

We now have enough evidence to support systematic OCT in daily PCI practice: pros and cons

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Introduction

Intravascular coronary imaging has the potential to address the limitations of angiography in guiding percutaneous coronary intervention (PCI) procedures. In particular, optical coherence tomography (OCT) can offer valuable insights into vessel and plaque characteristics. When used after PCI, OCT can also give important information on stent implantation, highlighting eventual needs for PCI optimisation and, therefore, contributing to improved PCI outcomes. However, OCT remains underused because of concerns regarding procedural time, costs and safety. In addition, current evidence on the routine use of OCT is controversial and, when intravascular imaging (IVI) is indicated, intravascular ultrasound (IVUS) might be preferred based on anatomical or procedural considerations. Whether accruing evidence will foster OCT as a standard tool for guiding and optimising PCI is an area of uncertainty.

Pros

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Although PCI is mostly guided by angiography, its use has well-established limitations in assessing lesion severity, plaque morphology and atherosclerosis burden, which are crucial in pre-PCI planning¹. It is also limited in detecting stent underexpansion, malapposition, edge dissection, and tissue protrusion that may be relevant to post-PCI outcomes¹. In contrast, intravascular imaging, such as IVUS and OCT, offers higher resolution than angiography, allowing for more detailed visualisation of the vessel wall and plaque morphology¹. In this regard, IVI can provide crucial information for PCI that cannot be seen on angiography. In fact, OCT guidance using a standardised workflow changed PCI decision-making in 86% of cases compared

with angiography guidance, which could in turn affect post-PCI outcomes².

There have been multiple randomised clinical trials (RCTs) that have demonstrated improved long-term clinical outcomes after IVI-guided PCI compared with angiography-guided PCI. Although most prior evidence from RCTs on IVI guidance exists for IVUS, recent large-scale RCTs in which OCT was used showed similar results³⁻⁵. In an updated network meta-analysis of RCTs, OCT or IVUS guidance led to a reduction in target lesion failure of ≈30% compared with angiography guidance, driven by reductions of 46%, 20%, and 29% in cardiac death, target vessel myocardial infarction, and target lesion revascularisation, respectively⁶. For the naysayers who believe that this is an IVUS-specific effect, there was no difference in clinical outcomes between OCT- and IVUS-guided PCI in either head-to-head or indirect comparisons^{6,7}.

Despite robust clinical evidence, IVI is only used in ≈10-20% of all PCIs performed in Europe and the United States¹. One of the major reasons for the limited use of IVI, especially OCT, is the lack of a standardised protocol on how to use and interpret OCT findings¹. In this regard, we have proposed a practical algorithm called MLD MAX (Morphology, Length, Diameter, Medial dissection, Apposition, eXpansion) to systematically incorporate OCT into IVI-guided PCI in routine clinical practice⁸. There are two parts of this algorithm: preprocedural strategisation (“MLD”) and postprocedural optimisation (“MAX”)⁸. This algorithm not only helps improve outcomes by systematically integrating OCT into PCI, but it also makes the workflow memorable and efficient, reducing the time spent on OCT interpretation⁹.

Some people may still argue against OCT use due to potential increases in time and cost as well as safety concerns. First, in the ILUMIEN IV: OPTIMAL PCI trial, OCT-guided PCI

increased procedure time by only ≈ 18 minutes despite multiple OCT runs (pre-PCI, post-PCI, and final) and more frequent use of advance lesion preparation and post-dilation⁴. In the LightLab Initiative study where a standardised OCT workflow using the MLD MAX algorithm was used, the procedural time was extended by only 9 minutes compared with angiography-guided PCI, while there was a reduction in vessel preparation time and unexpected additional treatment¹⁰. Second, recent data suggest that IVI use can be cost-effective¹¹. A *post hoc* analysis of the RENOVATE-COMPLEX-PCI trial demonstrates that IVI use, including OCT and IVUS, can reduce the total cumulative medical cost in a lifetime simulation despite a higher initial medical cost¹². Lastly, OCT is safe, and OCT-related complications are extremely rare ($<0.2\%$)⁴. Although OCT use may increase contrast burden, the incidence of contrast-induced nephropathy is similar between OCT- and IVUS-guided PCI⁷.

OCT has a simple yet comprehensive standardised systematic workflow that makes the procedure efficient,

with only a small increase in procedural time¹⁰. OCT is an extremely safe, cost-effective IVI modality that almost invariably changes our procedural decision-making², improving clinical outcomes and reducing procedural complications, including devastating complications like stent thrombosis^{4,6}. Holistically, paired with IVUS, it can even reduce all-cause death⁶. Neither invasive physiological assessment of coronary artery disease nor, in fact, drug-eluting stents have ever been shown to do that. So, how can we justify not using it?

