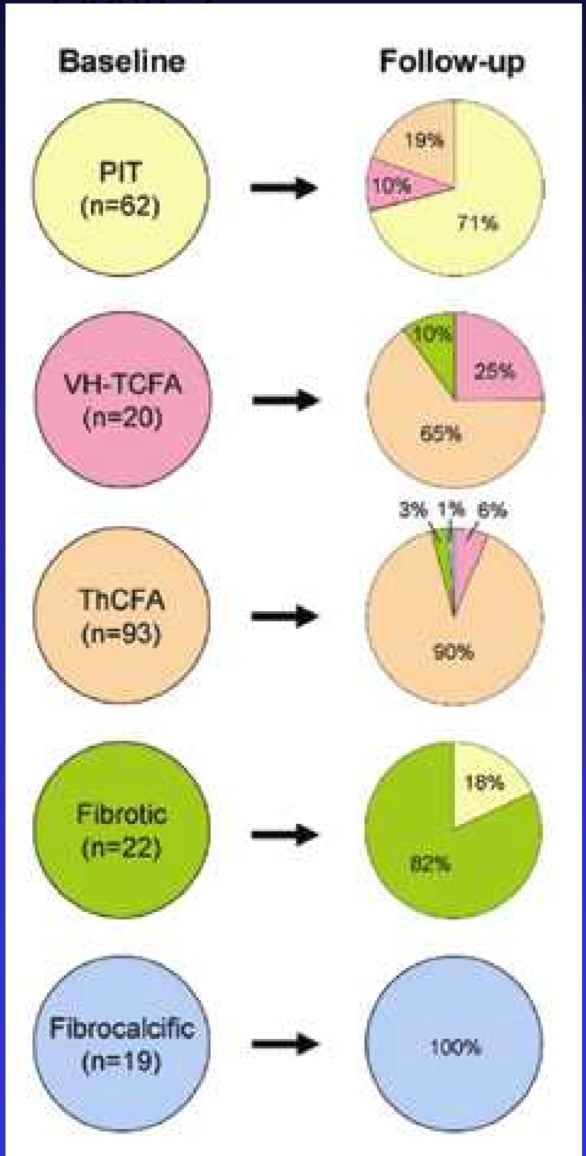
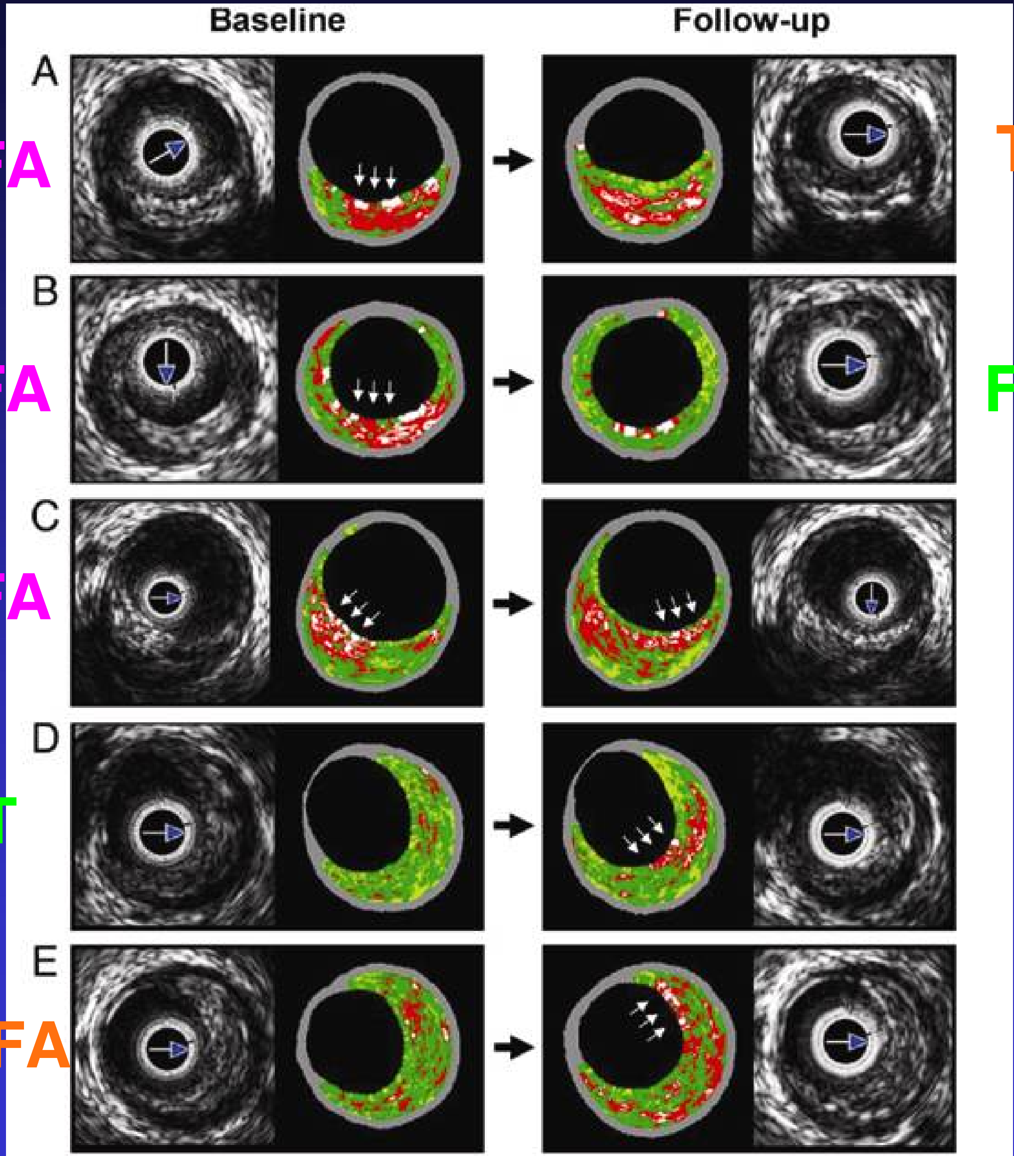
# Coronary lesion morphology by VH-IVUS

( Kubo T, et al. J Am Coll Cardiol 55;1590-1597, 2010 )

