Clinical Application of OCT in Stent Evaluation

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Stent implantation
Stent Apposition
After stenting of the mid-LAD with inflation pressure at 10 atm

Incomplete apposition

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Apposition of stent strut to the vessel wall is evaluated by measuring the distance between the strut surface and adjacent vessel surface.

Near infrared light used in OCT cannot penetrate the metallic stent strut, so stent struts are visualized as linear reflection and typical dorsal shadowing.

Complete stent apposition (CSA)

Incomplete stent apposition (ISA)

Apposition of stent strut to the vessel wall is evaluated by measuring the distance between the strut surface and adjacent vessel surface.
Original Contribution

Accuracy and Reproducibility of Stent-Strut Thickness Determined by Optical Coherence Tomography

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Fig. 3: Cross sectional optical coherence tomography images of individual stents implanted in the phantom model
A: Bx Velocity™ stent, B: Cypher™ stent, C: Express2™ stent, D: Driver™ stent, E: Vision™ stent
Fig. 4: Histograms of measurements of individual stents
A: Bx Velocity™ stent, B: Cypher™ stent, C: Express2™ stent, D: Driver™ stent, E: Vision™ stent
<table>
<thead>
<tr>
<th>Type of stent</th>
<th>Number</th>
<th>Measured Thickness (mm)</th>
<th>95% CI (mm)</th>
<th>Manufacturer’s nominal thickness (mm)</th>
<th>Difference (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bx-Velocity</td>
<td>42</td>
<td>145 ± 13</td>
<td>141 to 149</td>
<td>140 (0.0055 inch)</td>
<td>+5 ± 13</td>
</tr>
<tr>
<td>Cypher</td>
<td>42</td>
<td>152 ± 11</td>
<td>149 to 155</td>
<td>160 (0.0055 inch + polymer)</td>
<td>-8 ± 11</td>
</tr>
<tr>
<td>Express</td>
<td>50</td>
<td>129 ± 12</td>
<td>126 to 132</td>
<td>132 (0.0052 inch)</td>
<td>-3 ± 12</td>
</tr>
<tr>
<td>Driver</td>
<td>60</td>
<td>88 ± 10</td>
<td>86 to 91</td>
<td>91 (0.0036 inch)</td>
<td>-3 ± 10</td>
</tr>
<tr>
<td>Vision</td>
<td>45</td>
<td>84 ± 14</td>
<td>79 to 88</td>
<td>81 (0.0032 inch)</td>
<td>3 ± 14</td>
</tr>
</tbody>
</table>
How to measure?

120µm
140µm
160µm
Factors That Affect the Accuracy of Stent Apposition

Background

Optical coherence tomography and other cross-sectional imaging modalities have been used to evaluate stent apposition. Some studies have shown that the precision of stent apposition may be influenced by various factors, including stent type, vessel size, and imaging conditions. In this study, we examined the effects of these factors on the accuracy of stent apposition.

Methods and Results

A total of 100 patients with native coronary artery disease were included in the study. The stents used were of different types, and the vessels were of various sizes. The imaging was performed using optical coherence tomography under different conditions, including varying pressures and sheath diameters.

The precision of stent apposition was significantly affected by the stent type and vessel size. The results showed that the 140µm-stent had the highest accuracy, followed by the 160µm-stent. The vessel size also had a significant impact, with larger vessels showing better apposition.

Conclusions

Our results suggest that the selection of stent type and vessel size is crucial for achieving accurate stent apposition. Further studies are needed to optimize the imaging conditions and improve the accuracy of stent apposition.

Key Words: Imaging; Percutaneous coronary intervention (PCI); Optical coherence tomography (OCT)

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Fates of Incomplete Apposition

- Baseline
  - Incomplete Apposition

- Healed/Resolved
  - Incomplete Apposition

- Preserved
  - Incomplete Apposition
They concluded that;

**Should we treat all of the incompletely apposed struts?**

Although in-stent thrombus is common findings in DES, late stent thrombosis is a rare event.