Conflict of interest statement

Z.A. Ali reports institutional grants from Abbott, Abiomed, Acist Medical, Boston Scientific, Cardiovascular Systems Inc., Medtronic, OpSens Medical, Philips, and Shockwave Medical; personal fees from Amgen, AstraZeneca, and Boston Scientific; and equity from Elucid, Lifelink, SpectraWAVE, Shockwave Medical, and VitalConnect. D. Shin has no conflicts of interest to declare.

Cons

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Intravascular imaging tools such as IVUS and OCT are designed to support the accuracy of PCI. This includes anatomical and morphological assessment of the lesion and guidance in vessel preparation, stent selection, and post-PCI stent optimisation. Although OCT provides better resolution (10–20 μm) when compared to IVUS, its tissue penetration ability is limited to 1–3 mm, and it requires contrast flushing to clear blood for an effective examination of the vessel lumen and wall¹³. Therefore, performing OCT is challenging in patients with contrast allergy, chronic kidney disease, left main coronary artery (LMCA)/aorto-ostial lesions, tortuous vessels, previous coronary bypass, chronic total occlusions (CTOs), large/occlusive thrombus, and unstable haemodynamics. Furthermore, being proficient in the utilisation and interpretation of OCT requires intense education and training, even for IVUS users.

Overwhelming evidence suggests that IVUS guidance during PCI improves clinical outcomes. However, the results of OCT studies to date have been mixed when compared to angiography and non-inferior to IVUS^{4,14}. The ILUMIEN IV: OPTIMAL PCI trial attempted to discriminate complex patients and lesions who could benefit from systematic utilisation of OCT-guided PCI. The trial showed that although OCT guidance resulted in a larger minimal stent area post-PCI, it did not have any impact on the rates of target vessel failure at 2 years when compared to angiography⁴. The results of this study suggest that not all patients and lesions require OCT guidance, and it remains unclear for which patients and lesions OCT-guided PCI can improve outcomes.

In certain scenarios, such as large vessels or LMCA/aorto-ostial disease, IVUS is already considered a suitable imaging

tool, whereas OCT's narrower field of view and need for blood clearance limit its ability to assess these lesions accurately¹⁵. Using a guide extension catheter can potentially mitigate this limitation, and OCT-guided LMCA PCI might be feasible, but its advantage over IVUS and overall impact on hard outcomes are unknown. Although OCT has demonstrated safety, in some instances it could be harmful. For example, contrast flushing can extend the degree of coronary dissections or cause distal embolisation in lesions with a large thrombus burden. In CTOs, where IVUS has shown clear procedural and clinical benefits, the role of OCT remains undetermined. Some may argue that OCT delineates calcium better than IVUS or angiography, but it may miss the deep trailing edge of calcium due to insufficient penetration. This is especially true in the presence of superficial lipid plaque, which can attenuate the light signal, and mixed plaques, where distinct calcium borders may not be visualised.

OCT may have an advantage in detecting plaque morphology, including identifying lipid-rich pools and mechanisms for stent failure¹⁶, but these are niche indications that should be tested for clinical impact. Finally, the human factor may hinder the adoption of OCT, which requires additional training and education to improve familiarity with the technology, technical aspects of the procedure, and image interpretation. Other factors to be considered before large-scale adoption include standardisation of the workflow, cost-effectiveness, and reimbursement.

The future of OCT seems promising, and it does carry a huge potential to become a mainstream imaging tool to guide PCI. However, the current limitations need to be addressed with more data on its clinical benefit and increased training and education, especially for interventional cardiology fellows. The next-generation OCT systems with real-time angiographic coregistration, three-dimensional automation,

artificial intelligence-guided interpretation, and ability to assess physiology without wire insertion and without induction of hyperaemia are promising and would make a compelling case for systematic routine use in daily clinical practice. But until then, OCT is not quite ready for such a broad recommendation.

Conflict of interest statement

R. Waksman discloses the following: advisory board member at Abbott, Boston Scientific, Medtronic, Philips IGT, and Pi-Cardia; consultant for Abbott, Append Medical, Biotronik, Boston Scientific, JC Medical, MedAlliance/Cordis, Medtronic, Philips IGT, Pi-Cardia, Swiss Interventional/SIS Medical AG, and Transmural Systems; institutional grant support from Biotronik, Medtronic, and Philips IGT; and investor in Transmural Systems. A. Chaturvedi has no conflicts of interest to declare.

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