Figure 2

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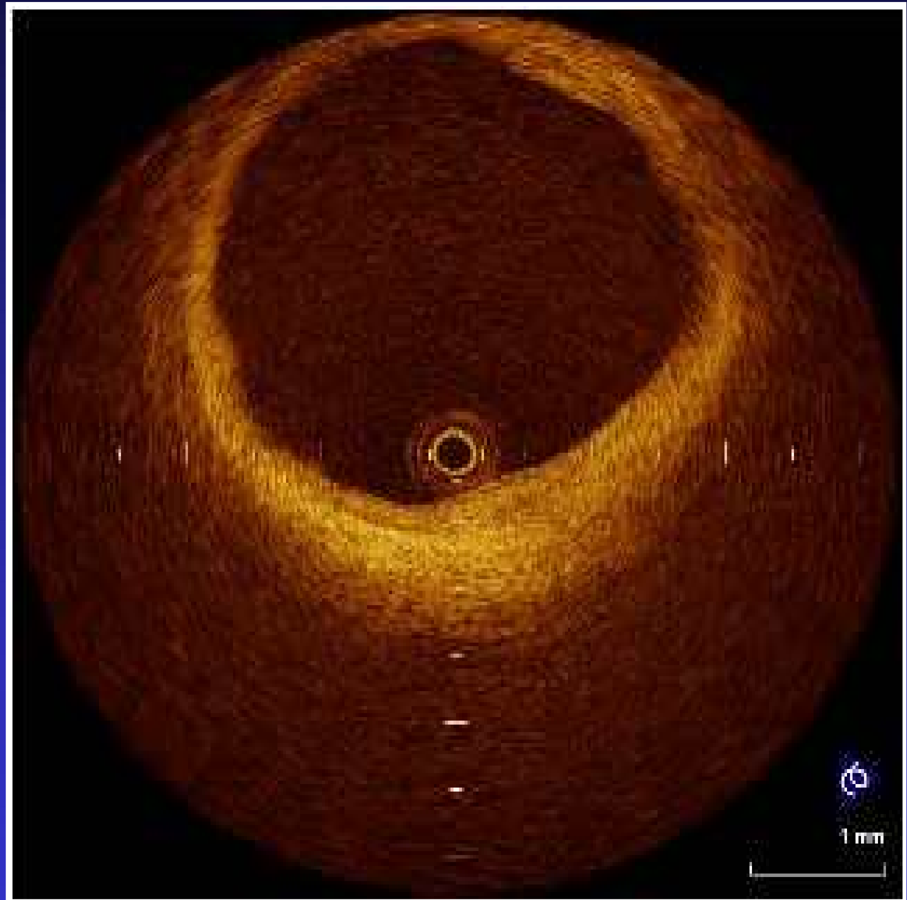
# Intracoronary Imaging
# Comparison among OCT, IVUS & Angioscopy

- Tissue characterization: comparison with histology
- Vulnerable plaque identification
- Stent follow-up

# ACS; 69 y.o. M #6 Cypher 3.5 x 18 mm

Post PCI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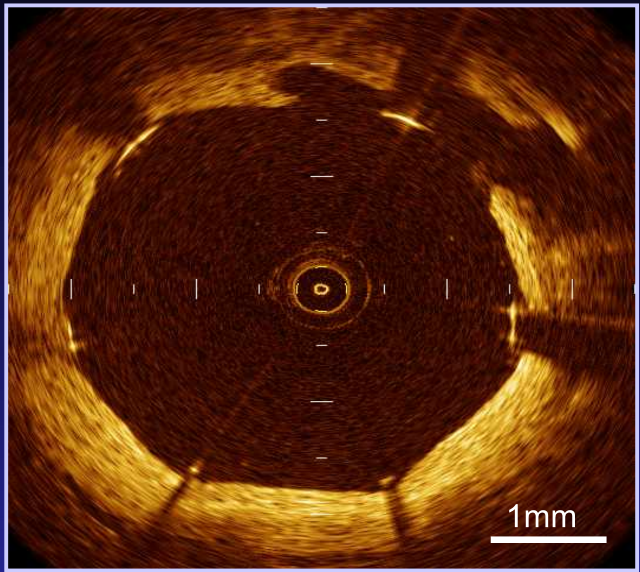
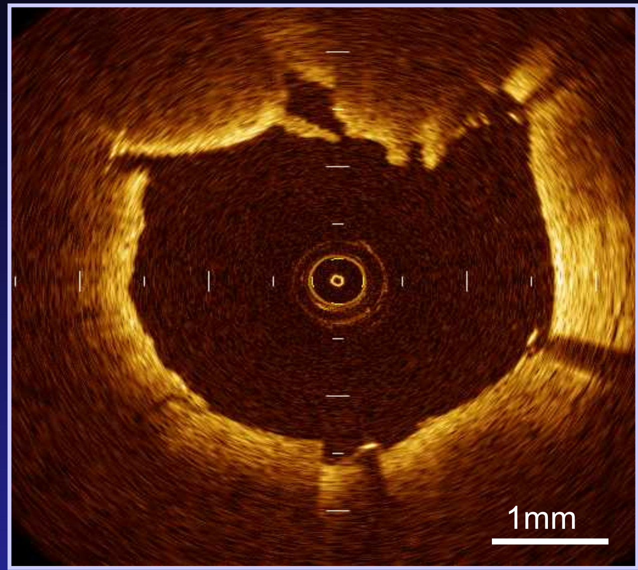
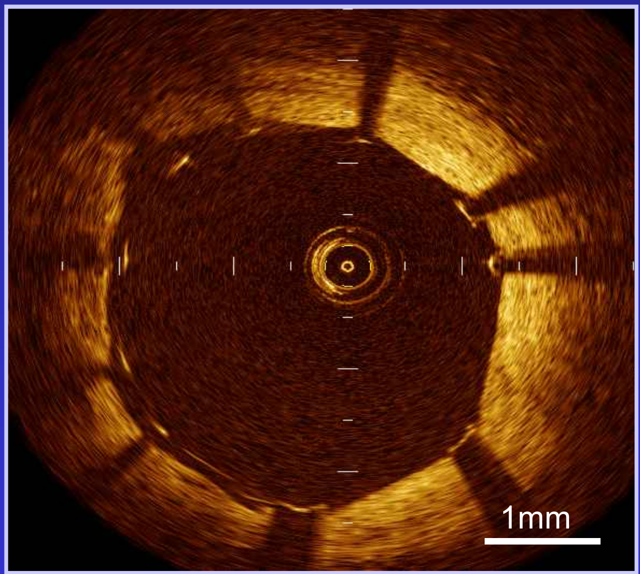
*Stent malapposition*



