Technical Considerations and Practical Guidance for Intracoronary Optical Coherence Tomography

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KEYWORDS

• Intravascular imaging • Optical coherence tomography • Coronary intervention

KEY POINTS

- Optical coherence tomography (OCT) is an intravascular imaging technology analogous to intravascular ultrasound (IVUS), using near-infrared light rather than ultrasound, thereby providing higher-resolution images.
- Successful OCT image acquisition requires adequate positioning of the imaging catheter and sufficient luminal blood clearance with contrast injection.
- Guide catheter size should generally be at least 6F, and the guide catheter shape should provide well-seated, coaxial alignment with the coronary ostium.
- For power injection, specific settings for the left and right coronary arteries should be used.
- Relevant OCT measurements before percutaneous coronary intervention (PCI) include lesion length, minimal luminal area, proximal and distal reference vessel locations, and diameters.
- Relevant post-PCI OCT assessment includes stent expansion, apposition, edge dissection, plaque prolapse, and geographic miss.
- Successful, safe, and efficient OCT imaging requires an understanding of the system setup, imaging catheter characteristics, and methods to improve image quality.

INTRODUCTION

OCT is a recently established modality for intracoronary imaging. Although initially developed for in vivo retinal imaging, OCT has, after nearly 2 decades of research, evolved into a clinically applicable diagnostic tool for interventional cardiology. OCT uses light in the near-infrared spectrum (wavelength 1250–1350 nm) to provide a large amount of qualitative and quantitative information regarding vessel lumen diameter, plaque morphology, lesion length, and lesion characteristics. In so doing, it is an important tool to guide PCI strategy. The wavelength range used by OCT permits adequate tissue penetration with an axial resolution of 12 to 18 μm and a lateral resolution of 20 to 90 μm (as a function of distance from the arterial wall). This degree of resolution is approximately 10-fold higher than that of IVUS.[1] This review provides a practical guide to OCT imaging, with a particular emphasis on the techniques and approaches to optimize image acquisition, improve the evaluation of coronary lesions, and guide the strategies for PCI.

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OPTICAL COHERENCE TOMOGRAPHY SYSTEMS AVAILABLE IN THE UNITED STATES AT PRESENT

Coronary OCT systems in their first incarnation were time-domain (TD) systems that required balloon occlusion to provide the blood-free lumen necessary to acquire adequate images. These systems are now of only historical interest, because they have been supplanted by the development of frequency/Fourier-domain (FD) systems, which can rapidly acquire images and therefore enable the use of contrast injection to clear luminal blood, eliminating the need for balloon occlusion. The ILUMIEN and ILUMIEN OPTIS systems (St. Jude Medical, Inc, Westford MA, USA) are OCT-FD systems that are approved for use by the US Food and Drug Administration (FDA). These systems rapidly image along a relatively long segment of vessel in 3 seconds or less. The OPTIS system has 2 modes of image acquisition: survey and high resolution. The survey mode provides a rapid pullback of 75 mm over 2.1 seconds at 180 frames per second (ie, in 5 frames/mm). The high-resolution mode images a 54-mm vessel segment at a similar frame rate over 3 seconds (ie, 10 frames/mm), which provides twice the frame density with the same pullback length and duration as the original ILUMIEN system (Table 1). The OPTIS system software also provides an automated lumen profile that can improve stent planning workflow, such as automatic lumen detection on every frame, a profile of mean diameter or area across the length of the pullback, automatic marking of the site of the minimal lumen area (MLA), and automated display of reference frame areas and diameters.

Table 1
Characteristics of OCT image acquisition with the ILUMIEN OPTIS system

Parameter	Survey Mode	High-Resolution Mode
Engine speed	180 frames/s	180 frames/s
Pullback speed	36 mm/s	18 mm/s
Frame density	5 frames/mm	10 frames/mm
Pullback length	75 mm	54 mm
Pullback duration	2.1 s	3.0 s
Total frames collected	375 frames	540 frames

In addition, the high-resolution mode allows for real-time, immediate 3-dimensional reconstruction of the vessel lumen, which aids in the analysis of complex anatomy.

CLINICAL APPLICATION OF INTRACORONARY OPTICAL COHERENCE TOMOGRAPHY

In 2010, the FDA approved OCT for imaging within native coronary arteries 2.0 mm to 3.5 mm in diameter. The 2011 American College of Cardiology Foundation/American Heart Association/Society of Cardiovascular Angiography and Interventions Guideline for PCI does not provide formal recommendations regarding the clinical use of OCT, in contrast to IVUS.[2] Despite the lack of formal recommendations, OCT is increasingly being used in a variety of clinical scenarios similar to guideline-directed IVUS imaging largely based on recent data, published consensus documents, and extrapolation from the IVUS literature. Key applications for OCT include evaluating nonostial lesions that are angiographically intermediate in severity, guiding coronary stent implantation, and assessing the mechanism of stent thrombosis or restenosis.

Optical Coherence Tomography for the Assessment of Coronary Stenosis Severity

Fractional flow reserve (FFR) has become the gold standard to determine the physiologic significance of coronary stenoses.[3,4] Nonetheless, the measurement of MLA by IVUS is also widely used to further evaluate the severity of angiographically intermediate coronary lesions. The basis for this approach comes from several studies that have shown moderate correlations between IVUS-derived MLA measurements and FFR values, with receiver operator characteristic (ROC) area under the curve (AUC) values ranging between 0.68 and 0.80.[5–7] Furthermore, an IVUS-based approach has been associated with good clinical outcomes and low subsequent adverse event rates.[8] OCT, similar to IVUS, can provide highly accurate and reproducible lumen area measurements.[9] The relationships between OCT-derived MLA, IVUS-derived MLA, and FFR have also been examined.[10] The optimal cutoff to predict an FFR less than or equal to 0.80 was an OCT-derived MLA threshold less than or equal to 1.95 mm^2, which provided a sensitivity of 82%, specificity of 67%, positive predictive value of 68%, and negative predictive value of 80%. Owing to only moderate specificity