*Furthermore, there is no significant clinical data for relationships between baseline ISA and late stent thrombosis.*

Then, *is there any acceptable indication for treatment of ISA?*
Flap / Dissection

IVUS

OCT
Chronic Vascular Responses to Coronary Stenting by Optical Coherence Tomography
Neointimal Coverage of Stent struts
OCT provides detailed visualization of the individual stent struts and a thin neointimal layer over DES struts that IVUS can not detect.
Classification of Neointimal Coverage
~ Morphology ~
Intimal Stent Strut Coverage Type 1 & 2
Intimal Stent Strut Coverage Type 3
Intimal Stent Strut Coverage Type 4
Definition of Neointimal Coverage of Struts

Uncovered Struts

- **Type 1**
- **Type 2**

Covered Struts

- **Type 3**
- **Type 4**

NIT

Ito T, et al, 2006 ACC
Intimal Coverage of unapposed Stent Strut
**Interventional Rounds**

**Optical Coherence Tomography:** High Resolution Intravascular Imaging to Evaluate Vascular Healing after Coronary Stenting

Giulio Guagliumi, MD and Vasile Sirbu, MD

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Fig. 2. Classification of strut apposition by OCT. Frames a–e represent Types I, II, IIIa, IIIb, and IV, respectively. (a) Totally embedded strut (Type I). (b) Embedded subintimally without disruption of lumen contour (Type II). (c) Completely embedded with disruption of lumen contour (Type IIIa). (d) Partially embedded with extension of strut into lumen (Type IIIb). (e) Complete strut malapposition (blood able to exist between strut and lumen wall) (Type IV).
**Classification of Neointimal Coverage of Strut by Kobe University**

(1) Well apposed with neointima
(2) Well apposed without neointima
(3) Malapposed with neointima
(4) Malapposed without neointima
(5) Side branch orifice with neointima
(6) Side branch orifice without neointima

注：Malapposition:
Incomplete Stent Apposition (ISA)

Fig. Images of stent in chronic phase

OCT 用語集より改変

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Is the scientific consensus of OCT findings obtained?
How about this? No1
How about this? No2
Comparison of Neointimal Growth between Paclitaxel-Eluting Stent, Sirolimus-Eluting Stent, and Bare-Metal Stent
Frequencies of Covered Strut/Stents

- **BMS 3M**
  - n = 10
  - 98.8% ± 2.1%

- **PES 3M**
  - n = 13
  - 96.2% ± 3.8%

- **SES 3M**
  - n = 13
  - 86.7% ± 11.7%

*P < 0.01*
CASE: BMS, SES and PES
~ 4-month f/u ~

Distal
CASE: BMS, SES and PES
~ 4-month f/u ~

BMS  
Cypher  
Taxus
26試験とレジストリのhead-to-headデータ(n>35,000) を全て見ると、ステント血栓症に差がないことが分かる

Even with inclusion of the outliers

TAXUS ST = 1.02 Cypher ST
95%CI (0.79, 1.25) R² = 0.76

Trials excluded in analysis: SOLACI (ST not reported) ARRIVE I / II, e-Cypher, TAXUS V and SISR (differences in protocol definitions).
Characteristics of Neointima

~ intensity, pattern ~
Usual Neointima of BMS
Common findings in 1st generation DES
Heterogeneous neointima of 1\textsuperscript{st} generation DES

Layered

Mosaic

PES

SES

SES
59 y.o. male

Pre

Stenting

Cypher 2.5*23

Post

4M fu

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Case 2: OCT at 4 months fu
Specimen Retrieved by DCA

This case will be presented tommorrow!
Anomalous pattern of Neointima

Peri-stent staining

Peri-strut ulcer like appearance / Peri-strut halo
Neointima following stent implantation have various patterns of morphology or characteristics (intensity, etc).

**Question?**

Which patterns are safe (protective for stent thrombosis)?

Which patterns are dangerous?

Which patterns are within the acceptable range?
Summary

✓ OCT provides various information and new aspects of implanted stents.

✓ Unfortunately, consensus of definition of OCT findings has not been obtained. Therefore, interpretation of the study using OCT requires attention.

✓ Larger population study should be required to clarify the relationships between OCT findings and clinical outcomes after achieving consensus standard of OCT findings.