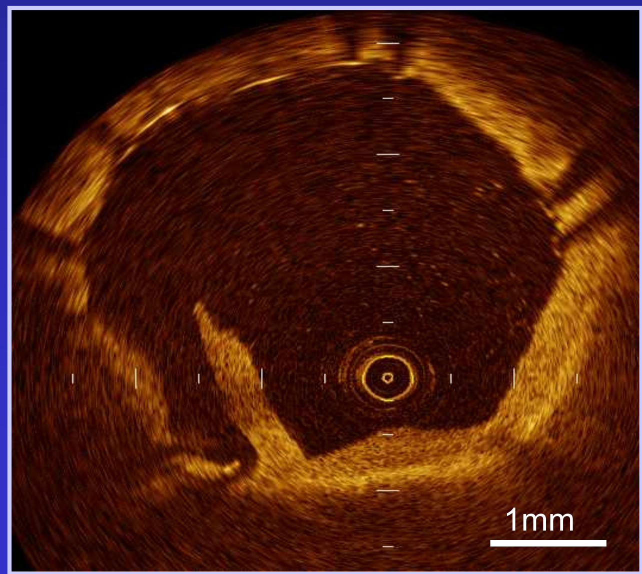

*Tissue protrusion*




*Incomplete stent apposition*

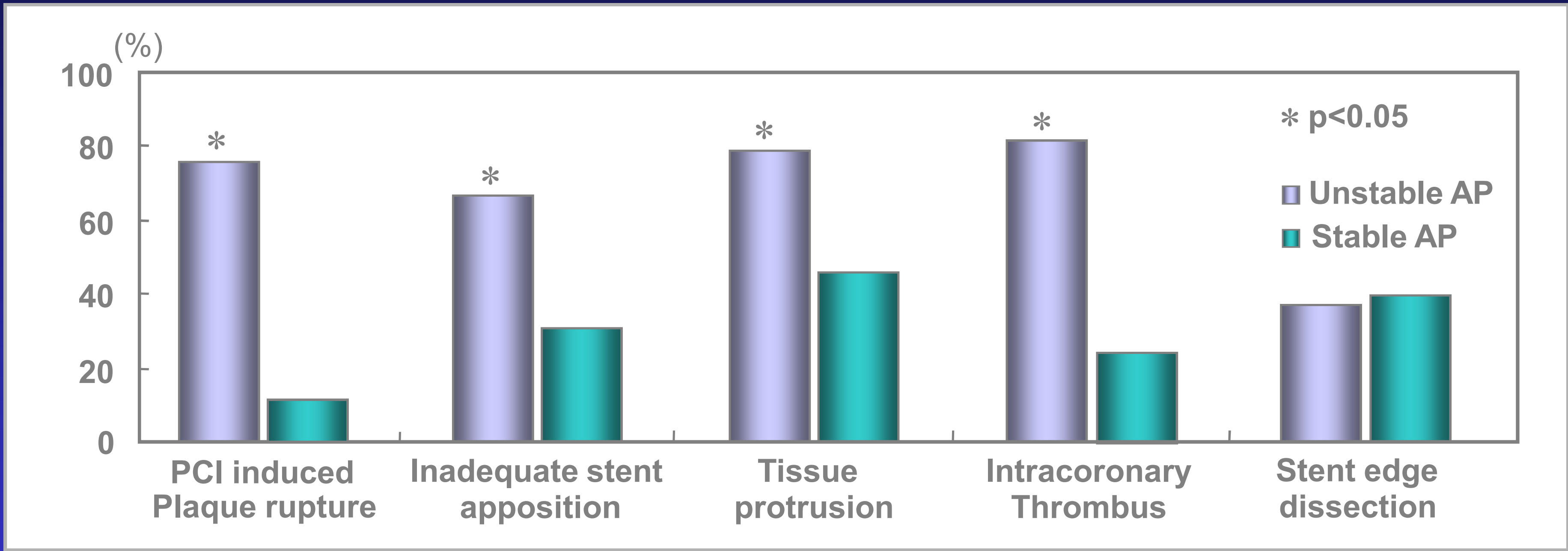



*Stent edge dissection*



# Vascular response after stent implantation between unstable and stable AP

**24 unstable and 31 stable AP patients were examined by OCT to evaluate lesion morphologies after stent implantation.**




**Conclusion: The inadequate lesion morphologies after stenting were observed more frequently in unstable AP patients.**

*Kubo T, et al, JACC Img. 2008 1:475–484*

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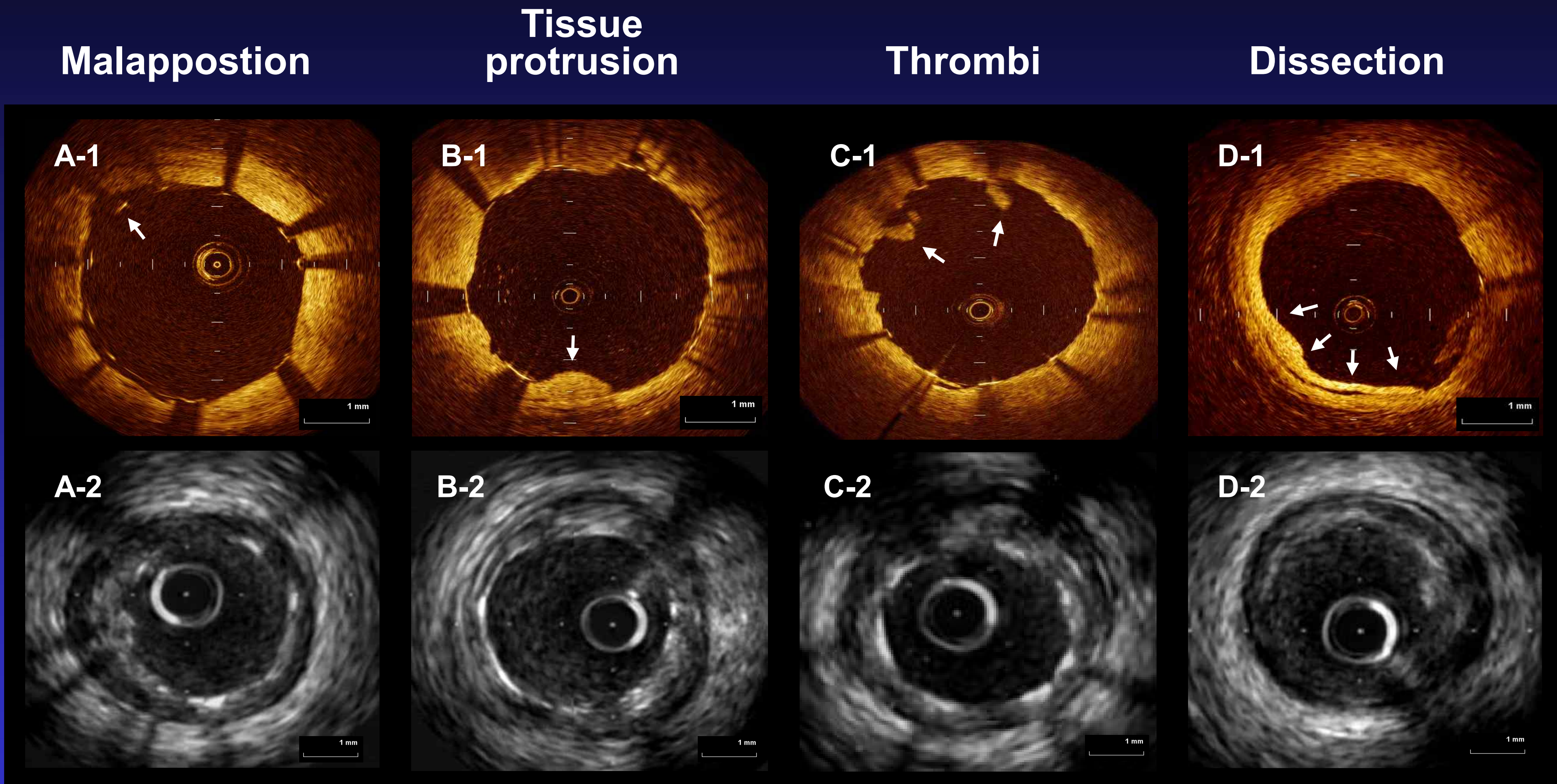
# OCT and IVUS images of stented lesions




*Kubo T, et al, JACC Img. 2008 1:475– 484*

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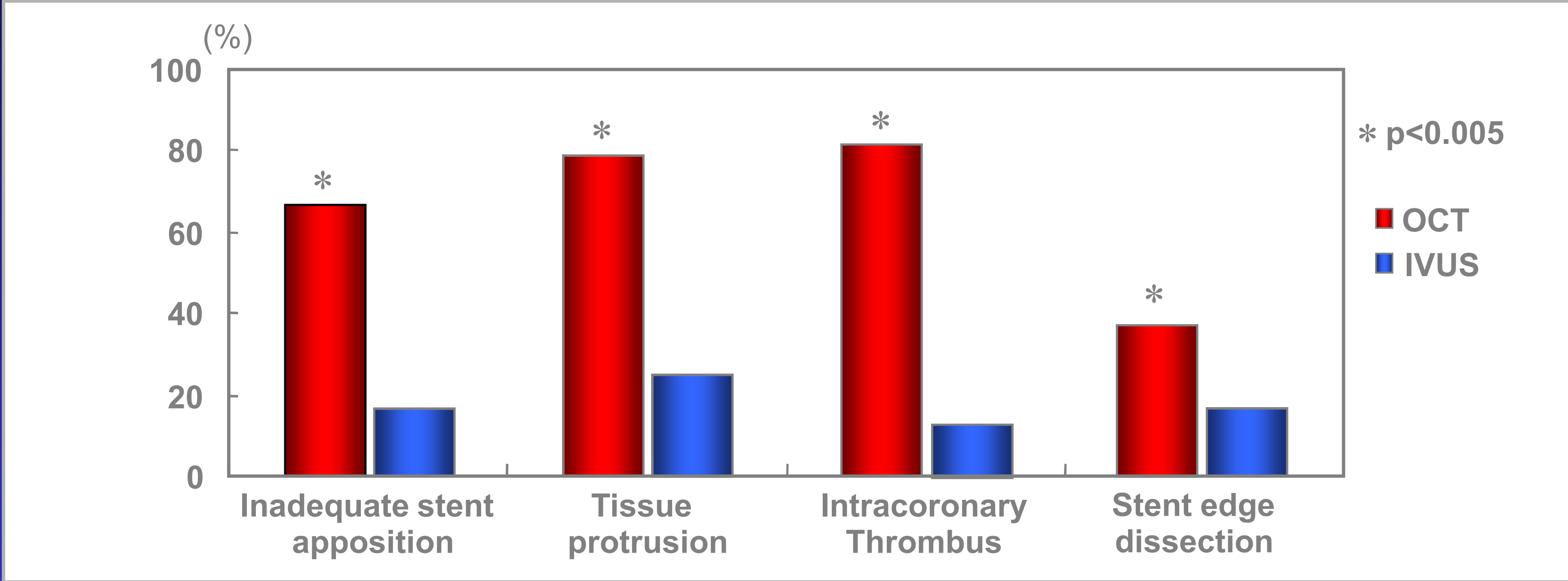
# Comparison of the ability for monitoring stent deployment between OCT and IVUS

