Optical coherence tomography versus intravascular ultrasound for culprit lesion assessment in patients with acute myocardial infarction

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Abstract

Introduction: In patients with acute myocardial infarction (AMI) undergoing primary percutaneous coronary intervention (PCI) the implanted stent may not fully cover the whole intravascular ultrasound (IVUS)-derived thin-cap fibroatheroma (TCFA) related to the culprit lesion (CL).

Aim: Whether this phenomenon is more pronounced when optical coherence tomography (OCT) assessment of the CL is performed is not known.

Material and methods: Thus, we aimed to assess CLs in 40 patients with AMI treated with PCI, using VH (virtual histology)-IVUS and OCT before and after intervention. The results were blinded to the operator and PCI was done under angiography guidance.

Results: Uncovered lipid-rich plaques were identified in the stent reference segments of 23 (57.5%) patients: in 13 (32.5%) of them in the distal reference segment and in 19 (47.5%) of them in the proximal reference segment. In 9 of them (22.5%) lipid plaques were found in both reference segments. In 36 (90%) patients OCT confirmed lipid plaques identified as VH-derived TCFA by VH-IVUS in the reference segments of the stented segment. However, OCT confirmed that only in 2 (5%) patients were uncovered lipid plaques true TCFA as defined by histology. Comparing IVUS and OCT qualitative characteristics of the stented segments OCT detected more thrombus protrusions and proximal and distal stent edge dissections compared to IVUS (92.5 vs. 55%, \(p = 0.001\); 20% vs. 7.5%, \(p = 0.03\) and 25% vs. 5%, \(p < 0.001\), respectively).

Conclusions: Due to its superior resolution, OCT identifies TCFA more precisely. OCT more often shows remaining problems related to stent implantation than IVUS after angiographically guided PCI.

Key words: percutaneous coronary intervention, acute myocardial infarction, optical coherence tomography, intravascular ultrasound, thin-cap fibroatheroma, culprit lesion.

Summary

In patients with acute myocardial infarction (AMI) undergoing primary percutaneous coronary intervention (PCI) the implanted stent may not fully cover the whole intravascular ultrasound (VH-IVUS)-derived thin-cap fibroatheroma (VH-TCFA) related to the culprit lesion (CL). Whether this phenomenon is more pronounced when optical coherence tomography (OCT) assessment of the CL is performed is not known. Thus we aimed to assess CLs in 40 patients with AMI treated with PCI, using VH-IVUS and OCT before and after intervention. Due to its superior resolution, OCT identifies thin-cap fibroatheroma more precisely. OCT more often shows remaining problems related to stent implantation than IVUS after angiographically guided PCI.
Introduction

Atherosclerotic plaque rupture resulting in thrombus formation most commonly leads to acute coronary artery occlusion resulting in acute myocardial infarction (AMI) [1, 2]. However, postmortem assessments revealed that the occlusion is mainly composed of a thrombus and the plaque rupture is located proximal or distal to the site of occlusion and is not always lumen compromising [3, 4]. Therefore, in the case of treating the culprit lesion with stenting, incomplete stent coverage of the true culprit lesion (culprit of the culprit lesion (CL) or the site of plaque rupture) may occur, when only the occlusion or the minimum lumen area (MLA) site is treated under angiographic guidance. This could be one of the possible mechanisms responsible for future cardiac events.

Using intravascular ultrasound (IVUS), it was previously shown that the stent does not fully cover the whole virtual histology (VH)-IVUS-derived thin-cap fibroatheroma (VH-TCFA) related to the CL in patients with AMI undergoing primary percutaneous coronary intervention (PCI) with the optimal angiographic result [5, 6]. With its greater resolution, optical coherence tomography (OCT) allows even more precise visualization and quantification of TCFA than VH-IVUS [7].

Aim

We aimed to compare OCT and VH-IVUS assessment of the CL after primary PCI in patients with AMI.

