# OCT Assessment of Post-DES Vascular Healing: Experimental Insights and Histology Correlates


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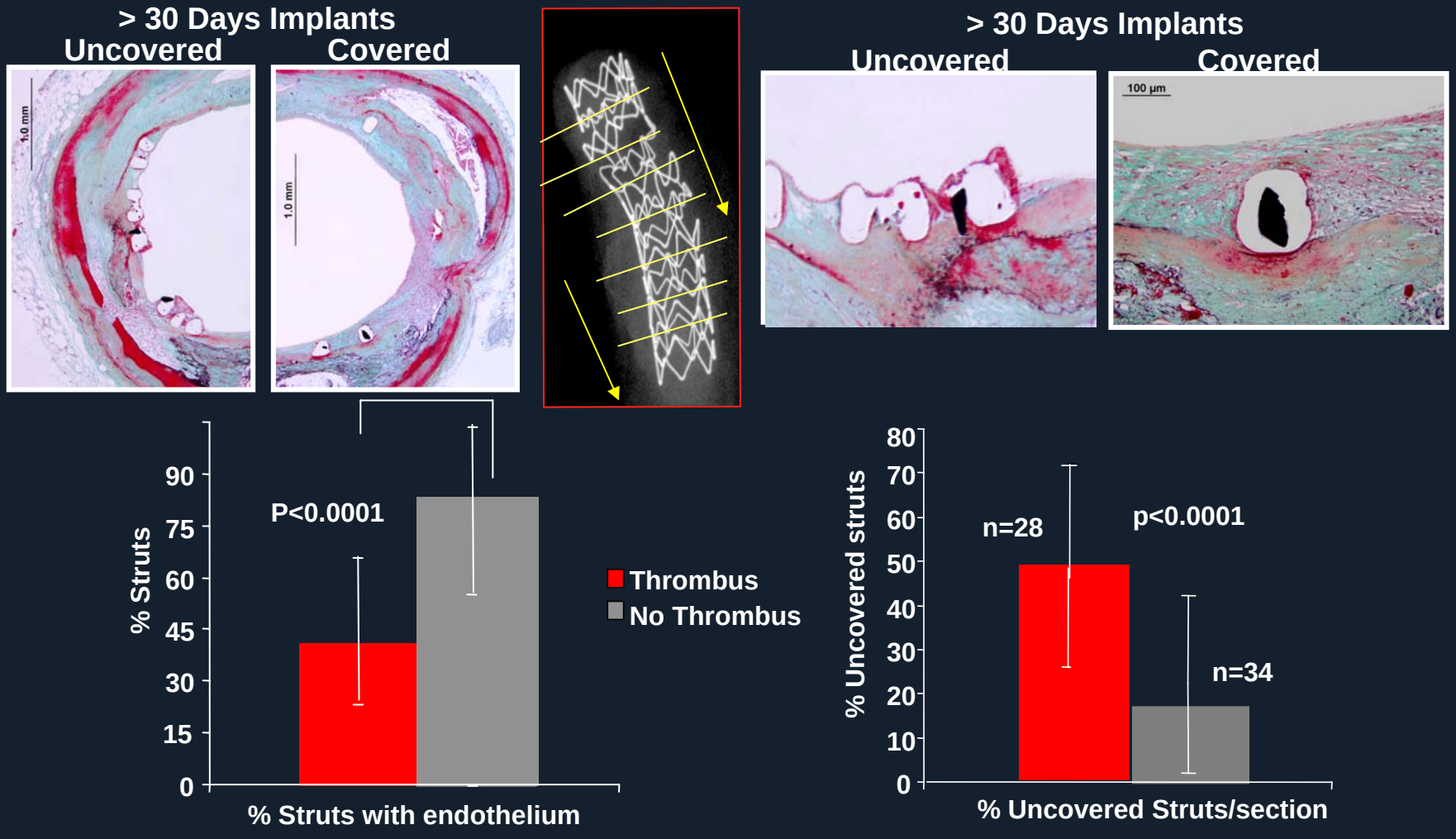
# Pathological Correlates of Late DES Thrombosis: Strut Coverage




*Finn AV, et al., Circulation 2007;115:2435-2441*

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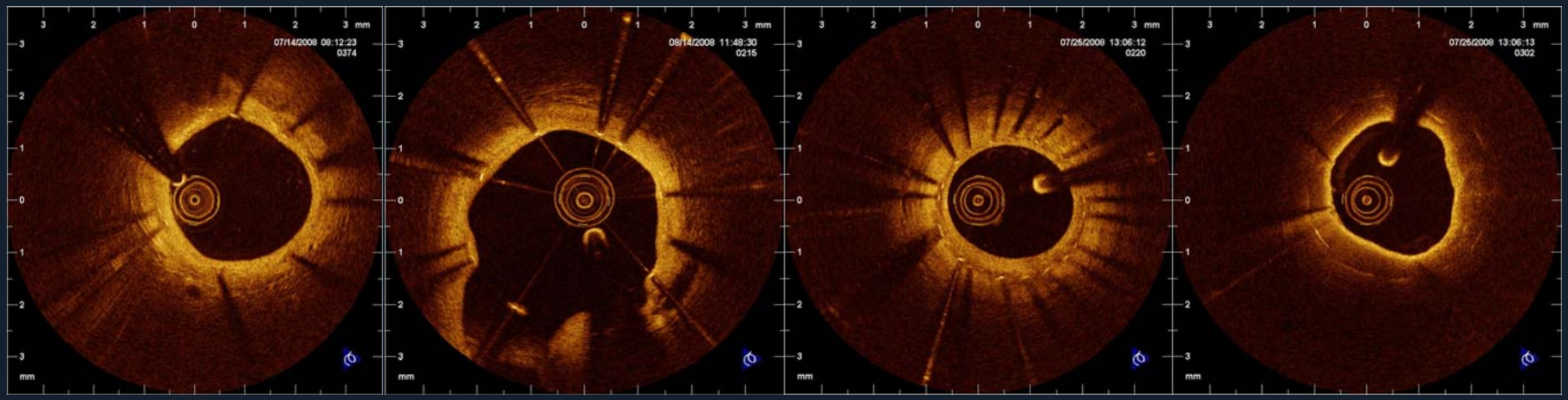
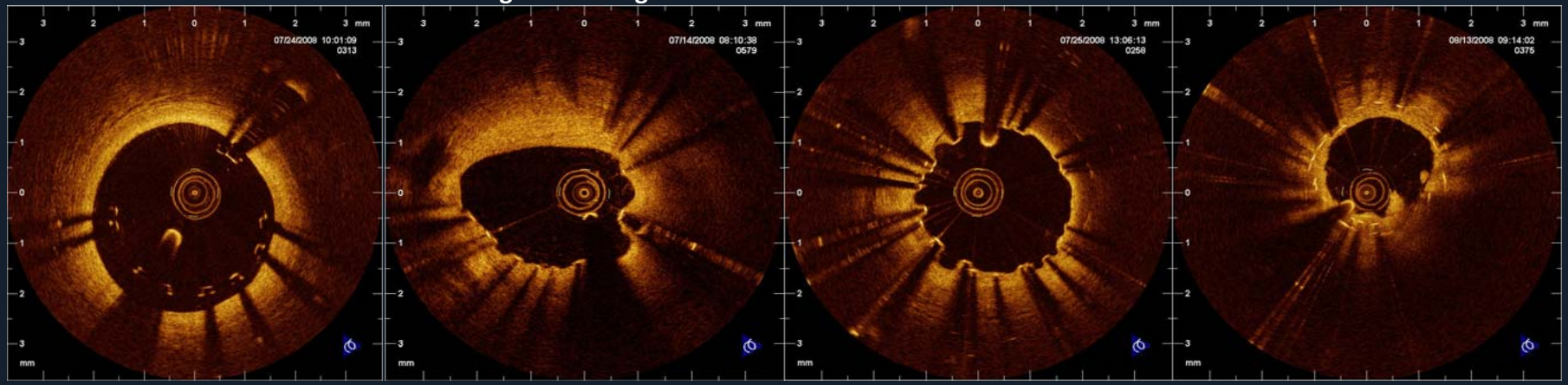
# High Resolution Near Field Imaging of Stent and Peri-Stent Areas



Homogeneous NI growth | Homogeneous NI growth | Inhomogeneous NI growth | Post balloon



Malapposed uncovered struts | Malapposed covered struts | Malapposed covered struts | Malapposed struts w/ thrombus

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# OCT and Vascular Healing Assessment Following DES Implantation

- **Due to the high resolution, OCT is rapidly emerging as the "ideal" clinical tool for evaluating vascular healing following DES implantation:**
  - *Visualization of intimal proliferation of drug-eluting stent and bare mental stent by use of optical coherence tomography. Chen et al. Zhonghua Yi Xue Za Zhi. 2006 Apr 25;86(16):1102-6.*
  - *Neointimal coverage of sirolimus-eluting stents at 6-month follow-up : evaluated by optical coherence tomography. Matsumoto et al. Eur Heart J. 2007 Apr;28(8):961-7.*
  - *Neointimal coverage of bare-metal and sirolimus-eluting stents evaluated with optical coherence tomography. Chen BX eat al. Heart. 2008 May;94(5):566-70.*
  - *Neointimal coverage of sirolimus-eluting stents 6 months and 12 months after implantation: evaluation by optical coherence tomography. Yao ZH. Chin Med J (Engl). 2008 Mar 20;121(6):503-7.*
  - *Optical coherence tomography: high resolution intravascular imaging to evaluate vascular healing after coronary stenting. Guagliumi G et al. Catheter Cardiovasc Interv. 2008 Aug 1;72(2):237-47.*
- ***However, the ability of OCT to make accurate measurements of stent strut coverage has not been validated in vivo.***

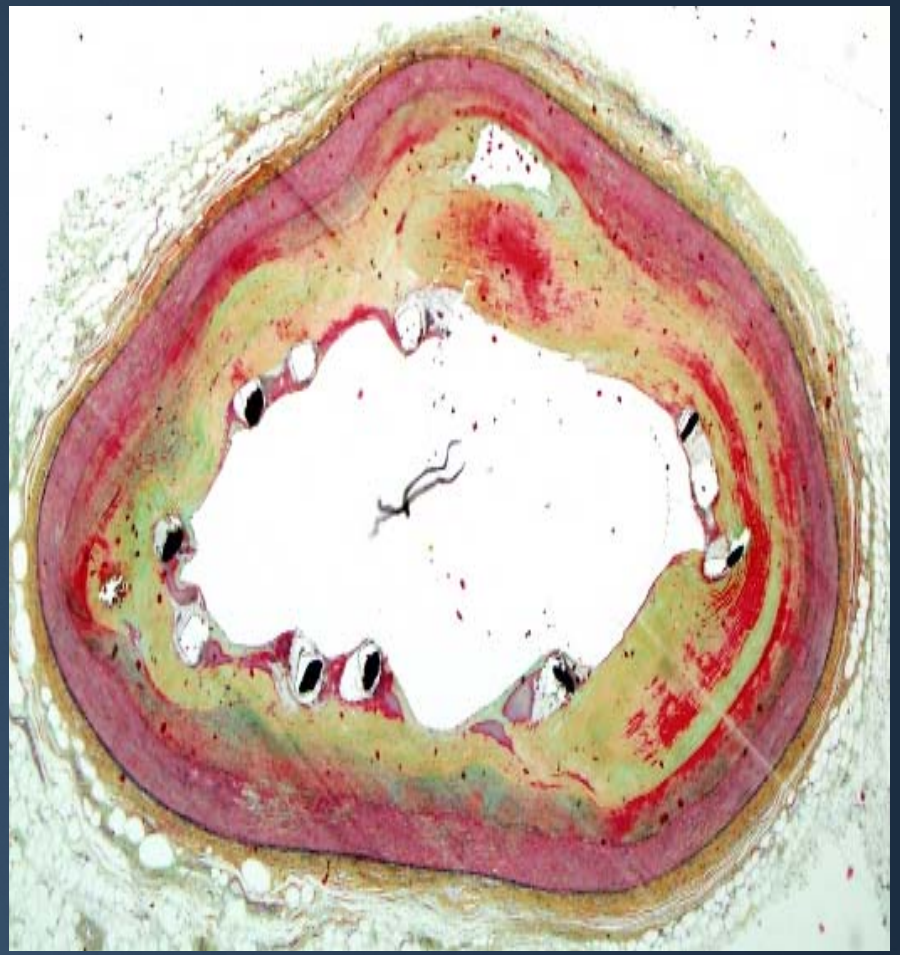
# How Could OCT Evaluate Vascular Healing Following DES Implantation?

