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REVIEW

Optical Coherence Tomography Guided Percutaneous Coronary Intervention

Francis J. Ha, BMedSci [a], Joel P. Giblett, BM, MD [b], Nitesh Nerlekar, MBBS, MPH [a], James D. Cameron, MBBS, PhD [a], Ian T. Meredith, MBBS, PhD [a], Nick E.J. West, MB BChir, MD [b], Adam J. Brown, MB BChir, PhD [a*]

[a]Monash Cardiovascular Research Centre, Monash University and MonashHeart, Monash Health, Melbourne, Vic, Australia
[b]Department of Interventional Cardiology, Papworth Hospital NHS Trust, Cambridge, UK

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Optical coherence tomography (OCT) is an increasingly available intracoronary imaging modality that provides high-resolution imaging of coronary arteries. Its fundamental reliance on the emission and reflection of light enables rapid data acquisition without compromise of image resolution. As such, OCT can inform operators planning percutaneous coronary intervention (PCI) by accurately defining luminal geometry and detailing plaque composition. Following PCI, OCT imaging delivers a thorough assessment of the treated arterial segment and can identify specific features not always visible on alternate imaging modalities, including stent edge-related dissection, plaque tissue prolapse, incomplete stent apposition and the presence of intra-coronary thrombus. Clinical trials highlight that procedural strategy is frequently altered based on OCT findings, while concerns over final stent dimensions have been mitigated through use of a sizing protocol based on external elastic lamina dimensions in the reference arterial segment. Randomised trials are now warranted to definitively ascertain whether OCT-guidance improves clinical outcomes when utilised during PCI.

Keywords Optical coherence tomography • Percutaneous coronary intervention • Coronary artery disease

Introduction

Percutaneous coronary intervention (PCI) remains an established therapeutic option for the treatment of coronary artery disease. Although advances in stent technology, adjuvant pharmacology and secondary preventative medical therapies continue to improve outcomes following PCI, recurrent major adverse cardiovascular events remain an ongoing problem [1]. Importantly, around half of these events are attributable to the previously treated arterial segment [2]. Recurrent stent-related clinical events are associated with poor outcomes, with repeat intervention often challenging [3]. Thus, strategies that can reduce the risk of stent failure are of great importance, especially as interventional cardiologists move towards tackling increasingly complex patient and lesion subsets.

Optical coherence tomography (OCT) is an increasingly available intracoronary diagnostic imaging modality that provides high-resolution imaging of coronary arteries. Use of OCT during PCI provides operators with reliable information on reference vessel dimensions and target lesion characteristics, while following stenting, OCT allows for a comprehensive assessment of the stented arterial segment. In this review, we outline the rationale for OCT use during PCI procedures and explore the available clinical evidence to date.

OCT Technology

In recent years OCT has become an established form of medical imaging in interventional cardiology and ophthalmology.

*Corresponding author at: Monash Cardiovascular Research Centre, Monash University and MonashHeart, Monash Health, Clayton, Vic, Australia.
Tel.: +61 3 9594 2726, Fax: +61 3 9594 6939., Email: ajdbrown@me.com

The basis of intracoronary OCT relies on the emission and reflection of light from tissue surfaces during simultaneous withdrawal along the artery [4]. Images are formed by the backscattering of light from the vessel wall to the photo-detector. However, direct quantification of backscattered signal is not possible due to the inherent speed of light (3×10^8 m/s). Instead, interferometry techniques are used, which involves directing one-half of the beam to the tissue (sample path) and the other half to the reference arm (reference path), which encompasses a mirror for light reflection (Figure 1). The time taken for the emitted light to reach the tissue and reflect back to the photo-detector, otherwise known as the echo-time delay, determines image formation. Near-infrared wavelengths between 1250 and 1350 nm are used, with longer wavelengths providing deeper tissue penetration at the expense of image quality. Optical coherence tomography is also reliant on the absence of red blood cells during imaging due to their significant light attenuation. The maximal vessel wall penetration with OCT of 1 to 3 mm is lower than with intravascular ultrasound (IVUS) (Table 1). However, OCT has enhanced image quality, as axial and lateral resolutions approximate 10 to 20 μm and 70 to 90 μm, respectively [5].