Material and methods

The present study was a two-center, prospective, observational registry. The study protocol was approved by the Institutional Review Boards and conformed to the statute of the Declaration of Helsinki. All patients provided written informed consent before enrolment. Patients aged > 18 years with uncomplicated AMI (ST- and non-ST segment elevation myocardial infarction, 20 subjects in each group) within 12 h after onset of symptoms qualifying for emergent PCI were eligible. Patients were not eligible if angiography showed left main coronary artery occlusion resulting in acute myocardial infarction (AMI) based on angiography alone and was followed by direct stent implantation with post-dilation if required to achieve the optimal angiographic result (residual angiographic diameter stenosis of < 20% and TIMI flow 3). After finishing the procedure, VH-IVUS and OCT pullbacks were repeated. Operators performing PCI were blinded to VH-IVUS and OCT findings and therefore these findings did not impact PCI, which was carried out according to the standard practice of the center. IVUS pullbacks were performed with the Volcano SS system and the EagleEye Gold catheter (Volcano Corporation, Rancho Cordova, CA, USA). The automated pullback was performed at the speed of 0.5 mm/s. The scan area was from 10 mm distal to the CL to the aorto-ostial junction. All pullbacks were stored on a compact disc for off-line analysis. Radiofrequency backscatter data were collected simultaneously and triggered by the R-wave peak of the patient’s electrocardiogram using a dedicated IVUS console (Rancho Cordova, California). The region of interest was defined in each vessel as the stented lesion plus 10 mm proximal and distal to the edges of the stent. Each region of interest imaged by IVUS and VH-IVUS was analyzed by 2 different analysts to address inter- and intraobserver variability. Planar and volumetric IVUS and VH-IVUS analyses were performed according to established standards [8, 9]. The IVUS analysis was performed using echoPlaque 4 software (INDEC Medical Systems, Santa Clara, California). The VH-IVUS analysis was performed using pcVH 2.2 and qVH software (Rancho Cordova, California) for tissue characterization and advanced analysis, respectively. IVUS and VH-IVUS data were analyzed by 2 independent analysts blinded to the clinical data and procedural information, and all analyses were reviewed by a single independent reviewer. Overall, inter- and intraobserver variability for TCFA detection showed a good intraclass correlation (κ = 0.933 and 0.894, respectively). Two OCT pullbacks were performed. The first pullback was for the assessment of the CL and its reference segments with TIMI grade 3 flow in IRA and the administration of 250 µg of intracoronary nitroglycerine. The second pullback was performed after stent implantation for the assessment of the stented segment and its reference segments. OCT pullbacks were performed with the OCT Iliumien system and the DragonFly OCT catheter (St. Jude Medical, St. Paul, MN, USA). For effective clearance of blood from the imaging field, angiographic contrast medium was injected with an automated power injector. Specifically, injection of 14 ml of contrast at a rate of 4 ml/s and the pressure of 400 PSI sufficed to achieve imaging time of 2–3 s consistently in all the major coronary arteries. Pullback speed was 20 mm/s. The scan area was 5.4 cm. All pullbacks were stored on a compact disc for off-line analysis. The analysis of OCT pullbacks...
was performed in an independent core laboratory by two experienced analysts blinded to clinical data, IVUS and angiographic images. The intra- and interobserver variability showed a good correlation ($\kappa = 0.912$). The analysis was performed using the Ilumien off-line analysis workstation software (St. Jude Medical, St. Paul, MN, USA). The analysis was performed following the Consensus Standards for Acquisition, Measurement, and Reporting of Intravascular Optical Coherence Tomography Studies [9]. Inter- and intraobserver variability for OCT-derived TCFA detection showed a good intraclass correlation ($\kappa = 0.912$ and 0.889, respectively). Off-line qualitative and quantitative coronary angiographic (QCA) analysis was performed according to the well-established protocol [10, 11]. QCA analysis was performed using the Sanders Data Systems QCAPlus software (Palo Alto, California) by an experienced analyst blinded to clinical data and procedural information.

**Statistical analysis**

Statistical analysis was performed using SPSS Statistics for Windows v17.0 software (SPSS Inc., Chicago, IL, USA). Continuous variables are expressed as mean ± standard deviation (SD) or median (interquartile range), as appropriate. The categorical data were compared using Fisher’s exact test or the $\chi^2$ test. Normally distributed data were compared using Student’s $t$-test and non-normally distributed data using the Mann-Whitney test. A $p$-value < 0.05 was considered statistically significant.

**Results**

Forty patients were eligible, and 40 CLs were analyzed in this study. Baseline clinical characteristics and procedural data are shown in Table I. Final TIMI grade 3 flow was achieved in all lesions. No death, reinfarction, or repeat interventions were reported during in-hospital, at 30-day, and at 1-year follow-up. Results of quantitative and qualitative coronary angiography assessment before stent implantation and after PCI are presented in Table II. Detailed IVUS and OCT lesion characteristics are presented in Tables III and IV. Uncovered lipid plaques were identified in the stent reference segments of 23 (57.5%) patients, in 13 (32.5%) of them in the distal reference segment and in 19 (47.5%) of them in the proximal reference segment (in 9 (22.5%) of these patients lipid plaques were found in both reference segments). In 36 (90%) patients, OCT confirmed lipid plaques identified as VH-TFCA by VH-IVUS in the reference segments of the stented segment of the IRA. However, OCT confirmed that in only 2 (5%) patients with AMI uncovered lipid plaques were OCT-derived TCFA. MLA was lower when assessed with OCT (4.61 ±4.06 vs. 7.19 ±6.85 mm, $p = 0.01$).

