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Editorial

Optical Coherence Tomography to Optimize Stent Deployment: Seeing is Believing

Optimización del implante de *stents* guiado por tomografía de coherencia óptica: ver para creer

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Optimal coherence tomography (OCT) is a new light-based intracoronary imaging modality with unprecedented spatial resolution.[1,2] Currently, its axial resolution is only 15 μm, that is, 10 times higher than that of more classical techniques such as intravascular ultrasound (IVUS) based on ultrasounds (150 μm). Optimal coherence tomography therefore provides extremely high-quality images of the coronary wall, especially of the structures closest to the vessel lumen.[1,2] Moreover, numerous studies with histological validation have confirmed its ability to adequately differentiate the distinct types of atheromatous plaque, including fibrous plaques (homogeneous, signal-rich regions), lipid plaque (progressively signal-poor regions) and calcified plaque (signal poor, sharp border lesions). For the first time, OCT allows precise measurement of the thickness of the fibrous cap covering the lipid cores and in vivo diagnosis of the presence of thin-cap fibroatheromas. Similarly, this technique can identify the characteristic signs produced by the accumulation of macrophages and cholesterol crystals in the vessel wall, as well as the presence of small ruptures of the intima and of intracoronary thrombi that could not be visualized with IVUS until now.[1,2] All these properties explain the enormous attractiveness of this technique in the characterization of vulnerable plaques and in the study of the micromorphology of plaques that have already developed a complication. However, the penetration of OCT in the vessel wall is limited and consequently visualization of structures beyond the lumen (near the adventitia) is compromised when there is a substantial amount of atheromatous plaque. Equally, OCT cannot penetrate through red thrombi (fibrin-rich), which produce an intense posterior shadow.[1,2] Therefore, OCT is not suitable for measuring the total volume of atheromatous plaque. To do this, IVUS remains the technique of choice when the aim is to study the progression or regression of coronary atherosclerosis.

From a practical point of view, with the initial technology (time domain), image acquisition was relatively slow and, due to the need to completely eliminate blood from the interior of the coronary segment, the size of the segment that was finally visualized was small. With the current technology (frequency domain), highly rapid automatic withdrawal of the OCT catheter allows perfect visualization of coronary segments up to 70 mm in length during a simple injection of radiological contrast medium.[1,2]

Optical coherence tomography also offers new possibilities for evaluating the results of coronary interventionalism, particularly those of stent implantation.[1–3] Thus, due to its high resolution, OCT can analyze and measure the residual lumen, the degree of stent expansion with respect to the reference segments, complete apposition of its struts to the vessel wall, the existence of intrastent prolapse of plaque or thrombotic material, and the development of dissections (intrastent or in its borders), even when very small, with unmatched accuracy.[1–3] The sensitivity of OCT in detecting all these phenomena is much higher than that of IVUS. However, its most interesting feature is probably its ability to evaluate the reparative response produced in the vessel wall in the long-term. In fact, for the first time, OCT allows visualization of stent strut coverage (or its absence) and precise measurement of neointimal proliferation.[4] Again, the capacity of OCT to analyze all these vascular healing phenomena is far superior to that of IVUS, which does not allow clear visualization of stent coverage and has substantial limitations in the analysis of the mild grades of neointimal hyperplasia that are usually produced after implantation of drug-eluting stents (DES) (Figure). It is unsurprising, therefore, that multiple studies have identified OCT as the technique of choice to compare vascular response after the implantation of distinct types of DES. In many of these studies, some of the above-mentioned morphological parameters have been chosen as primary endpoints. These morphological variables are of the utmost importance, both from the physiopathological and mechanistic points of view, and have been widely accepted as valid surrogate endpoints of efficacy and safety.[1–4] In addition, the sample size needed to compare these morphological parameters of delayed vessel healing is much smaller than that required when using the classical angiographic endpoints which, in turn, is already much smaller than that required in studies with clinical endpoints, whether safety-related (stent thrombosis, myocardial infarction) or efficacy-related (need for a repeat revascularization of the target lesion).