**PRESENT:**

- Assessing the ***amount*** ***of neointimal tissue*** formed on the surface of the strut.
- Quantifying the ***number*** ***of stent struts*** that are properly covered.

**FUTURE:**

- Assessing the degree of ***functional stent coverage***.
- Characterizing the ***tissue type*** covering the struts (i.e., fibrin).



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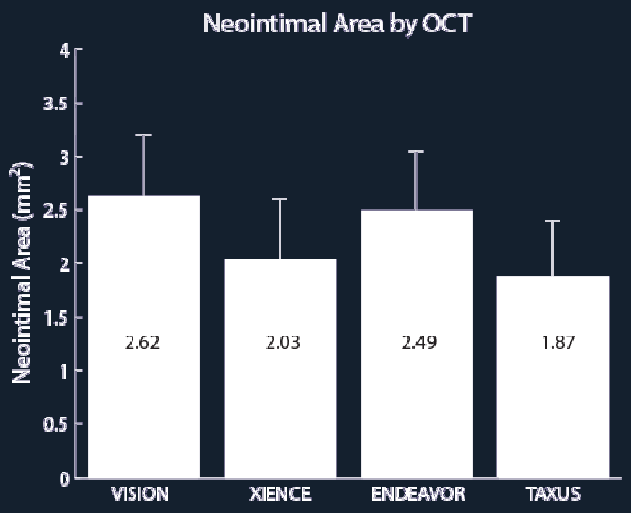
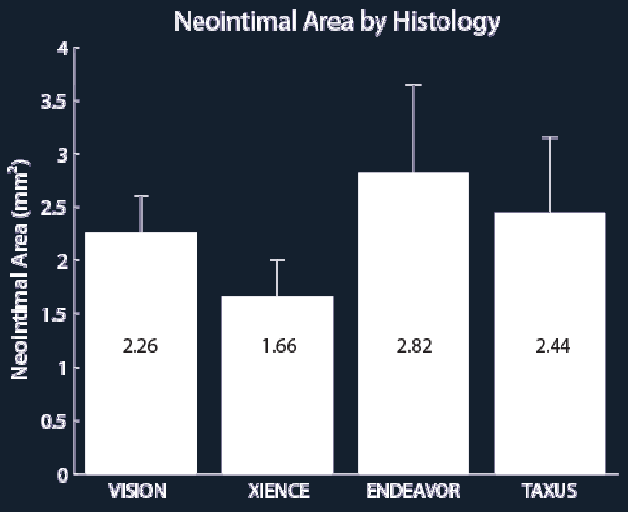
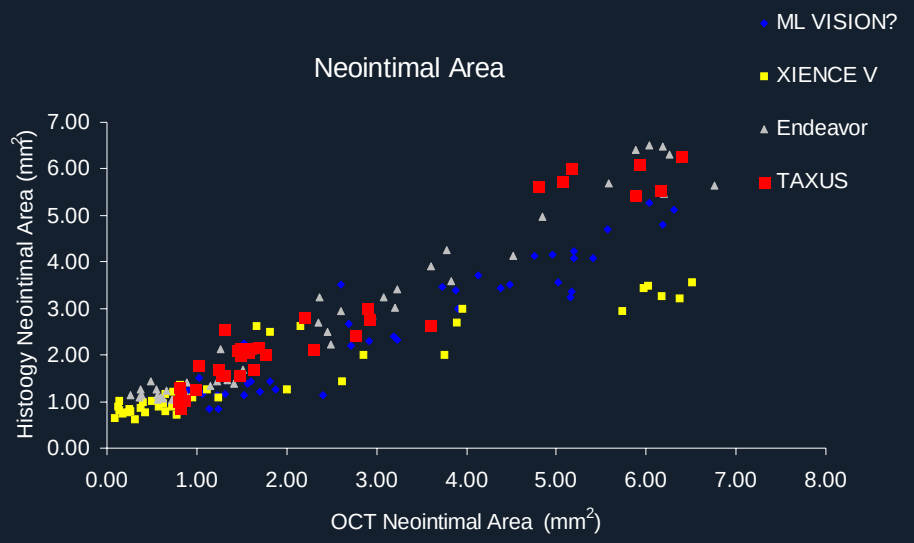
# Validation of Several Morphometric Parameters Analyzed Following OCT: A Histology Correlation Study in Swine

- 14 Swine, Stents (11 Vision, 11 Xience, 10 Endeavor, 10 Taxus)
- OCT acquisition: LightLab Imaging, time domain OCT, 1300nm reported resolution of 15 um, pullbacks obtained at 1mm/sec, 15.6Hz frame rate:
  - *396 total frames were analyzed (143 matched with histology).*
  - Second observer for intra and inter observer variability
  - Measured: NA, %AS, NT, uncovered and covered struts.
- Histology analysis:
  - Sectioned to correspond with OCT, stained with H&E and van Gieson's
  - Histomorphometry: Neointimal area, %AS, NT, uncovered and covered struts.
  - SEM: overall assessment of lumen coverage and endothelialization

# Analysis of Neointimal Area Using OCT in Different DES Types (28 Days)




| Neointima | | Correlation Coefficient | 95% Confidence Interval |
|---|---|---|---|
| | Endeavor | 0.9821 | 0.9667, 0.9904 |
| | TAXUS | 0.9667 | 0.9339, 0.9834 |
| | ML VISION | 0.9546 | 0.9190, 0.9748 |
| | XIENCE V | 0.9302 | 0.8712, 0.9628 |

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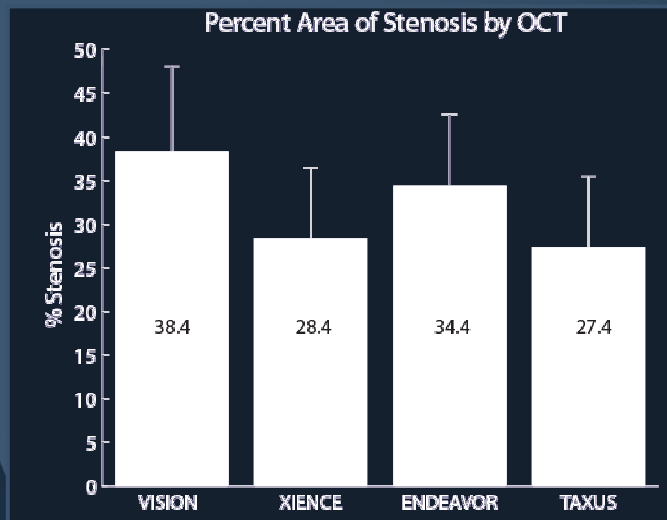
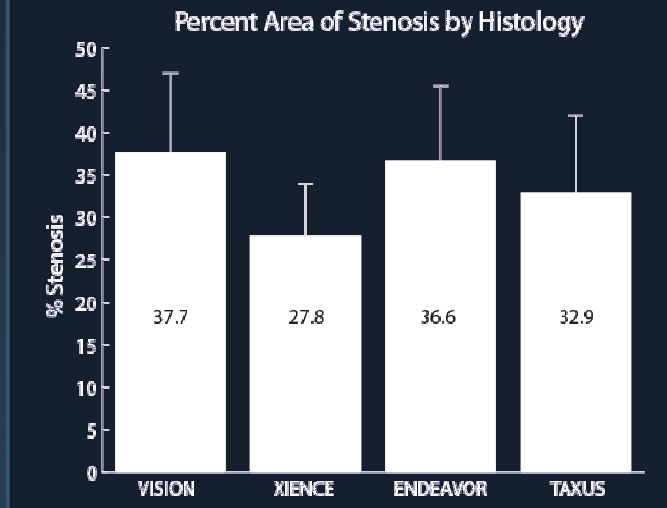
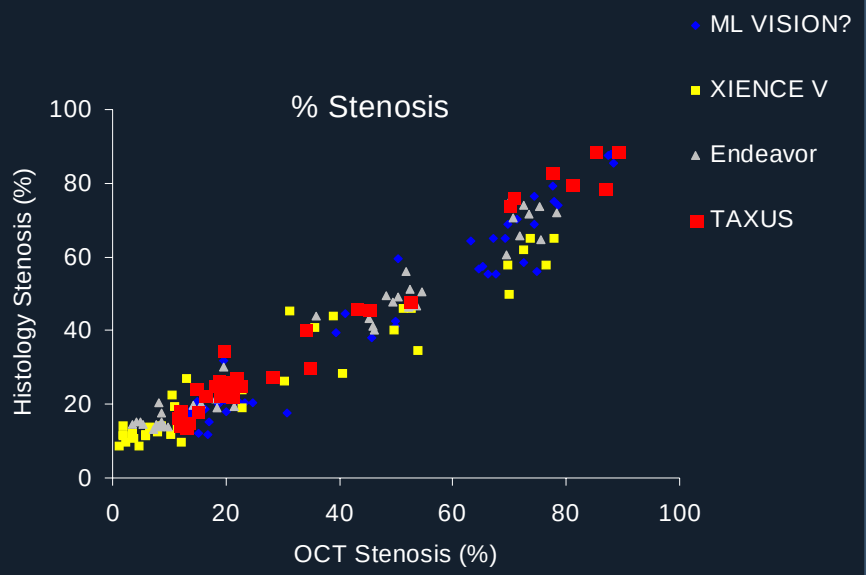
# Analysis of %AS Using OCT in Different DES Types (28 Days)




| % Stenosis | | Correlation Coefficient | 95% Confidence Interval |
|---|---|---|---|
| | Endeavor | 0.984 | 0.9702, 0.9914 |
| | TAXUS | 0.9867 | 0.9730, 0.9935 |
| | VISION | 0.9748 | 0.9549, 0.9859 |
| | XIENCE V | 0.96 | 0.9252, 0.9788 |

