Optical coherence tomography for differentiation of lesion morphology in peripheral vessels

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Disclosure

Speaker name: Marianne Brodmann

I have the following potential conflicts of interest to report:

- [x] Consulting
- Employment in industry
- Stockholder of a healthcare company
- Owner of a healthcare company
- Other(s)

- I do not have any potential conflict of interest
Background

- Re-obstruction following endovascular intervention is a common clinical challenge
- Occurs more frequently in different vessel regions
- Frequency and severity also depend on primary treatment modality
- Currently treatment is guided by angiography
  - no information regarding the activity of atherosclerotic disease can be derived
  - no prognosis can be made on the occurrence of re-obstruction

Optical coherence tomography (OCT) is a novel technology for cross-sectional and three-dimensional imaging in biological systems with ultra-high resolution which might become an appropriate diagnostic measure.
OCT _differentiation_ lesionmorphology
Peripheral vessels

OCT _principle

Catheter-based intravascular optical imaging method

✓ Combines the principles of ultrasound with the imaging performance of a microscope
✓ Measures the intensity of back-reflected near-infrared light to measure the thickness of different biological tissues
✓ OCT uses light which provides a significantly higher spatial resolution than that of any ultrasound technique
✓ OCT images can have axial resolution of 10µm. The velocity of light is extremely high

   Near-infrared light is delivered to the imaging site through a simple optical fiber, split into two arms, a sample and reference arm. These separate paths of light will ultimately be reflected back to the fiber-optic beam splitter and combined. When these two light pulses coincidence an interference pattern is generated, which can be measured by a photo detector. It is then amplified, digitalized, and passed to a computer for OCT image reconstruction
Schematic representation of time-domain optical coherence tomography (TD-OCT, left panel) and frequency or Fourier-domain optical coherence tomography (FD-OCT, right panel)

Both systems use a reference arm and an interferometer to detect echo time delays of light. The interferometer uses a beamsplitter, dividing the light into a measurement arm (tissue sample) and a reference arm.

The reference arm in TD-OCT is mechanically scanned (by a moving mirror) in order to produce a time-varying time delay. In the FD-OCT, because the light source is frequency swept, the interference of the 2 light beams (tissue and reference) oscillates according to the frequency difference. In both systems the interference of the signal ultimately provides amplitude and frequency data. In the FD-OCT system, all echo delays are acquired simultaneously enabling significant increases in the speed of image acquisition.

OCT _ differentiation _ lesion morpholo

Peripheral vessels

OCT_principle
OCT differentiates lesion morphology
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OCT Clinical Applications

Malapposition Quantification

Fibrotic Cap Measurement

A longitudinal reconstruction (lower panel) and cross-sectional images (upper panels) acquired with a frequency or Fourier-domain optical coherence tomography (FD-OCT) system (Lightlab) at 20 mm/s immediately after stent implantation. Note that a 5-cm coronary segment was imaged with a 3-s contrast injection. (A) Distal edge dissection, with corresponding longitudinal view (arrows). (B) Well-expanded and well-apposed stent struts, with corresponding longitudinal view. (C) Malapposed struts between 11 and 1 o’clock, with corresponding longitudinal view (arrows). (D) Proximal calcified plaque with minimal fibrous coverage, with corresponding longitudinal view (arrows).
OCT differentiation lesion morphology
Peripheral vessels

OCT_Coronary imaging

Quantitative Stent Analysis

OCT_Histological correlation

**OCT_Histological correlation**

**A Fibrotic plaque:** characterized by high signal (high backscattering) and low attenuation (deep penetration)

**B Predominantly calcified plaque:** calcified regions have a sharp border, low signal, and low attenuation permitting deeper penetration

**C Lipid-rich plaque:** the lipid core has a diffuse border. High light attenuation results in poor tissue penetration (in contrast to calcified regions)
OCT differentiates lesion morphology

Peripheral vessels

OCT-Histological correlation

(A) A thin-cap fibroatheroma with associated thrombus (arrowhead) from a subject with an acute coronary syndrome. The image demonstrates a lipid rich plaque (lipid pools denoted by L) with a thin fibrous cap (arrow) measuring 43 μm. There is a high OCT signal with significant signal heterogeneity within the fibrous cap consistent with high macrophage content. The macrophage content derived from the raw OCT signal NSD was 6% and the subject's peripheral WBC count was 9.0.

(B) A fibroatheroma from another subject demonstrating a lipid pool (L) involving only one quadrant underlying a homogenous signal-poor thick fibrous cap suggestive of a low macrophage density. The macrophage density derived from the raw OCT signal NSD was 3% and the subject's peripheral WBC count was 5.4. WBC=white blood cell count (10^9 cells/L).

Scatter plots of (A) plaque fibrous-cap macrophage density to the logarithm of plaque fibrous cap thickness, (B) peripheral WBC count to plaque fibrous-cap macrophage density and (C) peripheral WBC count to the natural logarithm of plaque fibrous cap thickness. Pearson's correlation coefficient (r) and the p value are depicted in the insert. WBC=white blood cell count (10^9 cells/L).

Raffel OC; Arterioscler Thromb Vasc Biol. 2007 Aug;27(8):1820-7
OCT use as an ancillary imaging tool during SFA endovascular interventions
OCT_Peripheral arteries_Graz

**Aim:**

i) better understand

ii) finally assess re-obstruction characteristics in relation to primary lesion specifics and treatment approach using OCT technology

**Design:** prospective, single-center, pilot study
Patient population:
- For the first phase (differentiation of re-obstruction), 20 patients with symptomatic re-obstruction after endovascular treatment (10 POBA, 10 stent) of the femoropopliteal artery will be included.
- For the second phase (primary lesion character) another group of 20 patients with symptomatic lesions (Rutherford 2-3) will be evaluated.

Duration: Study assessments as baseline, 3, 6, and 12 months.
OCTPeripheral arteries Graz

**Current status:**

first phase (differentiation of re-obstruction): enrollment finished
second phase will start in april 2016
Thank you for your attention!
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