OCT – how it works

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The history of intravascular OCT

- 1990-91: Invention of OCT
  - Fujimoto (USA); Tanno (Japan)
  - (Brezinski, Tearney, Boppart, Bouma, Fujimoto et al)
- 2000-2002 First published clinical studies
  - Stent imaging (Grube et al, 2001; Bouma et al, 2002)
  - Plaque characterization (Yabushita et al, 2002)
  - Macrophage detection (Tearney et al, 2002)
- 2002 Commercialization phase
  - LightLab M2-M3
- 2008 New technology systems
  - Lightlab M4
  - MGH OFDI
  - Terumo OFDI
  - Volcano
**OCT – comparison to other intracoronary imaging modalities**

<table>
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<tr>
<th>Technology</th>
<th>Resolution</th>
<th>Fibrous cap</th>
<th>Lipid core</th>
<th>Inflammation</th>
<th>Calcium</th>
<th>Thrombus</th>
<th>Detection</th>
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</thead>
<tbody>
<tr>
<td>IVUS</td>
<td>&gt;100 μm</td>
<td>+</td>
<td>+</td>
<td>–</td>
<td>+++</td>
<td>+</td>
<td>Gross plaque morphology and dimensions, Remodelling</td>
</tr>
<tr>
<td>Angioscopy</td>
<td>100 μm</td>
<td>+</td>
<td>++</td>
<td>–</td>
<td>–</td>
<td>+++</td>
<td>Plaque surface visualisation</td>
</tr>
<tr>
<td>OCT</td>
<td>10 μm</td>
<td>+++</td>
<td>+++</td>
<td>++</td>
<td>+++</td>
<td>+</td>
<td>Detailed morphology, including fibrous cap, macrophages</td>
</tr>
<tr>
<td>Thermography</td>
<td>500 μm</td>
<td>–</td>
<td>–</td>
<td>+++</td>
<td>–</td>
<td>–</td>
<td>Surface temperature</td>
</tr>
<tr>
<td>Spectroscopy</td>
<td>–</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>–</td>
<td>Chemical and tissue characteristics</td>
</tr>
<tr>
<td>Intravascular MRI</td>
<td>160 μm</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>Gross plaque morphology and structure</td>
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</table>
Figure 2. Fibrous coronary plaque imaged in vivo by optical coherence tomography (OCT) (A) and intravascular ultrasound (IVUS) (B). (A) From 9 o’clock to 2 o’clock, this OCT image demonstrates visualization of the intima (with intimal hyperplasia [i]), media (m) and adventitia (a). The internal and external elastic laminae are visible as signal-rich lines bordering the media (inset). A plaque extending from 2 o’clock to 9 o’clock contains a homogeneous, signal-rich region consistent with a fibrous plaque (f) that is partially obscured by a guidewire shadow artifact (*). (B) In the corresponding IVUS image, the fibrous plaque (f) is also visualized. Tick marks, 1 mm.
OCT technology

- OCT is an intravascular imaging modality that utilizes near-infrared light to generate cross-sectional blood vessel images.

- Up to 10 to 15 μm of spatial resolution compared with the 100- to 200-μm resolution.

- OCT imaging depths range from 1 to 3 mm into the vessel wall, whereas IVUS imaging depths range from 4 to 10 mm.

- OCT imaging requires transient blood clearing during image acquisition (since near-infrared light is scattered by red blood cells).
OCT – time domain vs. frequency domain imaging

• **First generation** – **time delay OCT** (TD-OCT) systems
  – Utilized a moving reference mirror to calibrate reflected light waves for image acquisition (mirror mechanics were relatively slow)
    • **Acquisition time:** 1-2 mm/s

• **Second-generation technology** - **frequency domain (also called Fourier domain) OCT** (FD-OCT).
  – Compared with TD-OCT, FD-OCT has a better spatial resolution and 10 times faster image acquisition (because it utilizes an ultrafast frequency swept light source rather than a mechanical reference mirror)
    • **Acquisition time:** 20-40 mm/s
OCT intracoronary imaging

The ILUMIEN OCT system uses a 2.7F monorail C7 Dragonfly Intravascular Imaging Catheter. Delivered through a 6F guide over standard 0.014-inch intracoronary guidewire.

1. Advance the catheter distal to the segment of interest and position according to the vessel segment of interest.
2. Start scanning by activation from the image console (flushing the OCT catheter at this moment might damage the catheter which should be avoided).
4. Start OCT pullback when an optimal blood clearance is achieved as seen on the monitor of the image console.
5. Acquire the fluoroscopic images simultaneously.
6. Monitor ECG, heart rate and arterial pressure during pullback to rule out ischaemia.
7. Withdraw the OCT imaging catheter into the guiding catheter once the pullback is completed.
8. Re-insert the OCT catheter for image acquisition in another segment of interest if needed.

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Tools & Techniques: Intravascular ultrasound and optical coherence tomography
C7 OCT Vascular System
Consensus Standards for Acquisition, Measurement, and Reporting of Intravascular Optical Coherence Tomography Studies

A Report From the International Working Group for Intravascular Optical Coherence Tomography Standardization and Validation
OCT imaging catheter
OCT imaging
OCT imaging

Blood in catheter lumen

Purged catheter lumen
Cave: OCT artifacts
OCT image: plaque rupture and plaque erosion

OCT for evaluation of stent healing

Neointimal coverage of sirolimus-eluting stents at 6-month follow-up: evaluated by optical coherence tomography

Figure 1 Classification of SES strut conditions by OCT. (A) Well-apposed with neointimal coverage. (B) Well-apposed without neointimal coverage. (C) Malapposed without neointimal coverage.

Figure 5 Distribution of SES strut condition. Of the 6840 stent struts in 57 SES, 6236 (91%) were classified as well-apposed with neointima, 455 (7%) as well-apposed without neointima, 79 (1%) as malapposed without neointima, and 70 (1%) were at the site of a major side branch.
OCT – 3 dimensional reconstruction

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Thank you