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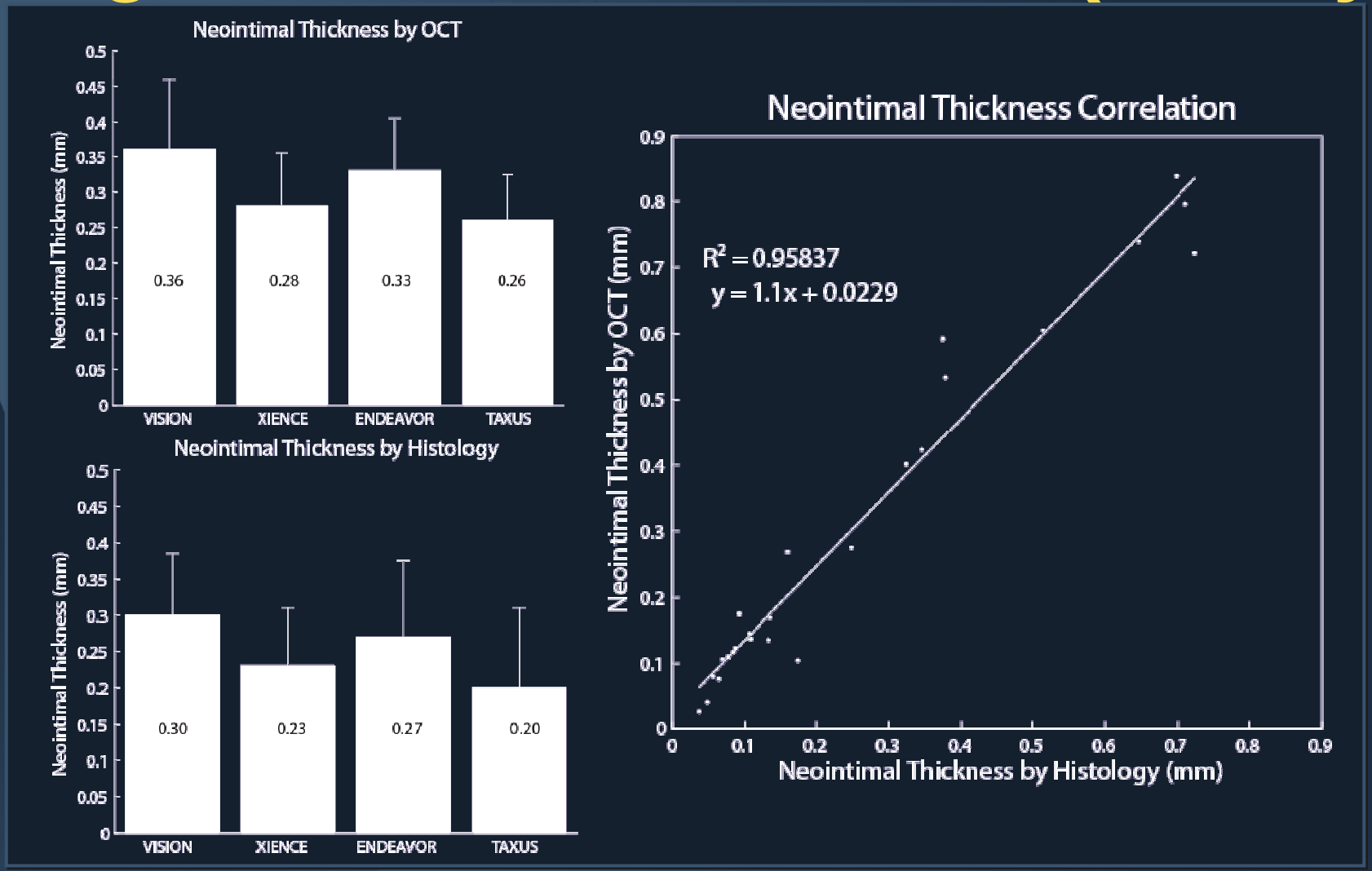
# Analysis of Neointimal Thickness Using OCT in Different DES (28 Days)

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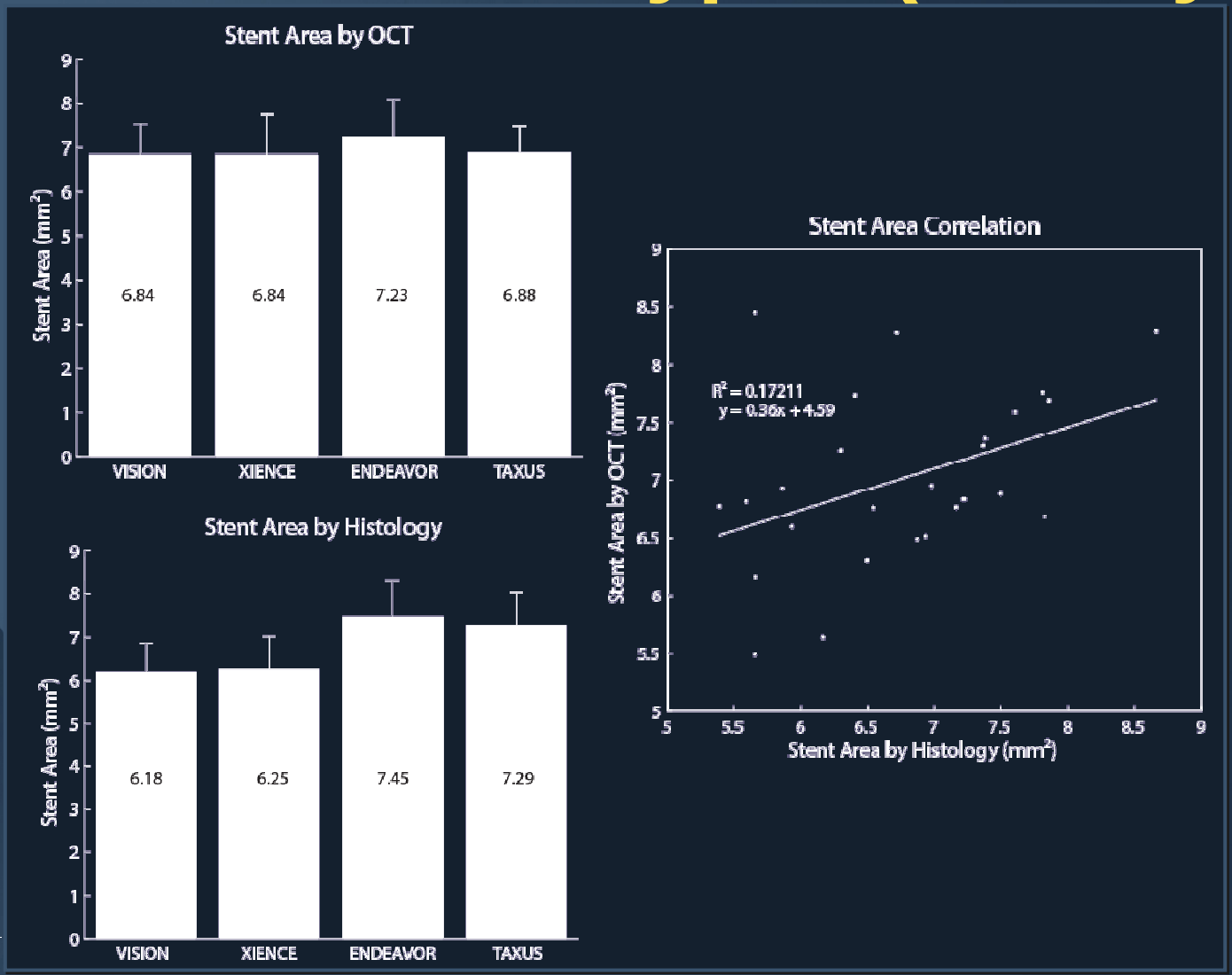
# Analysis of Stent Area Using OCT in Different DES Types (28 Days)

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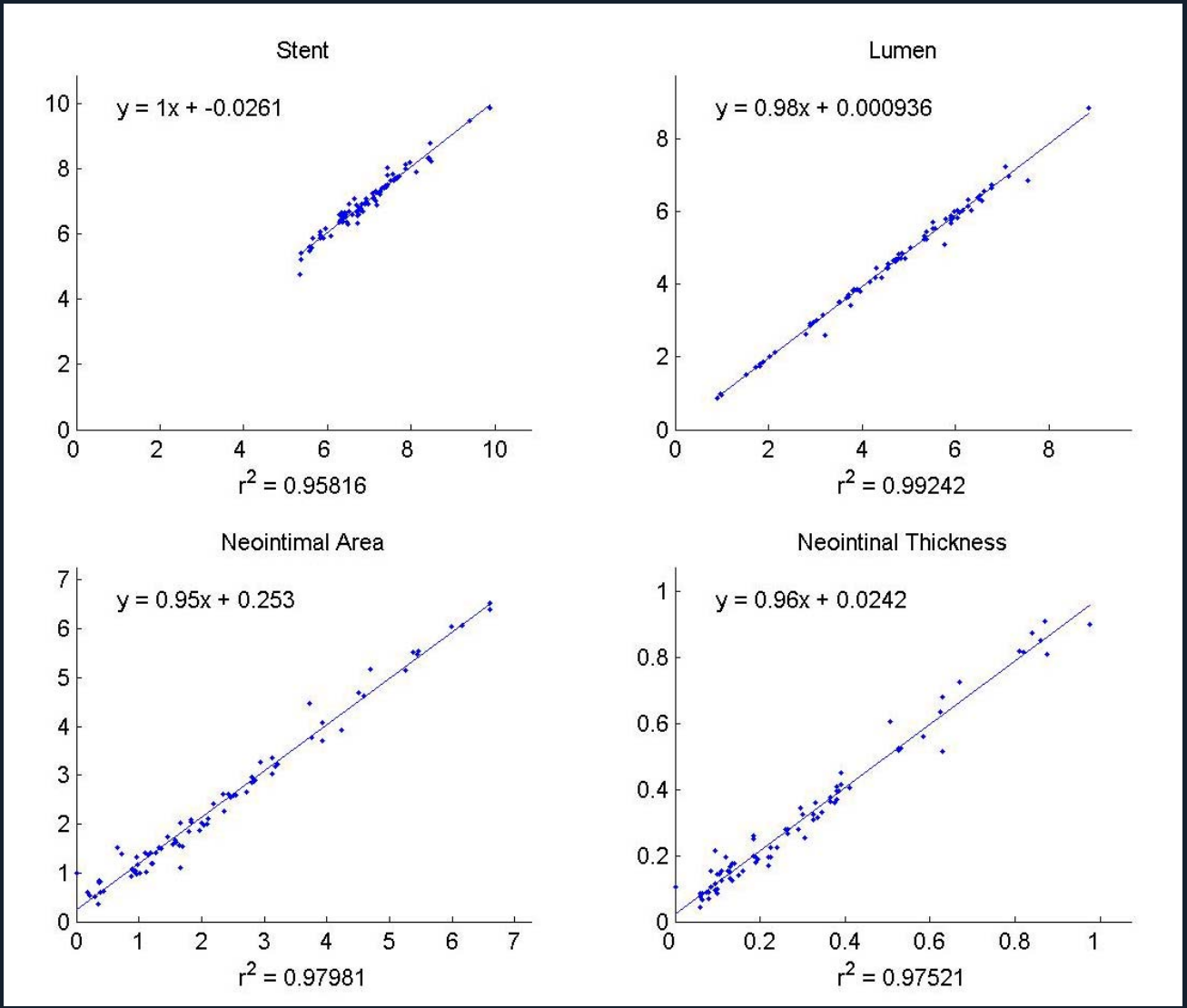
# OCT Intra-Observer Variability

