Stent Apposition Assessment with Optical Coherence Tomography

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Keywords
- Optical coherence tomography (OCT)
- Intravascular ultrasound (IVUS)
- Stent apposition
- Stent thrombosis
- Percutaneous coronary interventions

Introduction
Over the past decade, a number of new percutaneous coronary interventions (PCIs) have been introduced, each offering advantages and disadvantages. In conjunction with the introduction of new PCI enhancements, including drug-eluting stents (DES), advanced imaging systems have emerged, including optical coherence tomography (OCT). This high-resolution intracoronary imaging technique has provided new insight into the characterisation of coronary atherosclerosis and the interaction between the stent and the vessel wall.

Background
Incomplete stent apposition (ISA) is defined as a separation of at least one stent strut from the vessel wall, not related with a side branch. The relevance of this phenomenon derives from intravascular ultrasound (IVUS) studies suggesting a potential relationship between ISA and stent thrombosis. The mechanism by which ISA can contribute to stent thrombosis remains unknown, but it has been suggested that the characteristics of the flow in the ISA region may facilitate the deposit of fibrin and platelets acting as a nidus for thrombus formation. Some evidence also suggests that malapposed struts have a higher probability of delayed endothelialization, another mechanism involved in stent thrombosis.

The high resolution of OCT (axial 10 μm) makes it the more sensitive tool currently available in the clinical practice for the evaluation of ISA. Several studies have demonstrated that OCT is able to detect small areas of ISA not visible with IVUS. Kubo et al., in a sample of 55 patients, found that the detection of malapposition by OCT was 47 %, versus 18 % for IVUS.¹

ISA can be acute, occurring at the time of stent deployment, or late, in which ISA is observed on follow-up.² Univariate predictors of malapposition include implantation of sirolimus-eluting stents, the presence of overlapping stents, longer stent lengths and a type C lesion.³ Regardless of the pathophysiological mechanism, the key concern of ISA is based on the assumption that areas of strut malapposition cause non-laminar and turbulent blood flow characteristics, which in turn trigger platelet activation and thrombosis.

Malapposition After Stent Implantation
ISA after implantation is a relatively common finding by OCT. The high resolution of the technique allows the detection of very small areas of ISA or even single malapposed struts. The clinical significance of ISA as detected by OCT, however, is poorly understood, and there is no consistent data indicating when it would be necessary to correct it. From a clinical perspective, we could consider treating it only when the degree of malapposition is significant (e.g. affects various struts and extends longitudinally in several frames (see Figure 1)).

The presence of ISA is influenced by several factors, such as stent design, lesion characteristics (calcification, bifurcation, length of the lesion) and procedural technique (high-pressure implantation, pre-dilatation, post-dilatation). OCT could be useful to identify lesions with a high risk of ISA and guide the procedure strategy in order to minimise the risk (e.g. use rotational atherectomy in heavily calcified...
lesions) and optimize the final result (e.g. post-dilatation with a non-compliant balloon).

**Malapposition at Follow-up**

At follow-up, OCT can also assess the presence of ISA (which can be persistent or late-acquired) and provide insights into its mechanisms (see Figure 2). Persistent ISA is generally caused by stent underexpansion related to the presence of severe calcification. Another cause can be the apposition of the struts over an intimal dissection that does not heal at follow-up. Several causes of late-acquired ISA have been proposed and also can be evaluated with OCT:

- Expansive remodeling with lumen enlargement or formation of an aneurysm secondary to chronic inflammation.
- Chronic stent recoil.
- Dissolution of the thrombus jailed between the stent and the vessel wall in PCI performed in patients with a high thrombotic burden.

To be able to recognise persistent ISA and to identify chronic stent recoil, post-implantation and follow-up imaging would be required. Treatment of ISA detected with OCT at follow-up is only recommended if the cause is correctable and has induced a clinical problem (e.g. stent underexpansion in stent thrombosis).

**Conclusion**

OCT can be useful in identifying lesions with a high risk of ISA and guide the procedure strategy in order to minimise risk and optimize the final result. At follow-up, OCT can assess the presence of late acquired malapposition and provide insight into its mechanisms. Finally, stent apposition has been observed more often with OCT than IVUS; IVUS studies suggest a possible relationship between incomplete DES apposition and subsequent thrombosis. However, the clinical significance of incomplete stent strut apposition as evaluated with OCT is not completely understood.

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**Figure 1: Longitudinal Optical Coherence Tomography View of an Aneurysm**

**Figure 2: Optical Coherence Tomography Cross-section in the Region of the Aneurysm Showed Severe Malapposition of the Stent**

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