**55 patients were examined by OCT and IVUS to evaluate lesion morphologies after stent implantation.**




**Conclusion: OCT can provide more detailed morphological information after stenting than IVUS.**

*Kubo T, et al, JACC Img. 2008 1:475–484*

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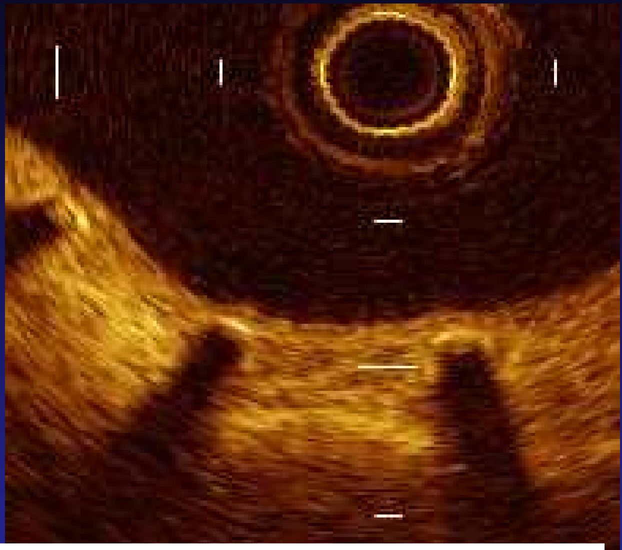
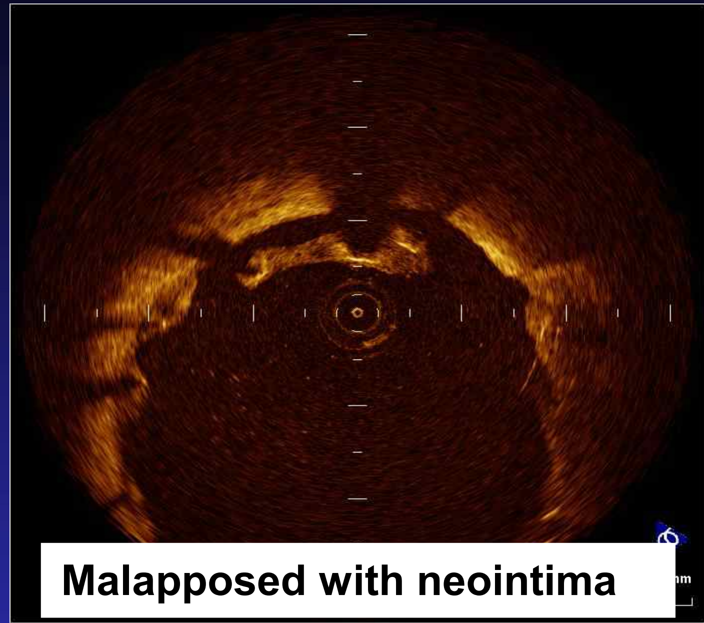
# Classification of strut condition