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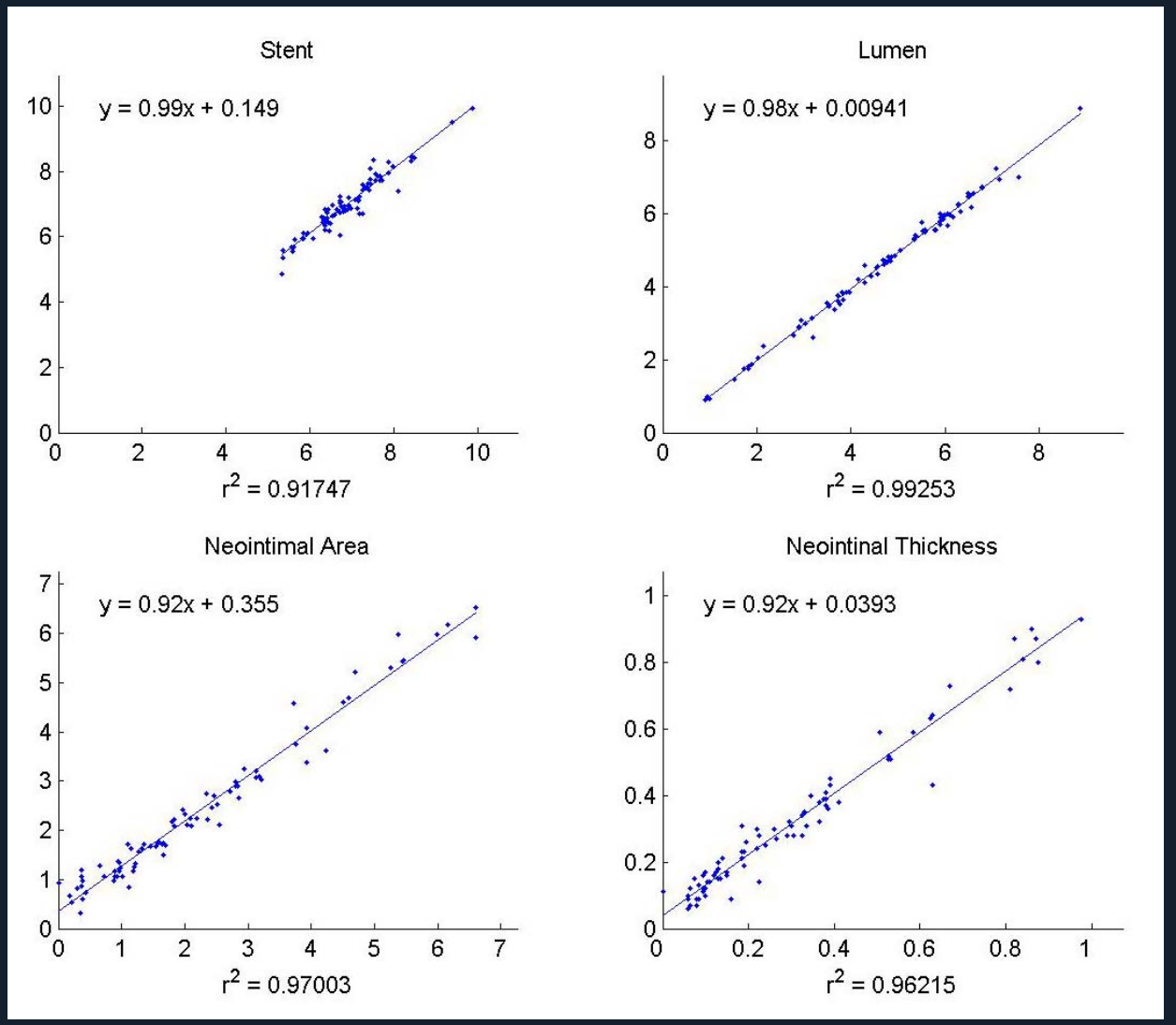
# OCT Inter-Observer Variability

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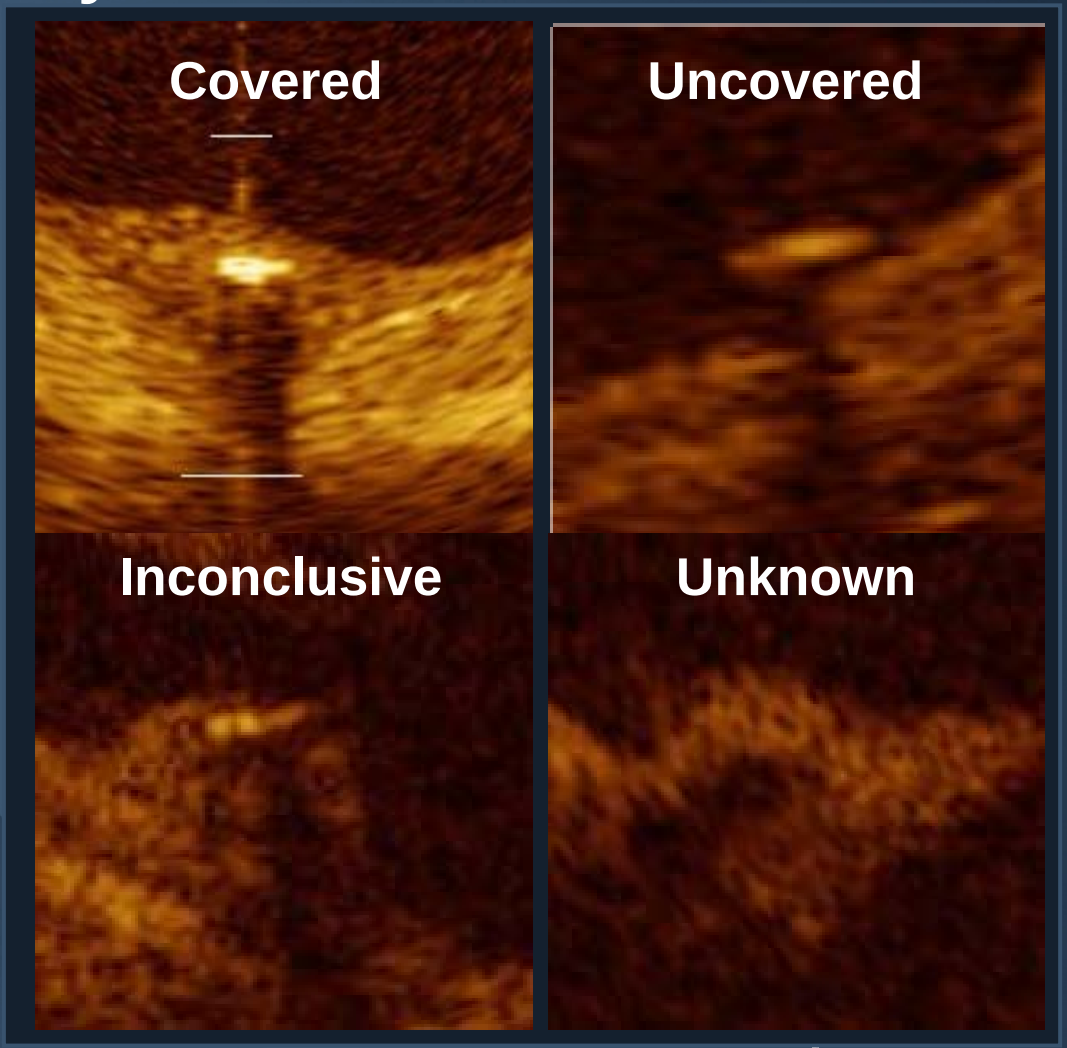
# Validation Study of Strut Coverage Analyzed Following OCT Imaging

## Accuracy for the Evaluation of Strut Coverage

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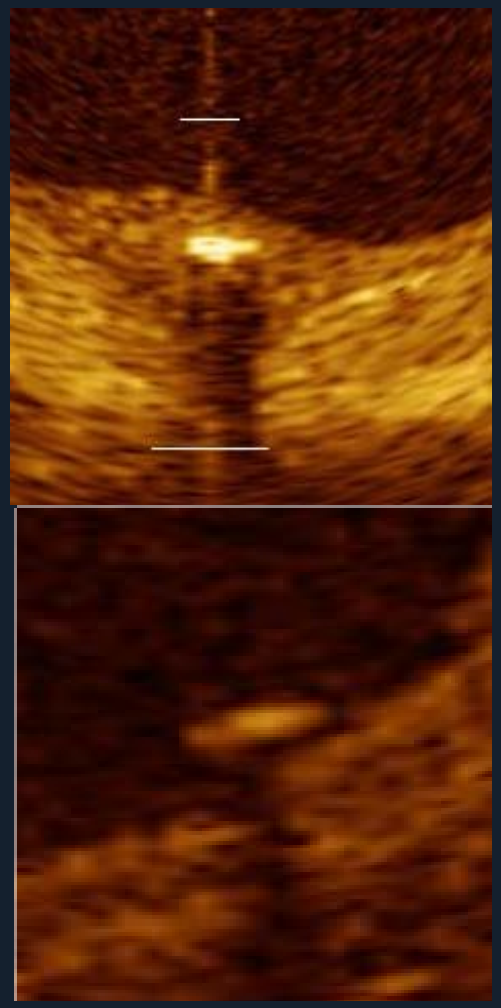
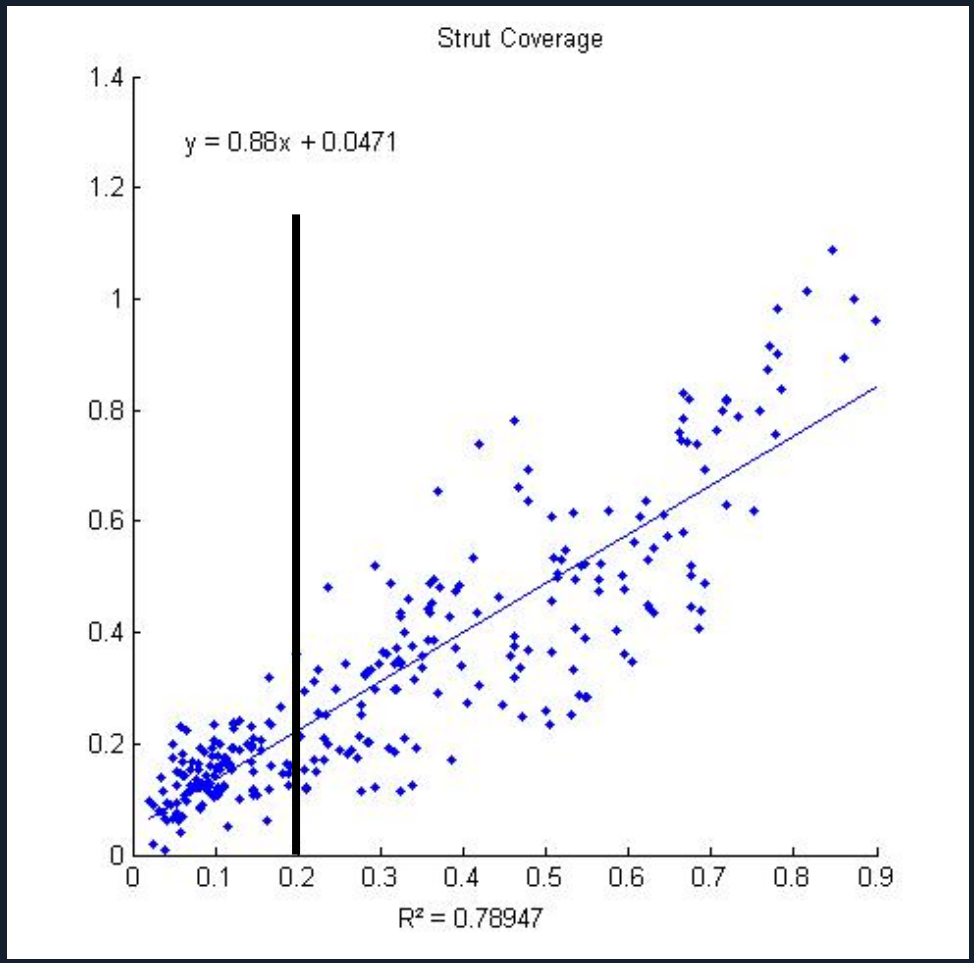
# Analysis of Strut Coverage Using OCT in Different DES Types (28 Days)



