Editorial

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# FD-OCT and IVUS for detection of incomplete stent apposition in heavily calcified vessels: novel insights

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In the present issue of *Open Heart*, Gudmundsdottir and colleagues compare two intracoronary imaging modalities, intravascular ultrasound (IVUS) and FD-optical coherence tomography (FD-OCT), in patients undergoing complex percutaneous coronary intervention (PCI) with rotablation for calcific coronary lesions. In particular, this study sought to detect incomplete stent apposition (ISA) using these different imaging modalities. ISA may play a role in the risk of target vessel failure, for example, stent thrombosis.[1]

Intracoronary imaging has become widely available with the advent of IVUS in the early 1990s.[2] IVUS-derived images with an axial resolution down to 150 µm have given novel insights into the clinical evolution of coronary artery disease and plaque composition.[3] This technology was rapidly embraced by the interventional cardiology community, mainly to assess coronary lesions of intermediate significance in larger coronary arteries, to size the stent diameter or to monitor optimal stent deployment and exclude coronary dissections post-stenting.[2] While this new intracoronary imaging fuelled enthusiasm, to date, limited data exist to demonstrate that IVUS-guided PCI translates into a superior clinical outcome with respect to incomplete stent apposition (table 1). However, a large observational analysis comparing IVUS-guided against angiography-guided PCI suggested that IVUS guidance was associated with a reduction in stent thrombosis, myocardial infarction and major adverse cardiac events within 1 year after DES implantation.[4] Moreover, some moderately sized clinical studies suggested an improved performance if IVUS was used, particularly for complex PCI procedures involving the left main stem.[5] There are several limitations inherent in this technology. First, the spatial resolution may be limited for optimal stent evaluation. Second, heavy calcification may cause artefacts and compromise image quality. And third, IVUS further increases procedural costs.[2] Current European Society of Cardiology guidelines suggest a class IIa recommendation for the use of IVUS to *optimise stent implantation* in selected patients, to assess severity of *left main stem disease* and optimise left main stenting, and to *reveal mechanisms of stent failure* (eg, stent thrombosis).[6]

The first coronary FD-OCT images in humans were published in 2002.[7] A major advantage of this technology is indeed the higher resolution, so that FD-OCT allows for qualitative plaque assessment with respect to plaque cap thickness or rupture.[8] However, definitions on plaque vulnerability by FD-OCT are still under development. FD-OCT was also referred to as 'virtual histology' due to its excellent axial resolution down to 15 µm.[3] This level of accuracy owes to emission of light of a near infrared spectrum (approximately 1300 nm) and immediate acquisition of backscattering by the FD-OCT probe.[9] Optimal image acquisition may only be achieved if red blood cells are cleared sufficiently from the vessel lumen during a flush with transparent contrast die.[9] Given the low penetration depth (1.0–1.5 mm) of near infrared light, only the inner vessel layers may be visualised with FD-OCT, while the whole vessel plaque burden can only be estimated with IVUS.[9] On the other hand, heavy vessel calcification does not necessarily impact on image quality in FD-OCT. In summary, the ESC guidelines do recommend FD-OCT to assess mechanisms of stent failure (class IIa) and to optimise stent implantation in selected patients (class IIb).[6]

Gudmundsdottir and colleagues investigated both intracoronary imaging modalities in a subset of patients with heavily calcified coronary lesions who underwent rotablation and PCI.[1] The primary outcome measure in this study was the detection of ISA to the

**Table 1** Association of IVUS-guided or OCT-guided PCI with outcome parameters

| Author (ref) | n | Type of stent | Assessment of ISA by | Follow-up (months) | Association of ISA and cardiovascular events |
|---|---|---|---|---|---|
| Cook *et al*[10] | 188 | SES/PES | IVUS | 8 | YES (ISA highly prevalent in patients with very late stent thrombosis |
| Cook *et al*[11] | 194 | SES/PES | IVUS | 8 | YES (presence of ISA after DES associated with higher risk AMI and very late stent thrombosis |
| Witzenbichler *et al*[4] | 8583 | DES | IVUS | 12 | YES (less ST, MI and MACE) |
| Tanabe *et al*[14] | 469 | PES/BMS | IVUS | 6 | NO |
| Steinberg *et al*[15] | 1580 | PES/BMS | IVUS | 9 | NO |
| Hong *et al*[16] | 557 | SES/PES | IVUS | 6 | NO |
| Guagliumi *et al*[17] | 21 | ZES | OCT | 6 | NO |
| Kubo *et al*[18] | 45 | SES | OCT | 9 | NO |
| Guagliumi *et al*[19] | 77 | SES/PES/ ZES/BMS | OCT | 6 | NO |
| Guagliumi *et al*[17] | 42 | EES | OCT | 6 | NO |

BMS, bare-metal stent; DES, drug-eluting stent; EES, everolimus-eluting stent; ISA, incomplete stent apposition; IVUS, intravascular ultrasound; MI, myocardial infarction; OCT, optical coherence tomography; PES, pacitaxel-eluting stent; SES, sirolimus-eluting stent; ST, stent thrombosis; ZES, zotarolimus-eluting stent.

vessel wall. ISA is defined as the lack of contact of stent struts with the vessel wall.[3] This phenomenon may occur *acutely*: (1) due to underexpansion of the stent with insufficient inflation pressure; (2) following poor or *late* selection of stent size during follow-up; (3) which may then be due to thrombus resolution after Primary PCI or (4) because of insufficient radial force of the stent and consecutive recoil.[3] The clinical relevance of improved detection of malapposed stent struts still needs to be better understood. Only several small studies investigated this subject with FD-OCT so far (table 1). However, two IVUS studies investigating first generation drug eluting stents found an association between ISA with very late stent thrombosis and myocardial infarction.[10 11] This may be explained by the lower resolution of IVUS, where only significant levels of ISA may be detected, but not necessarily single stent strut malapposition, which is not relevant. One small study revealed ISA in 74% of patients presenting with late stent thrombosis.[12] However, the majority of cases were declared as *late-acquired* ISA, so this likely could not be prevented by stent optimisation at baseline. Moreover, in-stent restenosis has been linked to ISA but existing data are rather limited.[13]

In the present manuscript, however, the clinical relevance of ISA was not the main focus.[1] Of note, FD-OCT use in these highly calcified vessels allowed for improved detection of ISA as compared to IVUS.[1] This finding is in line with previous studies and explained by the higher resolution of FD-OCT. Moreover, FD-OCT imaging triggered more intense postdilation, which reduced the extent of ISA from 34% of stent surface area to 19%[1] in this patient group with rotablation, and heavy calcification where ISA is expected, postdilation with a non-compliant balloon, may actually be considered standard procedure. If FD-OCT should be repeated after postdilation and if further more intense postdilation might yield superior outcomes was not examined in the present study.

In essence, the authors present an interesting study suggesting that FD-OCT provides more detailed information as compared to IVUS and may be a valuable imaging modality in the setting of heavily calcified coronary lesions. However, all of the aforementioned potential downsides need to be carefully considered, and more data are needed to determine the clinical role of FD-OCT in detection of ISA and the impact of different degrees of ISA on clinical outcome.

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