Contemporary OCT systems involve an imaging wire containing a single-mode, fibre-optic core which rotates within a transparent sheath [6]. The light beam is focussed at about 80° to the wire's axis, enabling circumferential imaging. During rotation, multiple axial scans, known as A-lines, are obtained and a complete cross-section is achieved after 360° rotation. Time-domain OCT (TD-OCT) uses a reference arm consisting of a mirror that moves at calibrated distances to produce fixed echo-time delays. As this mirror moves mechanically, TD-OCT has an inherently slow pullback rate (≤3 mm/sec) to enable sufficient imaging time. Temporary coronary balloon occlusion is also required to create the blood-free field, which may induce myocardial ischaemia with prolonged inflations. Frequency- (or Fourier-) domain OCT (FD-OCT) was developed to overcome these limitations by using a wavelength-swept laser that emits light of varying frequencies and a fixed mirror in the reference arm. This enables simultaneous detection of reflections from all echo-time delays and thus faster image acquisition. As such, FD-OCT is capable of producing up to two times more A-lines (~500 lines/frames) than TD-OCT within the same time scale without compromising image quality. This is achieved by its rapid pullback rate combined with the use of high viscosity contrast solution for superior displacement of red blood cells.

OCT Imaging Before PCI

Intracoronary imaging during PCI provides accurate and validated measurements of lumen/vessel dimensions, lesion characteristics and stent deployment. At present, IVUS remains the most commonly available intracoronary imaging modality. Its use has contributed significantly to our current understanding of coronary atherosclerosis, the effect of pharmacological therapies and informed clinicians during PCI

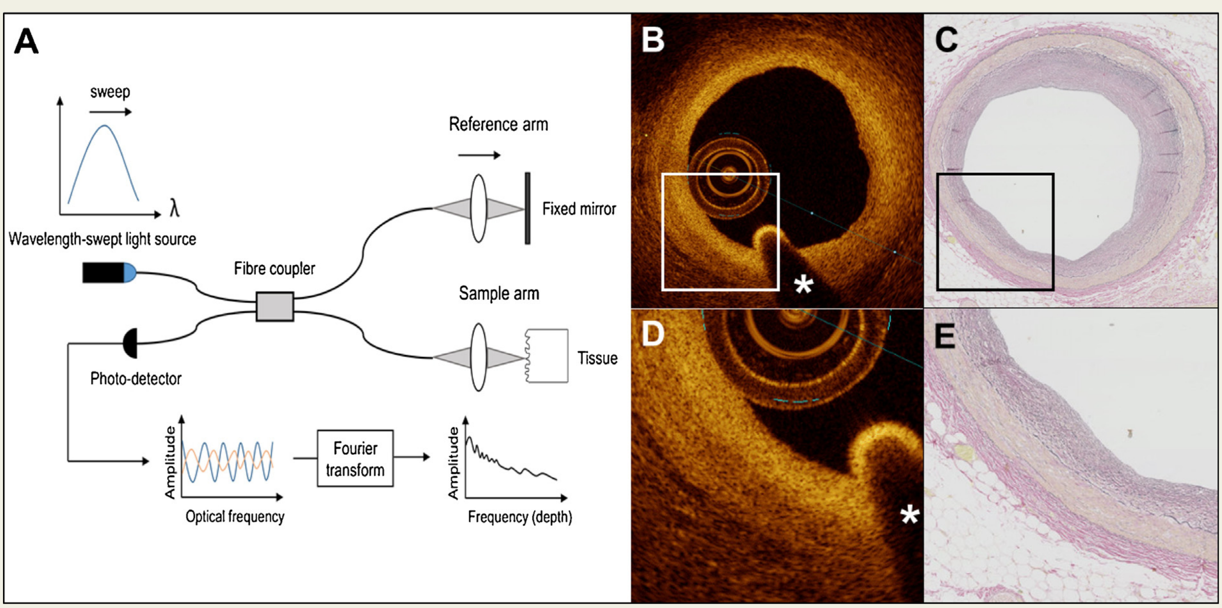

Figure 1 Optical coherence tomography imaging.
Schematic diagram (**A**) illustrating the key components required for data acquisition using frequency (or Fourier) domain optical coherence tomography (OCT) imaging. Cross sectional OCT image (**B**) of an autopsied coronary artery (**C**) demonstrating a relatively healthy arterial segment with only minor intimal thickening. Magnified OCT image (**D**) demonstrating the tri-layered appearances of the arterial wall (**E**).
*Guidewire artefact.

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