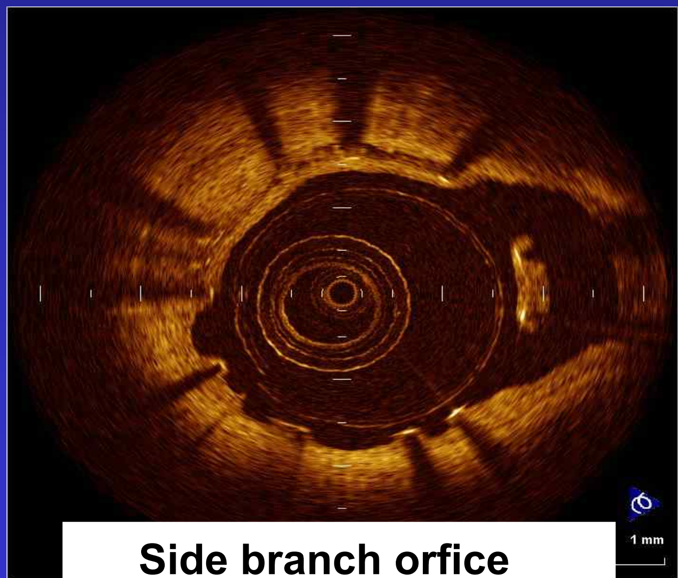
Wellapposed with neointima

Wellapposed without neointima



Malapposed with neointima

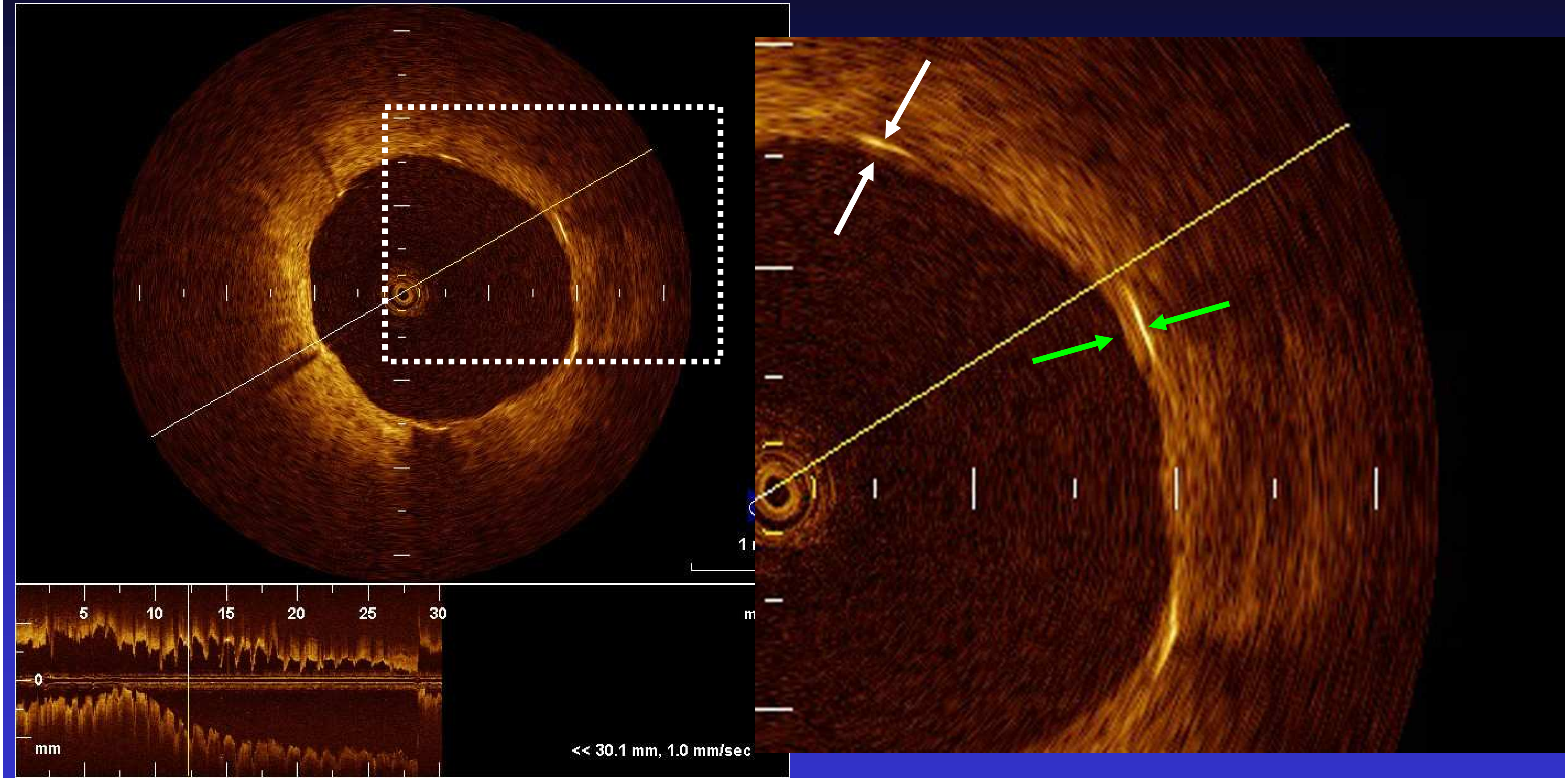
Malapposed without neointima




Side branch orfice
with neointimal coverage

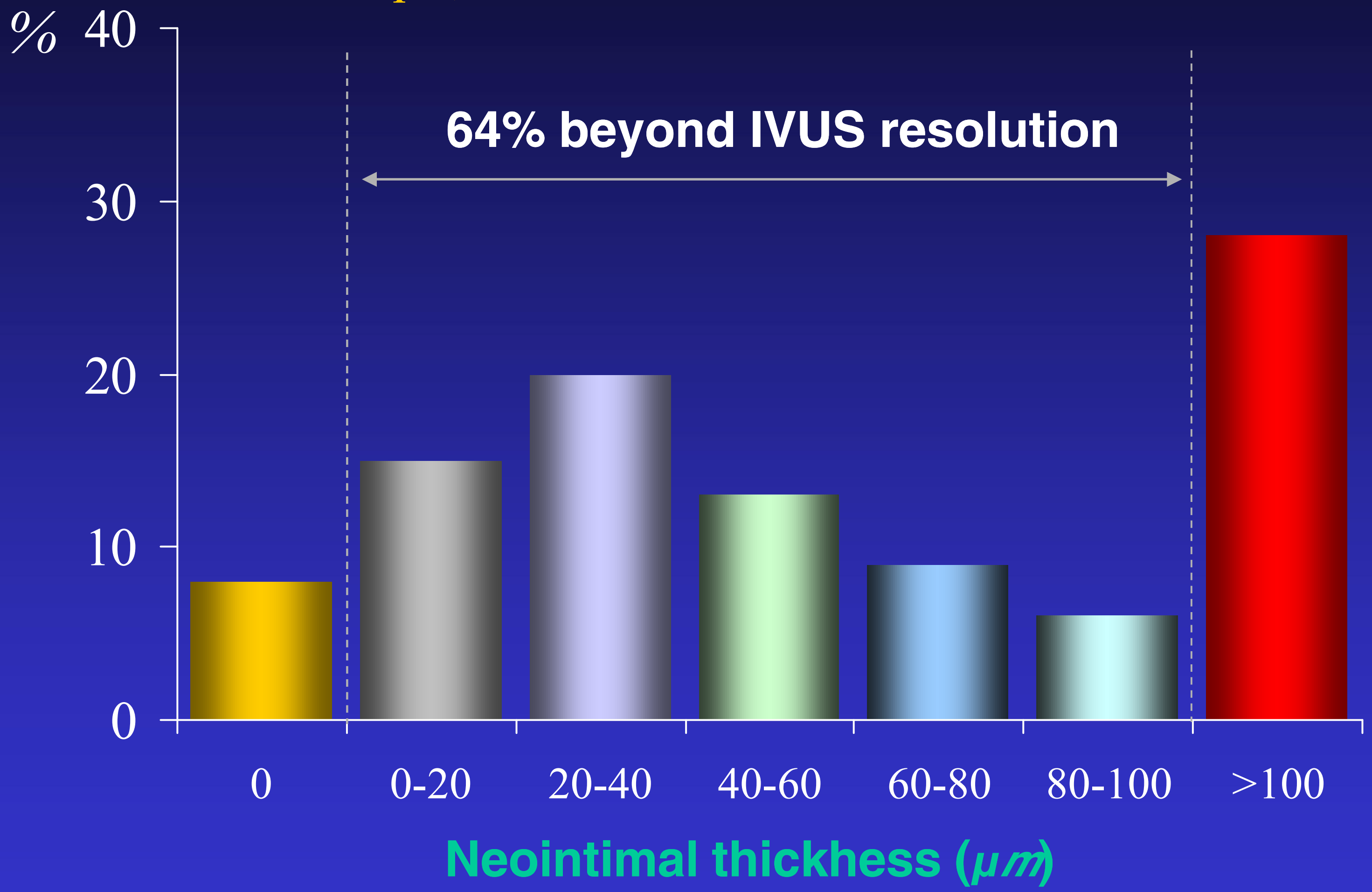
Side branch orfice
without neointimal coverage