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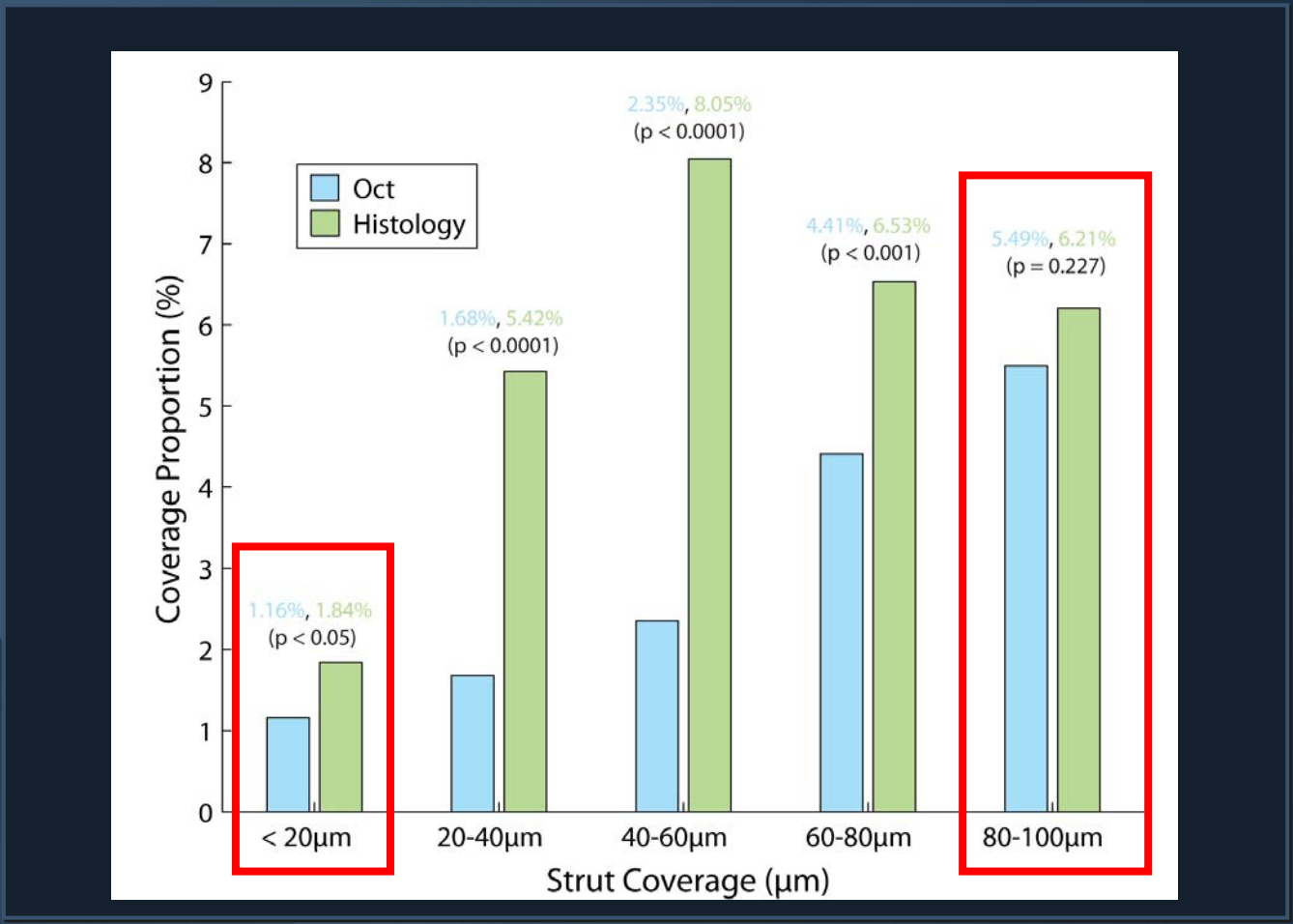
# Proportion of Neointimal Thickness by OCT & Histology in DES: Implications for Individual Strut Coverage Analysis

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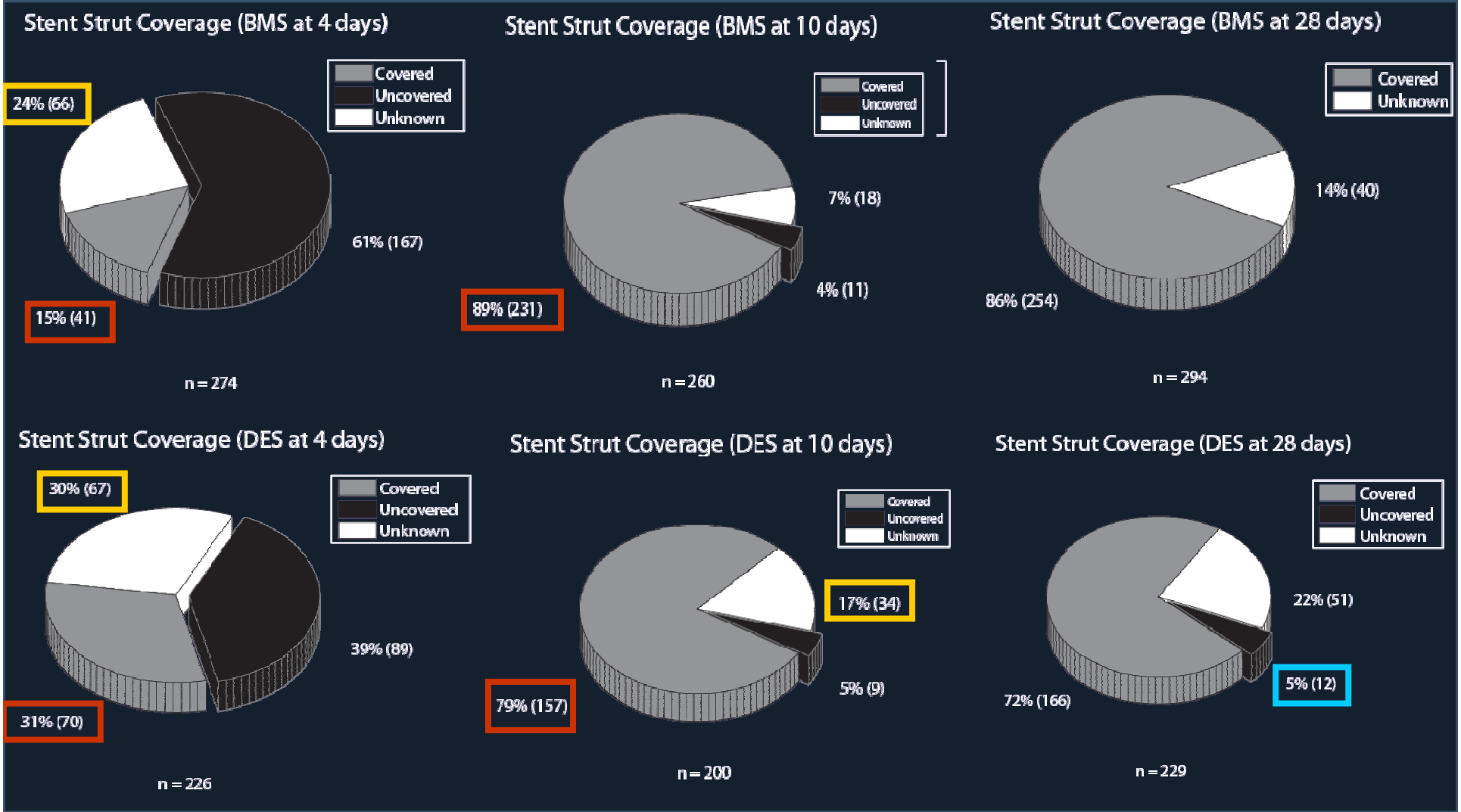
# Strut Coverage by OCT

## BMS versus DES at Different Time Points

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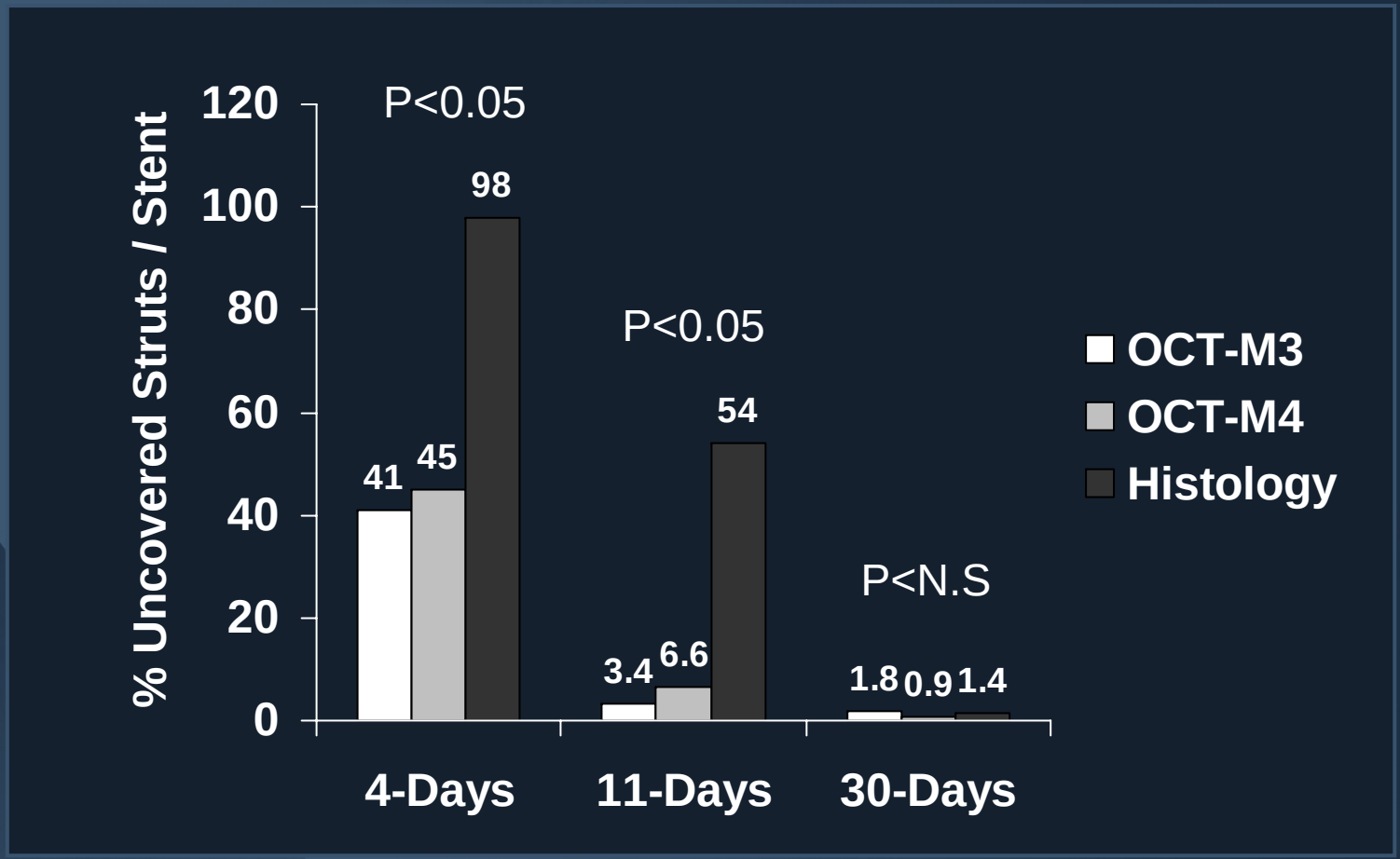
# Percentage of Uncovered Stent Struts as Assessed by OCT (M3 and M4) and Histology at Different Time Points