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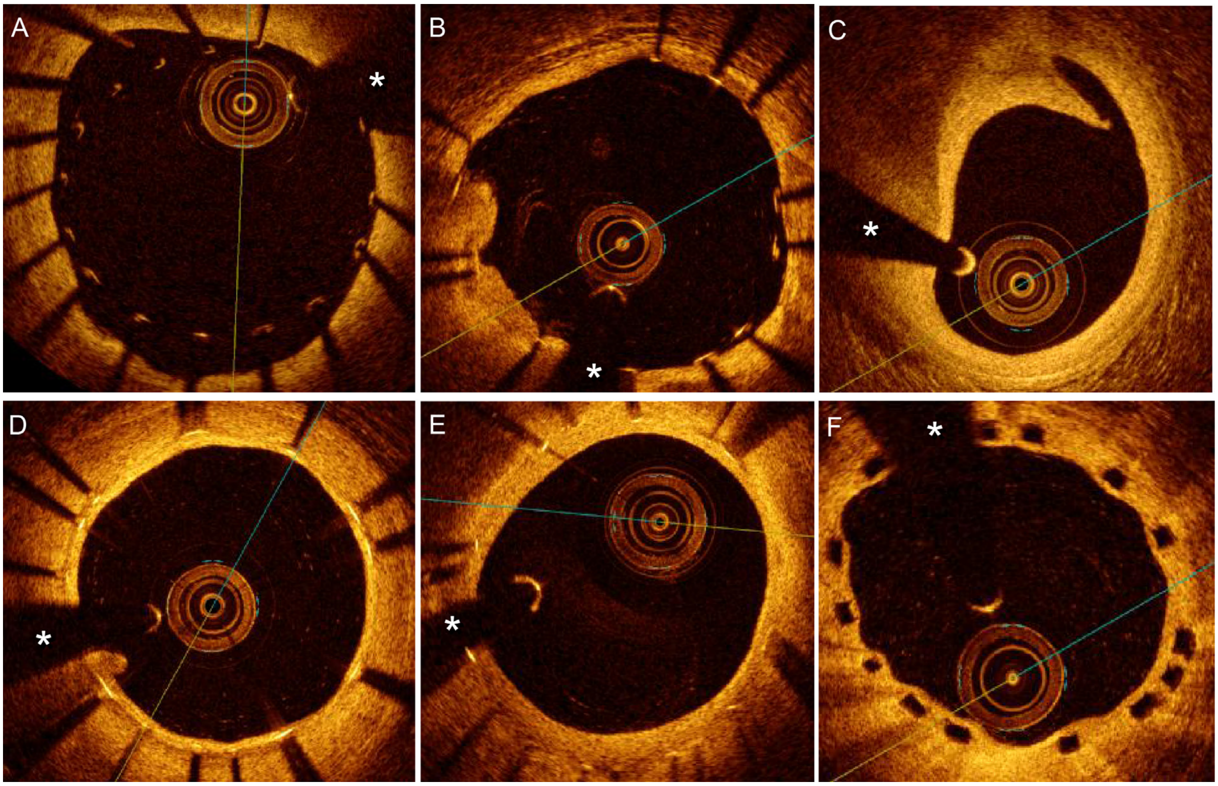

Figure. A-C: optical coherence tomography images obtained immediately after stent implantation. A: severe malapposition in the proximal portion of a stent showing an excellent initial angiographic result. B: slight malapposition of some stent struts (from 3:00 to 5:00 quadrant) in a patient with acute coronary syndrome; on the opposite side (from 7:00 to 9:00 quadrant) plaque prolapse can be seen. C: angiographically-silent dissection of the distal border of a stent. D-E: follow-up images. D: excellent late coverage of a drug-eluting stent. E: minimal neointimal proliferation during follow-up of a drug-eluting stent. F: adequate late coverage of a bioabsorbable vascular device. The struts of the metallic stent are seen as bright structures with a posterior shadow, while the plastic elements of the bioabsorbable device are seen as black squares that do not cast a shadow. *Shadow caused by the angioplasty guidewire.

The new generation of DES have significantly reduced restenosis and very late thrombosis rates,[5,6] but has not eradicated stent "failure". In theory, the development of in-stent restenosis is not a serious clinical problem, since its clinical presentation is usually benign; however, it continues to be an unresolved therapeutic challenge. In contrast, although exceptional, stent thrombosis can have catastrophic clinical consequences.[7] Incomplete or very delayed vessel healing may be an undesirable consequence of DES implantation.[8,9] Thus, histopathological studies have occasionally demonstrated local inflammatory phenomena (especially in first-generation DES), acquired stent malapposition, and, more frequently, a lack of stent endothelialization.[8,9] These phenomena may explain the presence of stents "vulnerable" to developing this dreaded complication.[7] For all these reasons, current therapeutic efforts focus mainly on guaranteeing perfect vessel healing after the implantation of these new devices. It is in this regard that OCT evaluation plays an enormously attractive role.[1–4]

OPTICAL COHERENCE TOMOGRAPHY-GUIDED STENT IMPLANTATION

Before a coronary intervention, evaluation of the severity, length, and morphological characteristics of lesions provides highly useful information. Moreover, immediately after stent implantation, OCT can show the degree of stent expansion and the state of its borders in terms of residual plaque or dissections.[1–3] This technique can also clearly detect malapposition. These findings are usually angiographically silent but must be corrected when highly evident (Figure). However, the significance of minor morphological alterations is uncertain.[1–3] Most investigators advise against continuing with aggressive dilatations in mild stent underexpansion or residual malapposition after reasonable attempts at optimization by using correct balloon diameters and high pressures.[1–3] Similarly, there is broad consensus that no treatment is required for the small dissections at the stent border that are very often detected with this technique. Equally, mild prolapse of intrastent material (thrombus or plaque) does not require specific treatment[1–3] (Figure).

Although broad experience has now been gained in the use of OCT and numerous consensus documents have been published on the topic, there is still a lack of clinically validated or at least widely accepted qualitative criteria that would serve as a guide to optimizing stent implantation.[1–4] With the excellent results obtained with the latest generation of DES, larger studies of OCT-guided implantation are required to demonstrate the clinical benefits of this strategy in reducing the restenosis rate and preventing stent thrombosis. Indeed, tremendous efforts were required in the past decade to confirm the clinical usefulness of IVUS (correcting much more severe morphological alterations) during the implantation of conventional stents (with much less favorable results than those achieved with the new DES).

However, some highly interesting data are already available. In the CLI-OPCI observational study, Prati el al[10] compared the clinical outcomes obtained after angiographically-guided implantation of conventional stents with those obtained with an OCT-guided stent implantation strategy. This multicenter, retrospective study included a total of 670 patients, 335 in the OCT group 335 in the angiography alone group. In the OCT group, 35% of the patients had adverse findings requiring further interventions. At 1-year of follow-up, the OCT group had lower cardiac mortality (1.2% vs