# Post-stent follow up



# Distribution of the neointima thickness on SES strut (6 months f/u)

34 pts, 6840 stent strut cross sections




**Matsumoto, D. et al. Eur Heart J 2007 28:961-967**

**Neointima thickness is under IVUS resolution in more than 70% pts.**

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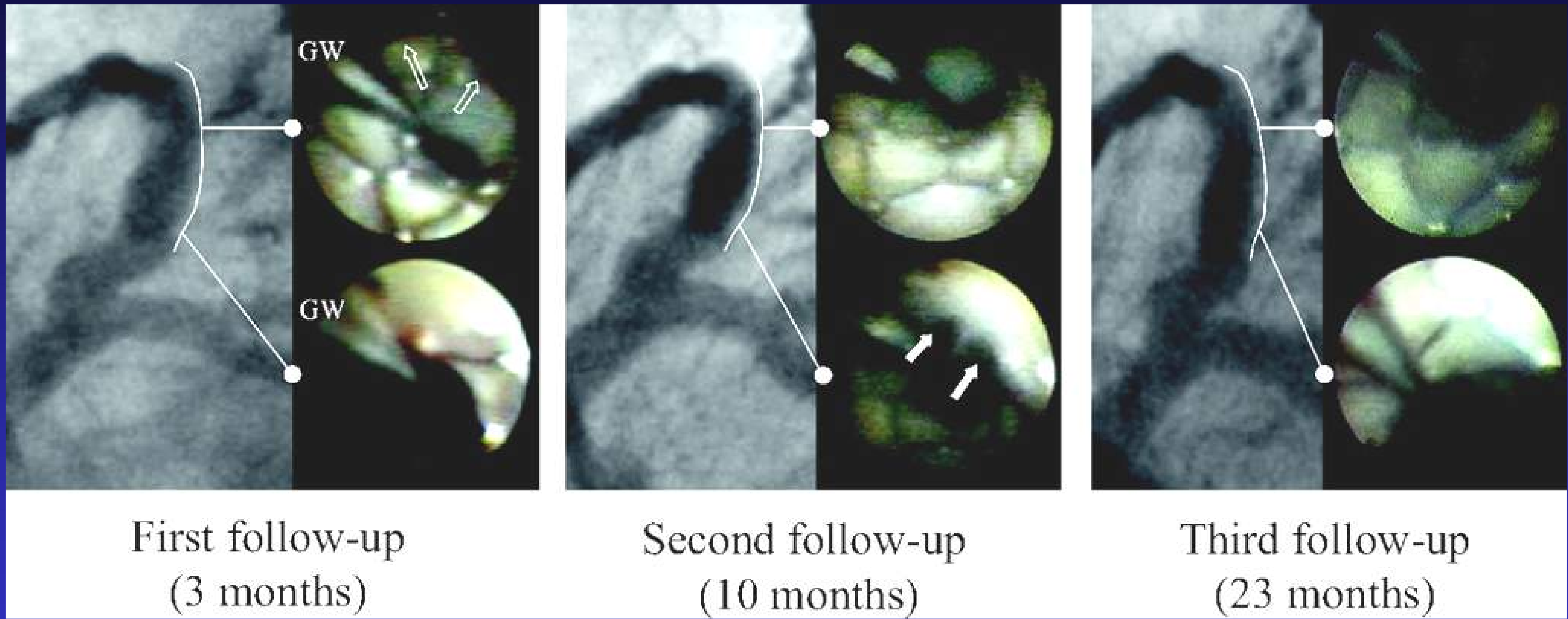
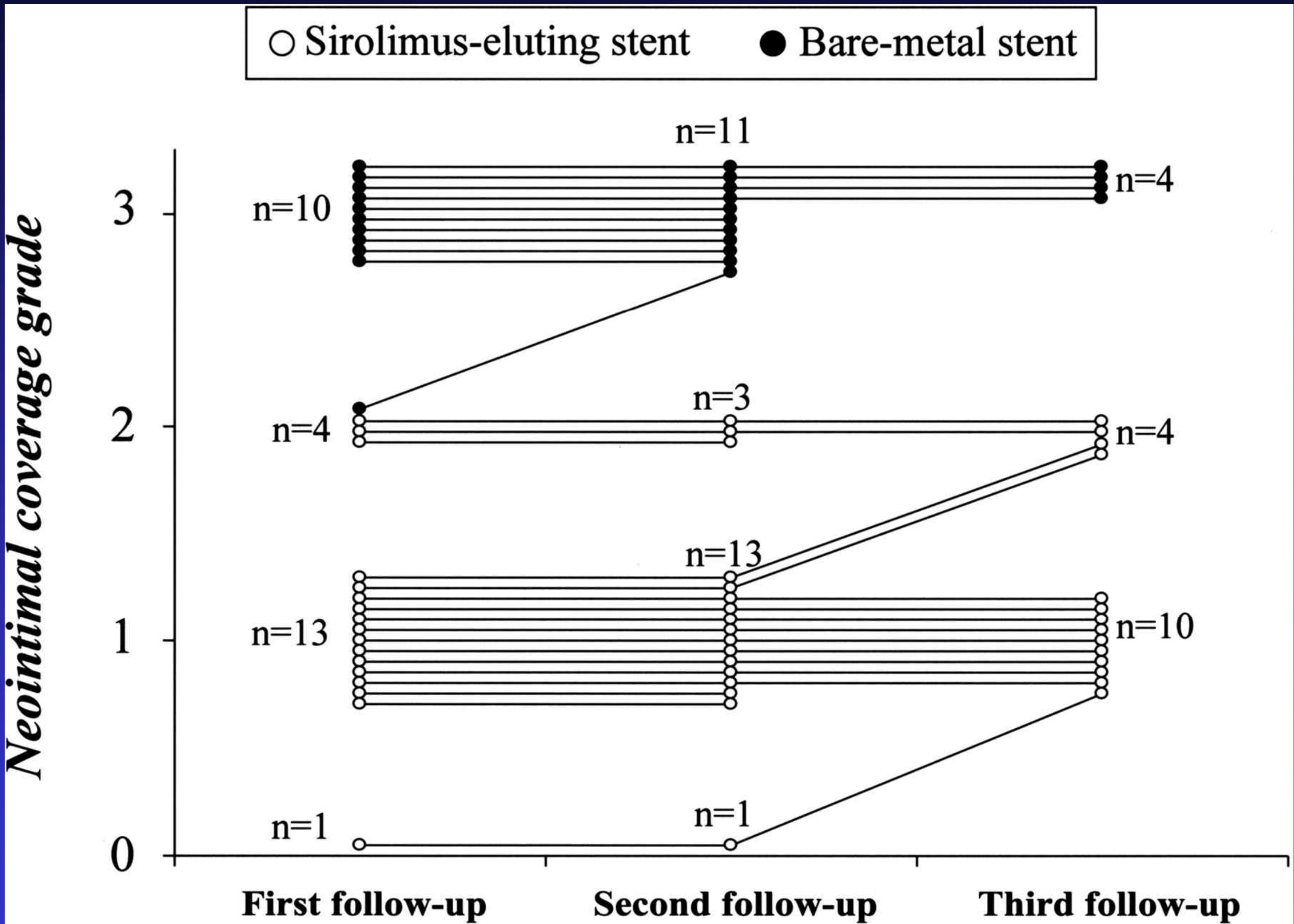
# An SES (Cypher, 3.5x23 mm) implanted proximally in the LAD




Stent struts bulged into the lumen and, although covered, were transparently visible

Awata, M. et al. Circulation 2007;116:910-916

# Changes in neointimal coverage grades from the first to the third follow-up in 28 stents




**Stent struts condition**

Fully embedded and not visible

Embedded by the neointima, but still visible translucently

Bulged into the lumen, although covered, transparently visible

Fully visible similar to soon after implantation

Awata, M. et al. Circulation 2007;116:910-916

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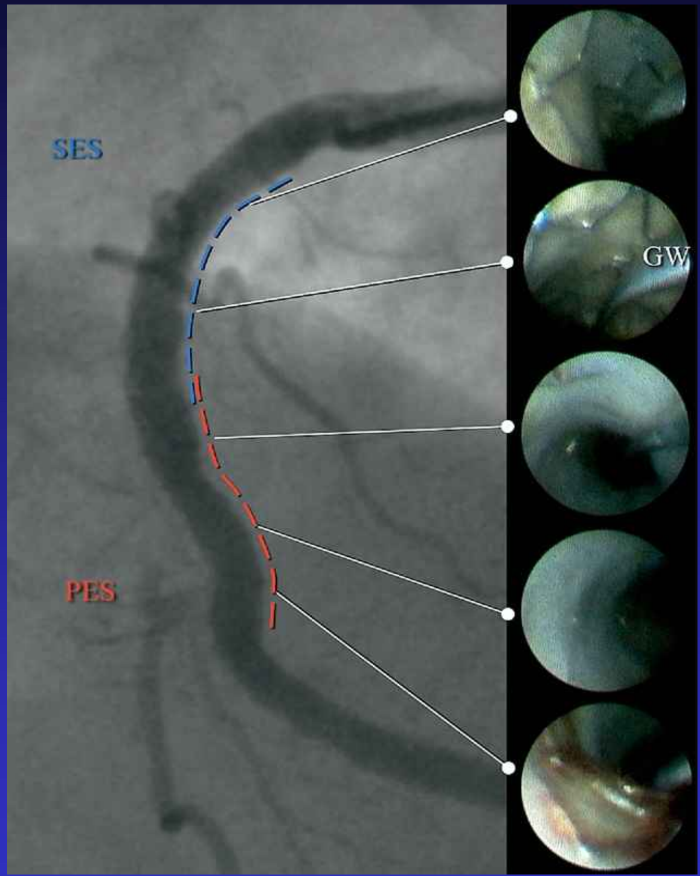
# Asymptomiatic instent thombus by CAS