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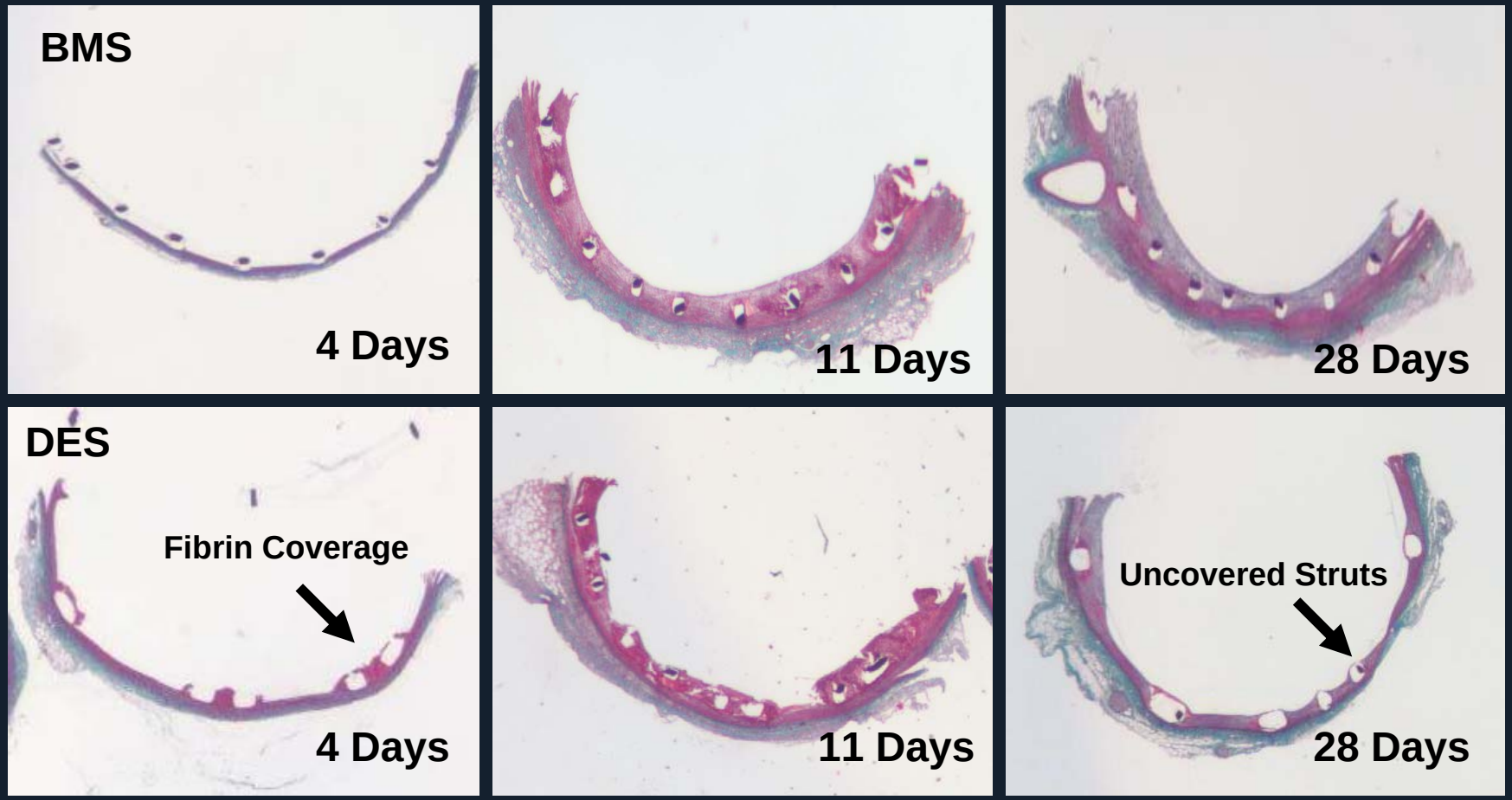
# Strut Coverage by OCT

## BMS versus DES at Different Time Points

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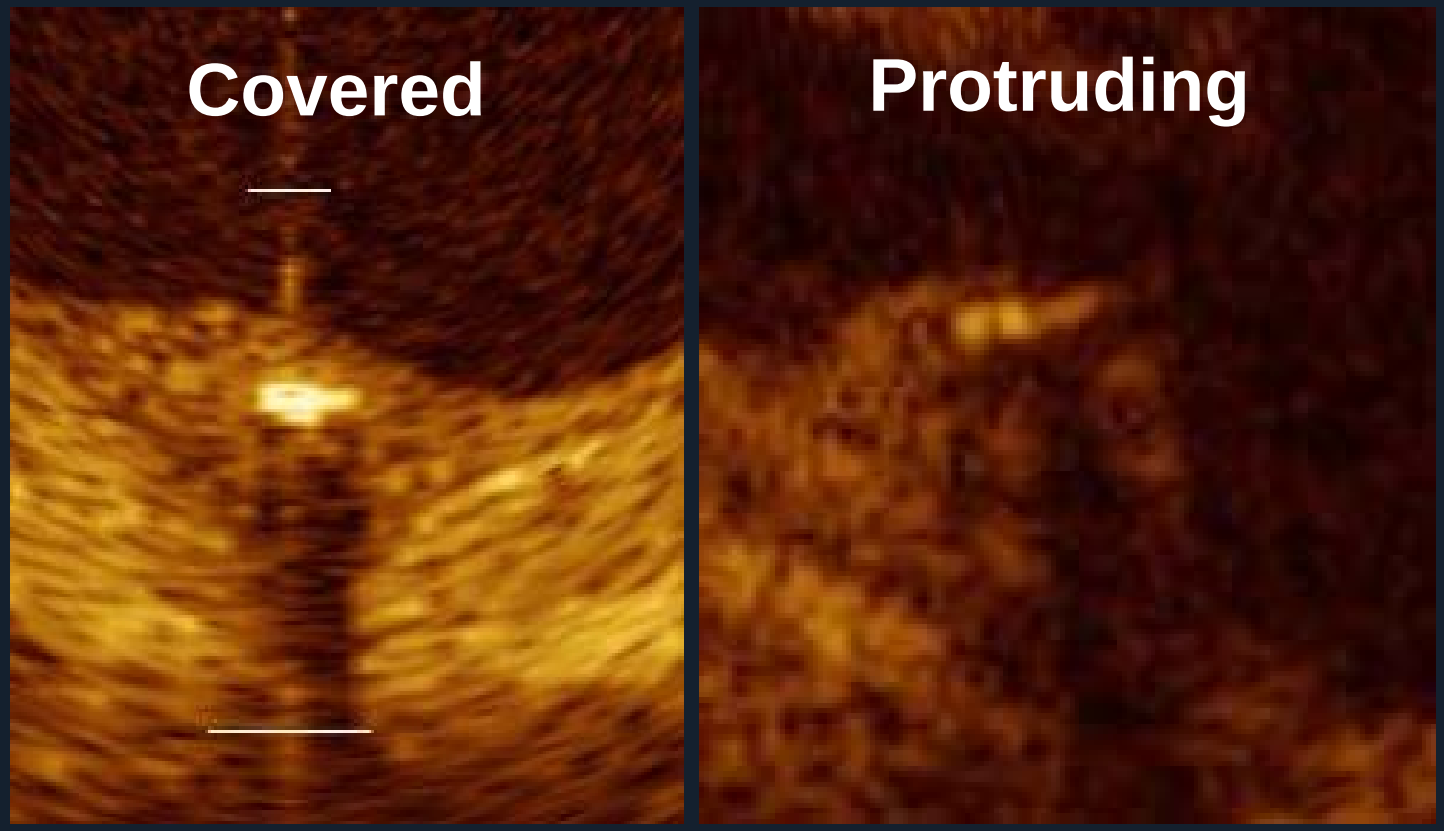
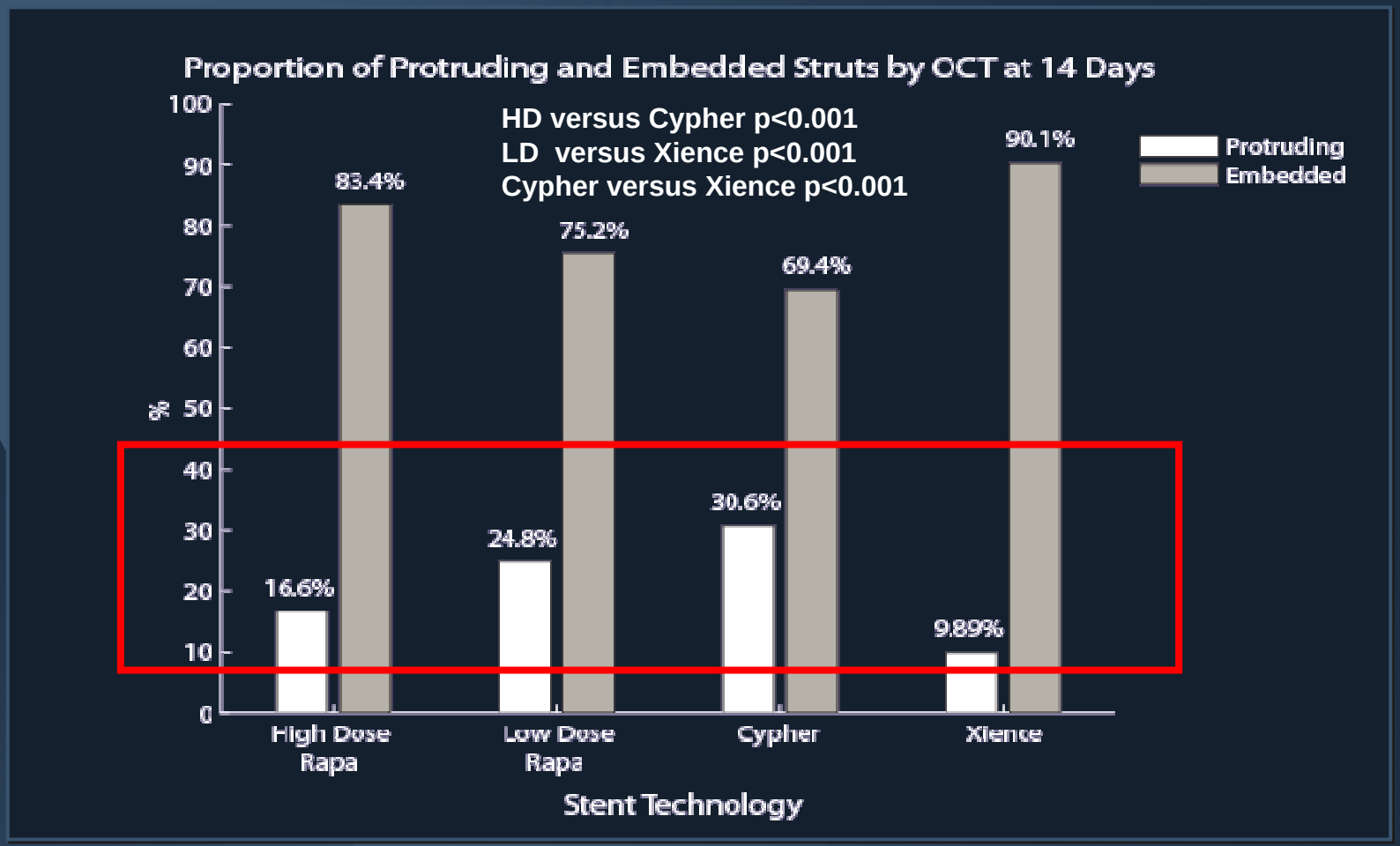
# “The Protruding Strut”: Implications for Healing and Coverage