SES : 33% BMS : 8%




SES : 19% PES : 43%

Takano et al. Eur Heart J 2006; 27: 2189-2195

Awata et al. J Am Coll Cardiol Intv 2009; 2: 453-458

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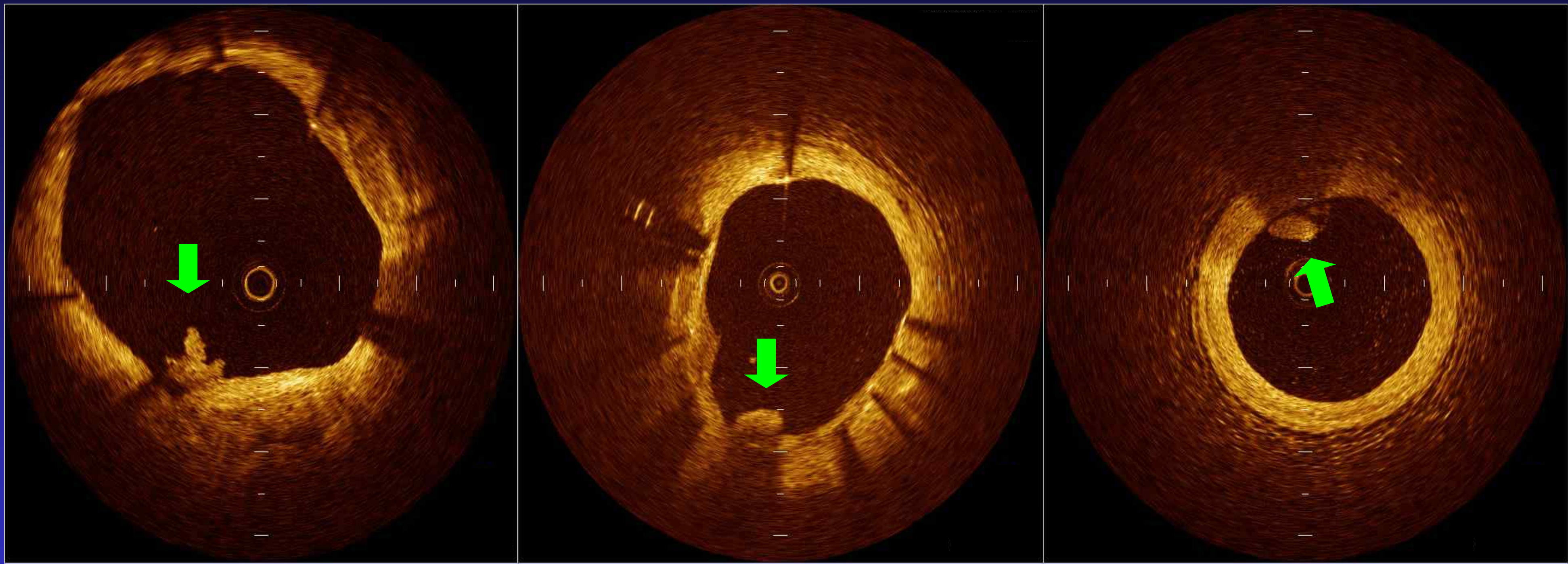
# Instent thrombus



DES BMS Distal to DES

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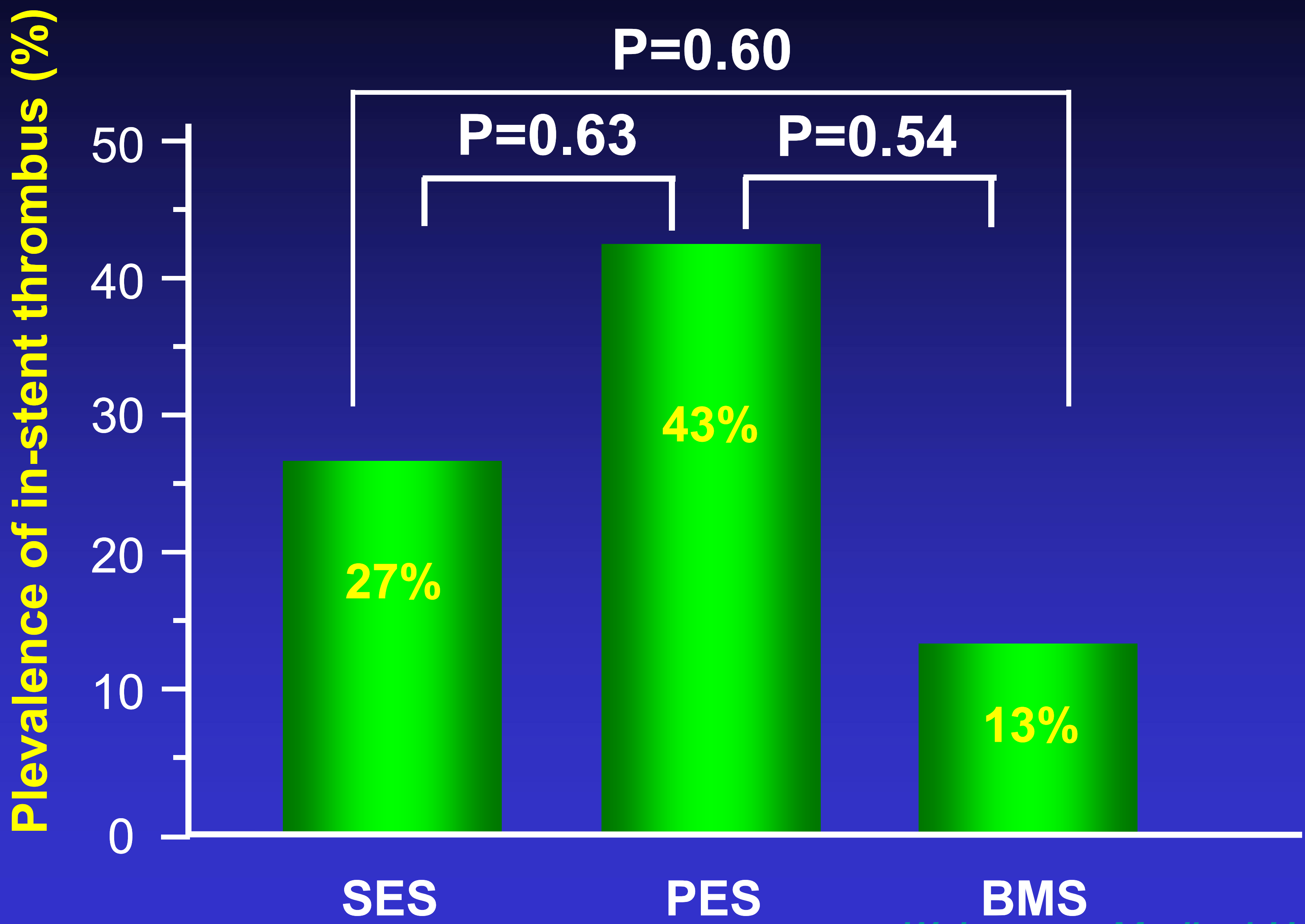
# Instent thrombus by OCT