# The Protruding Strut: Is It an OCT Surrogate of Vascular Healing?

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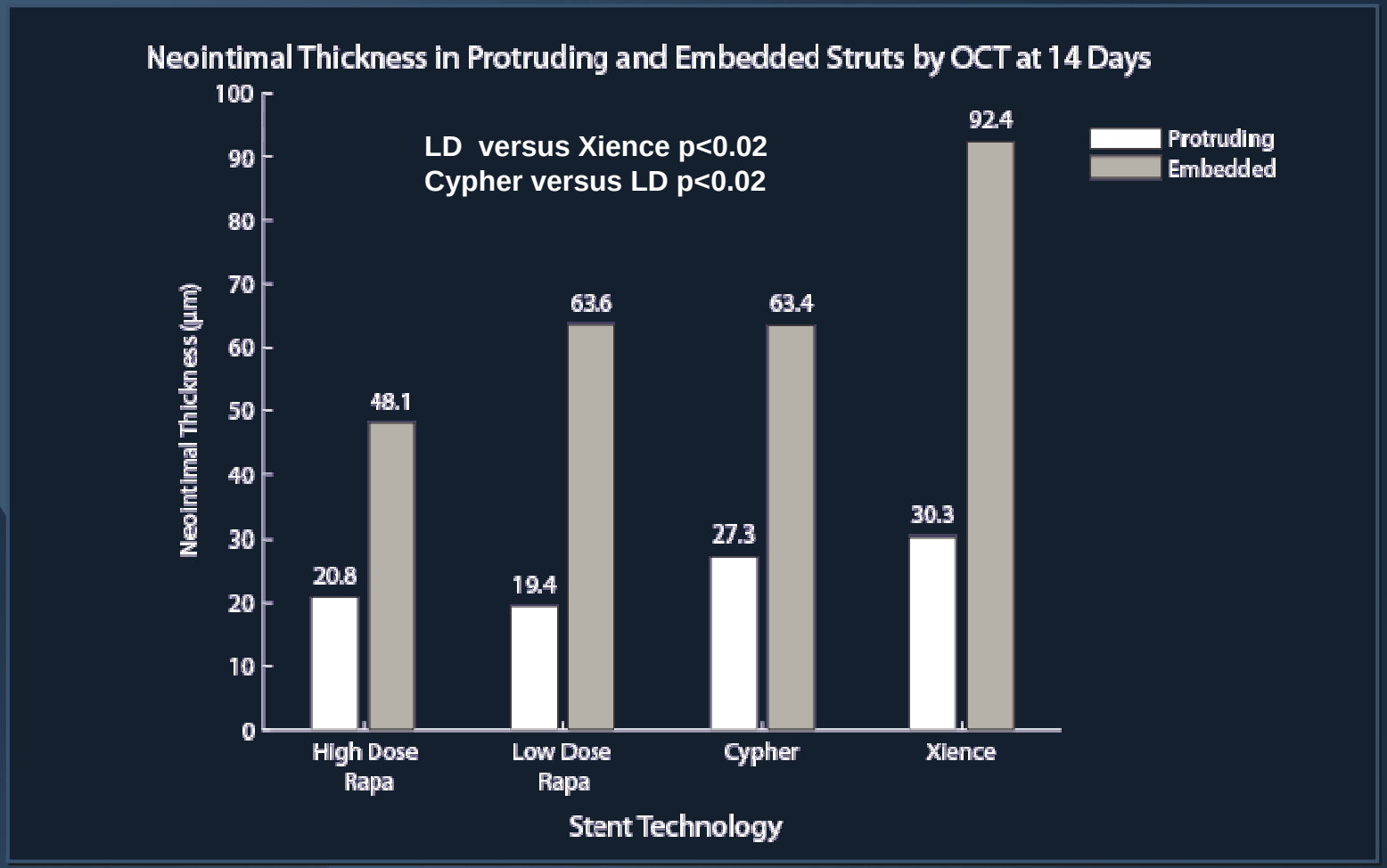
# The Protruding Strut and Neointimal Thickness at 14 Days

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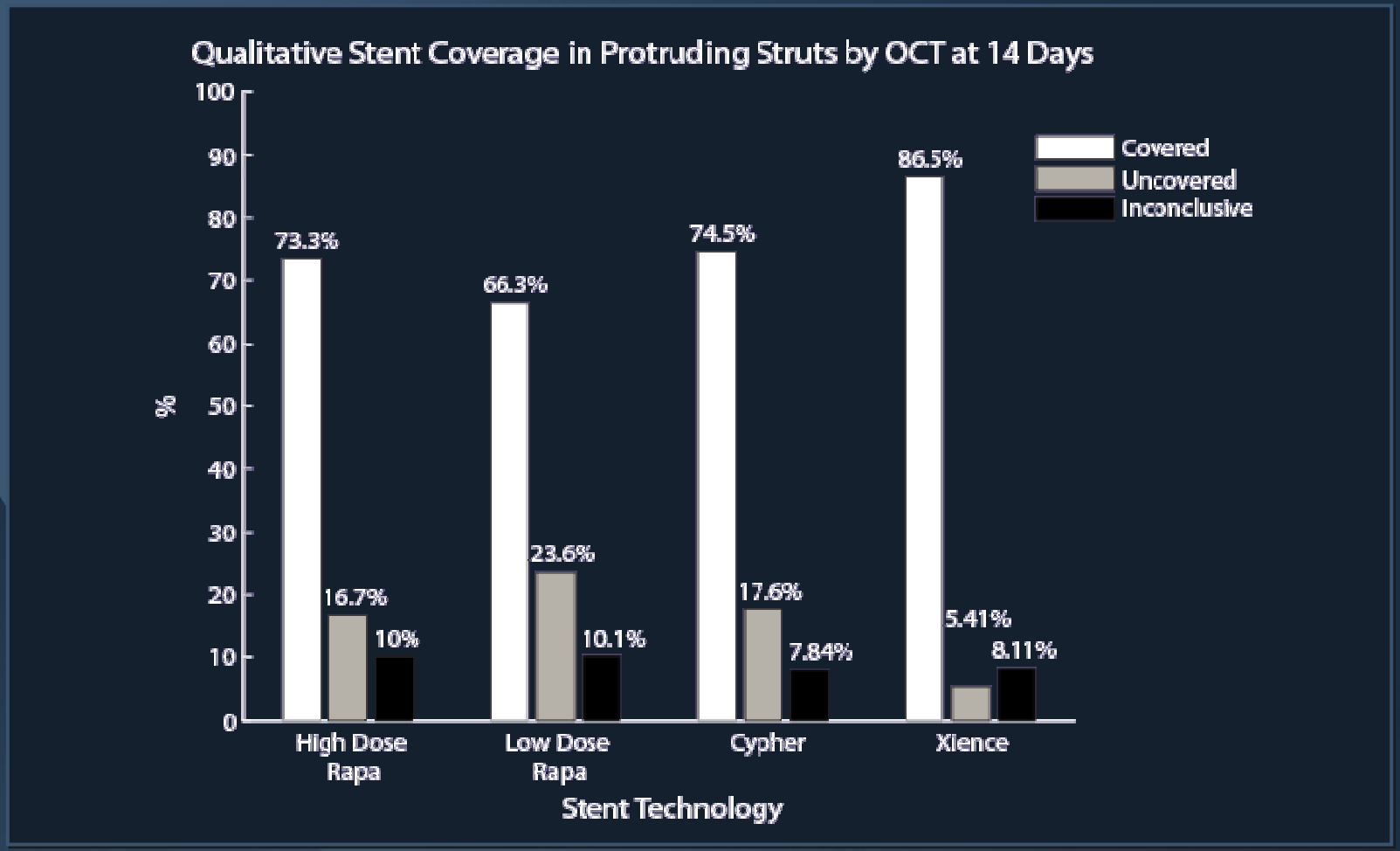
# The Protruding Strut and Strut Coverage at 14 Days

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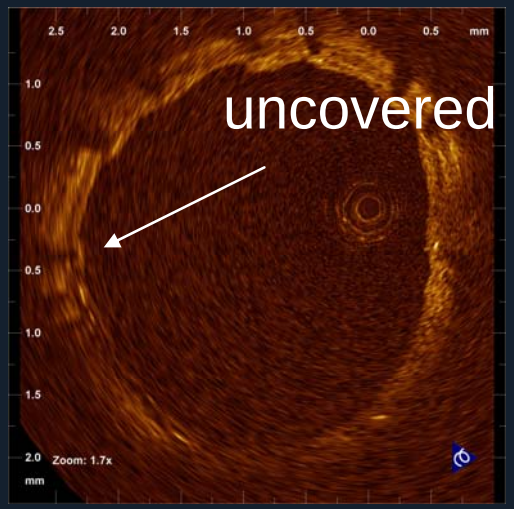
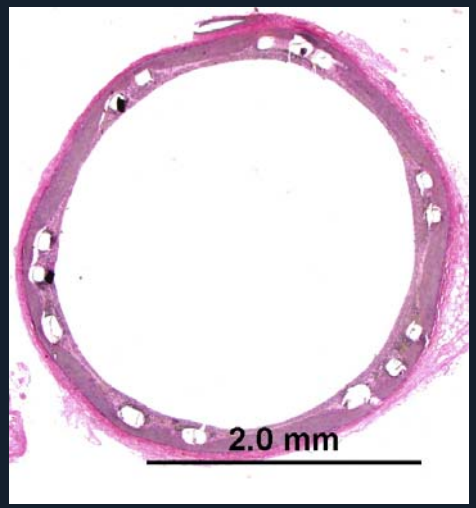
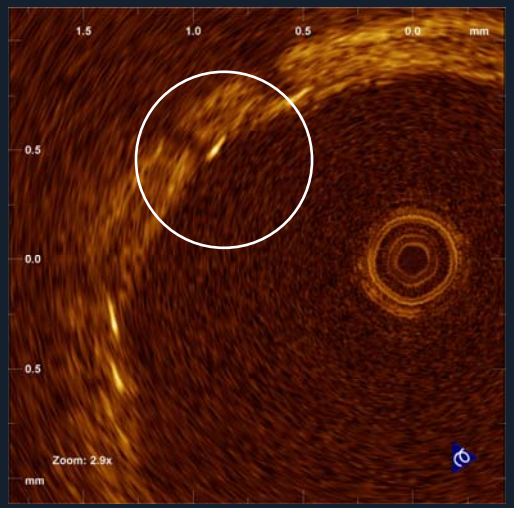
# Limitations: Insufficient Resolution to Detect Thin Neointima

**Histological NT: 0.04mm**

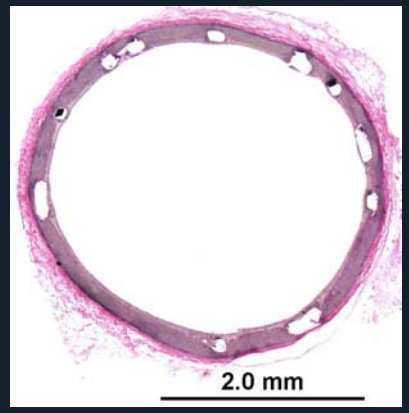



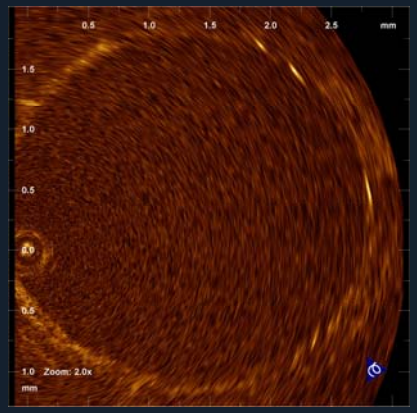




**Histological NT (mean):**

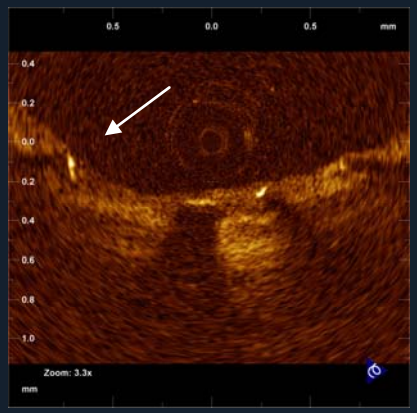
- **Xience 0.040 mm**
- **Taxus 0.038 mm**
- **Endeavor 0.042 mm**

# Limitations: Areas of Difficult Interpretation

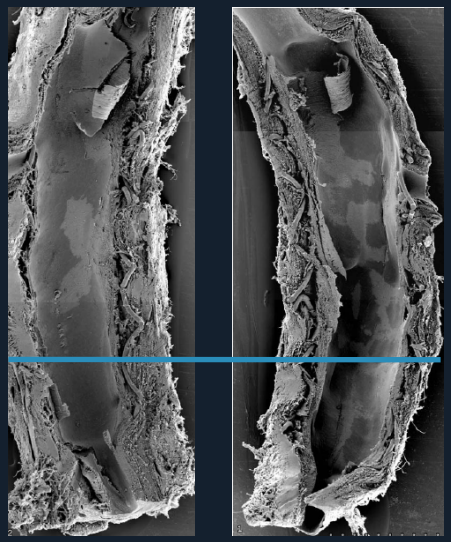


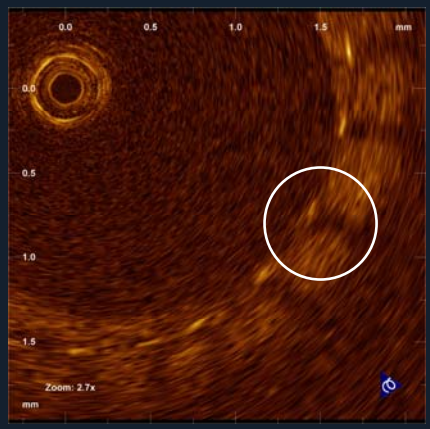



Poor Image quality

Out of plane stent





Poor tissue/stent contrast

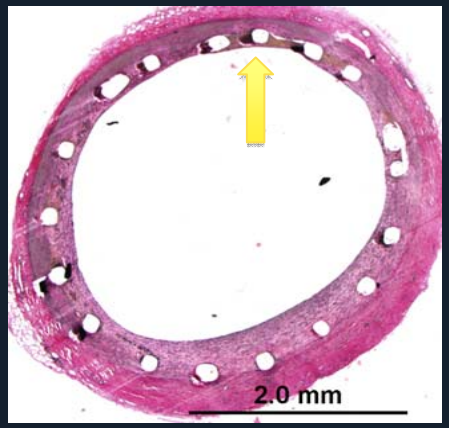
# The Challenges of the Qualitative Assessment of Strut Coverage by OCT

## Strut Coverage versus Endothelialization

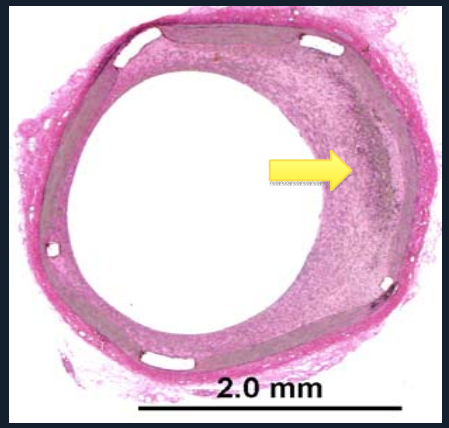
- The mean cross sectional diameter of an individual EC is out of the range of resolution of OCT.
- Therefore, strut coverage by OCT must be seen as a marker of the amount of ***tissue deposited*** on the surface of the stent and not as a marker of stent endothelialization.
- Strut coverage occurs early after stent implantation, occurring earlier and in a higher proportion in DES.
- In addition, the amount of strut coverage identified in vivo by OCT must be interpreted with caution as the strut may be covered by tissue other than healthy ECs (i.e., fibrin).

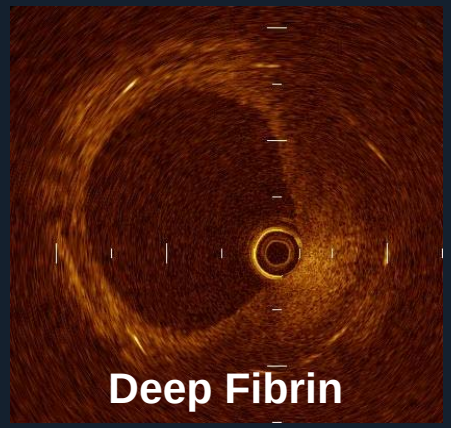
# OCT Histological Correlates

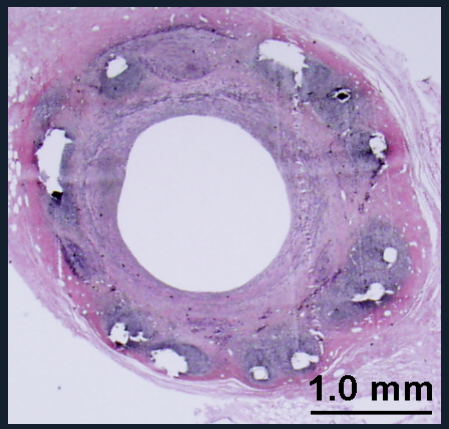
## *Drug Eluting Stents at 28 Days*

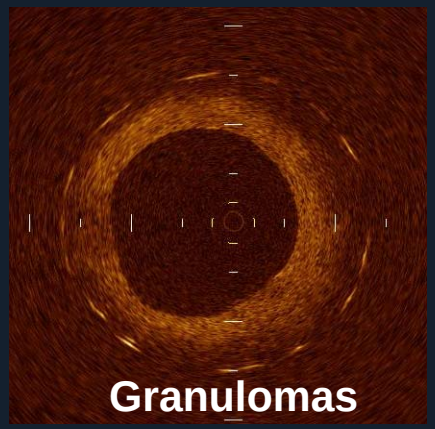







***Therefore, several OCT imaging patterns may be the result of the deposition of different tissue types carrying different biological consequences.***

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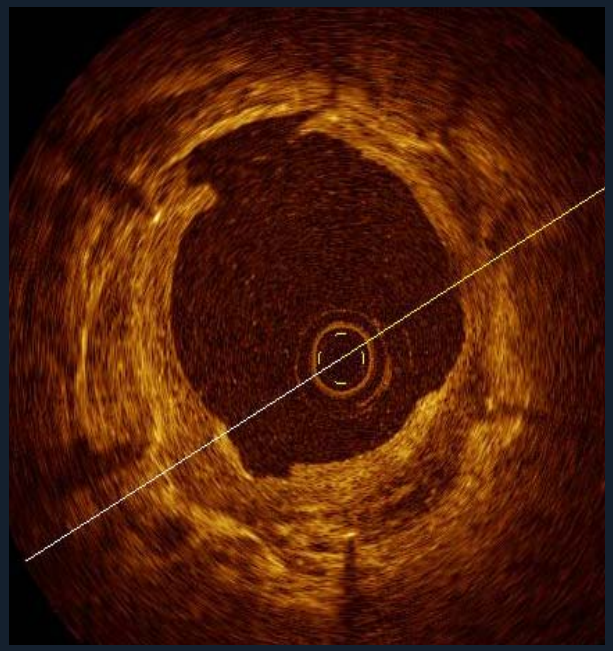
# Different Neointimal Patterns Seen in OCT Following DES Implantation

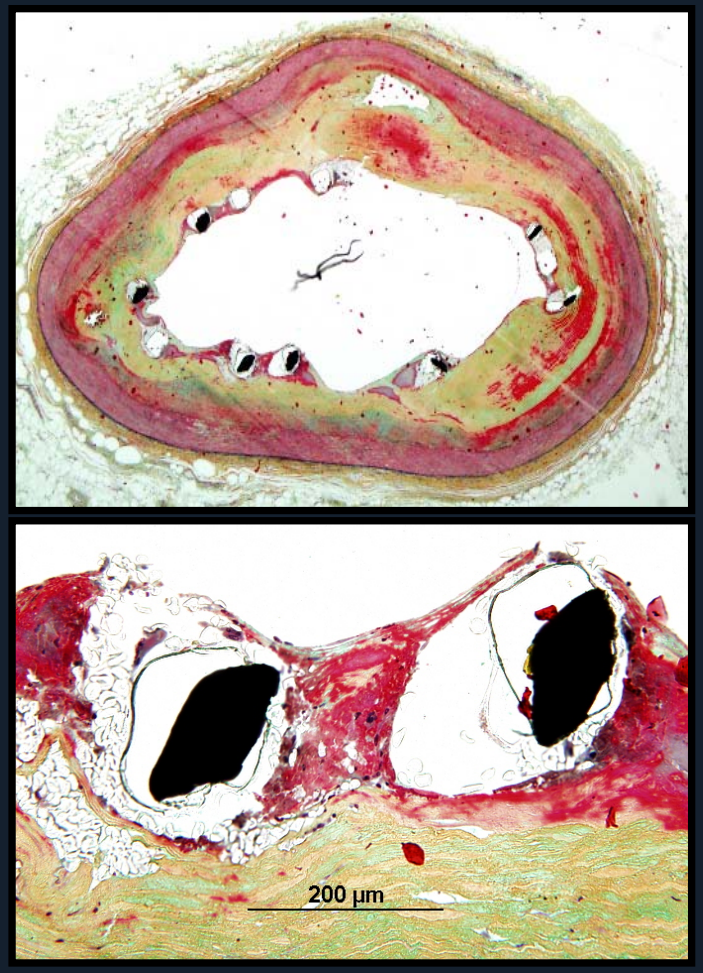
Cypher - 6 Months



Cypher - 6 Months

Taxus - 13 Months

# Endovascular Imaging and Vascular Healing: "Stent Coverage Risk Score"




- **Degree of strut coverage:**
  - **Endothelial Cells.**
  - **Others.**
- **Fibrin deposition:**
  - **Superficial (peri-strut).**
  - **Deep (vessel wall).**
- **Vessel wall inflammation.**
- **Overall vessel wall "assessment":**
  - **Pro-thrombogenic surface *versus***
  - **Anti-thrombogenic surface.**

# OCT Imaging and Vascular Healing Assessment Following DES Implantation

- Today, due to significant improvements in OCT technology, the in vivo assessment of vascular healing following stent implantation is possible.
- OCT can accurately and reproducibly measure subtle changes in neointimal area, thickness, and percent area of stenosis.
- The assessment of strut coverage is feasible and reproducible. However, its clinical significance is still unknown and further research is required to elucidate the importance of this finding.
- As these biological changes may be technology-specific, tissue characterization studies using different DES technologies are essential.
- Due to its technical limitations in the far field, IVUS-OCT combination techniques will be required...and developed.
- In the future, it is possible that lessons learned from prospective clinical trials using this technology, will provide the basis to enhance the safety profile of DES.