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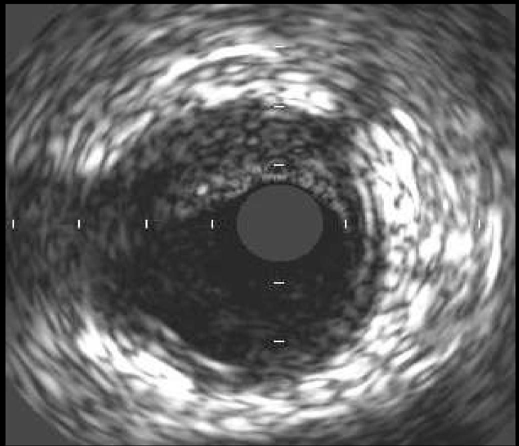
# Conclusions

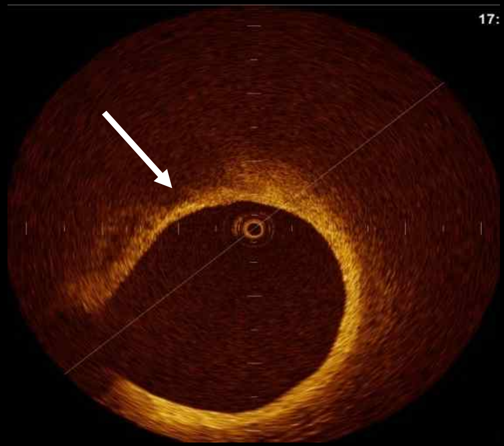
- OCT can identify lipid-rich plaques & differentiate the plaque types more sensitively compared with IVUS.
- OCT can demonstrate rupture or ulceration of fibrous cap with higher detection rate than that of IVUS or CAS.
- OCT could detect intracoronary thrombus almost exclusively which was confirmed by CAS.
- OCT may demonstrate the results of PCIs precisely, including mal-appositions, tissue (or thrombus) protrusion, and edge dissection immediately after the procedure and thin neo-intima formation and small thrombus within stents late after DES.

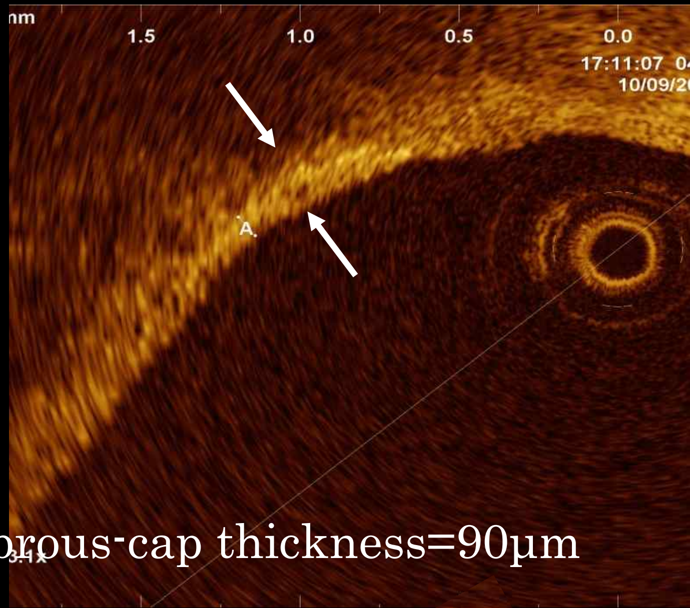
*Wakayama Medical University*

# Representative case of plaque stabilization : 66yo, male

primary PCI



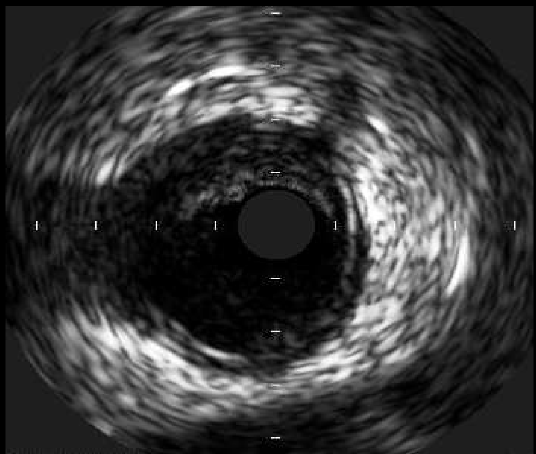


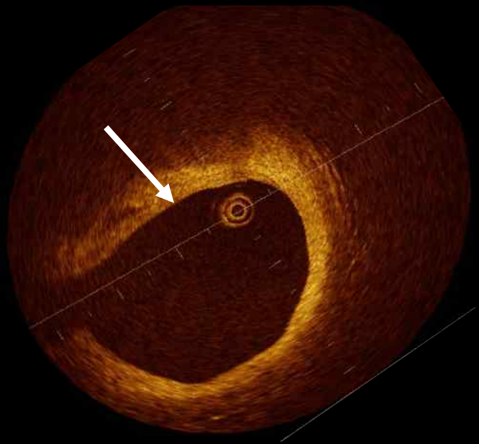


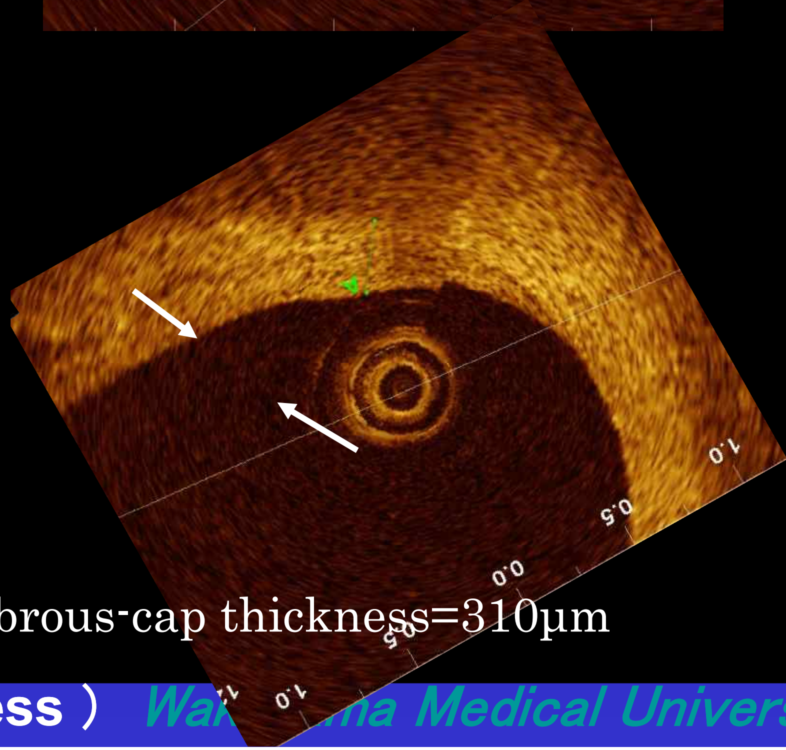

Total atheroma volume=63$mm^3$

Fibrous-cap thickness=90μm

9-months follow-up








Total atheroma volume=61$mm^3$

Fibrous-cap thickness=310μm

（Takarada S, et al. JACC Interv. 2010, in press ）