Comparing IVUS and OCT qualitative characteristics of the stented segments OCT detected more thrombus protrusions and proximal and distal stent edge dissections compared to IVUS (92.5% vs. 55%, $p = 0.001$; 20% vs. 7.5%, $p = 0.03$ and 25% vs. 5%, $p < 0.001$, respectively). Table V depicts detailed data of plaque types in stent reference segments as identified by VH-IVUS compared to OCT and the OCT cap thickness in lipid plaques in 40 patients with AMI.

**Discussion**

In the present study, IVUS VH-IVUS and OCT images, blinded to the operator, were used to assess in vivo longitudinal distribution of culprit lesion plaque components before PCI and to evaluate stent coverage of these

| Variable                                      | Results     |
|-----------------------------------------------|-------------|
| Age, mean ± SD [years]                       | 58 ±12      |
| Men                                           | 21 (52.5%)  |
| Arterial hypertension                         | 12 (30%)    |
| Hypercholesterolemia                         | 10 (40%)    |
| Current smoking                               | 4 (10%)     |
| Diabetes mellitus                             | 5 (12%)     |
| Peripheral artery disease                     | 0           |
| Chronic renal failure                         | 1 (2.5%)    |
| Previous coronary artery bypass grafting      | 0           |
| Previous stroke                               | 2 (5%)      |
| Positive family history of coronary artery disease | 5 (12%)  |
| Previous myocardial infarction                | 0           |
| Previous percutaneous coronary intervention   | 1 (2.5%)    |

**Infarct-related artery:**

- Left anterior descending artery: 16 (40%)
- Left circumflex artery: 9 (22.5%)
- Right coronary artery: 15 (37.5%)

- Thrombus aspiration due to baseline TIMI flow < 3: 17 (42.5%)
- Use of glycoprotein IIb/IIIa inhibitor: 3 (7.5%)
- Balloon predilatation: 16 (40%)
- Number of deployed stents, mean ± SD: 1.49 ±0.65
- Stent post-dilatation: 19 (47.5%)
- Bare metal stent: 12 (30%)

SD – standard deviation.
components after angiography-guided emergent PCI as well as stent strut assessment in patients with AMI. The main conclusions were as follows: (1) OCT confirmed that in only 5% of patients with AMI uncovered lipid plaques were true TCFA as defined by histology; (2) in 57% of the angiography-guided PCIs in patients presenting with AMI, stent placement missed coverage of the whole length of the culprit-related VH-TCFA; and (3) OCT detected more malappositions, thrombus protrusions and proximal and distal stent edge dissections than IVUS.

Table II. Quantitative and qualitative coronary angiography prior to and after stent implantation (n = 40)

| Variable                              | Results                        |
|---------------------------------------|--------------------------------|
| Prior to stenting:                    |                                |
| Quantitative coronary angiography:    |                                |
| Lesion length, mean ± SD [mm]         | 15.17 ±6.5                     |
| Reference vessel diameter, mean ± SD [mm] | 3.14 ±0.5                   |
| Minimum lumen diameter, mean ± SD [mm] | 0.51 ±0.47                   |
| Diameter stenosis (%), mean ± SD      | 84 ±22                         |
| Qualitative coronary angiography:     |                                |
| TIMI flow 3                           | 9 (22.5%)                      |
| TIMI flow 2                           | 15 (37.5%)                     |
| TIMI flow 1                           | 4 (10%)                        |
| TIMI flow 0                           | 12 (30%)                       |
| Angiographic presence of thrombus     | 24 (60%)                       |
| TIMI thrombus grade 0                 | 13 (32.5%)                     |
| TIMI thrombus grade 1                 | 3 (7.5%)                       |
| TIMI thrombus grade 2                 | 3 (7.5%)                       |
| TIMI thrombus grade 3                 | 5 (12.5%)                      |
| TIMI thrombus grade 4                 | 6 (15%)                        |
| TIMI thrombus grade 5                 | 10 (25%)                       |
| Post stenting:                        |                                |
| Quantitative coronary angiography:    |                                |
| Stent length, mean ± SD [mm]          | 23.54 ±6.17                    |
| Stent diameter, mean ± SD [mm]        | 3.47 ±0.57                     |
| Proximal reference lumen diameter,    | 3.59 ±0.53                     |
| mean ± SD [mm]                        | Distal reference lumen diameter,| 3.08 ±0.46                     |
| mean ± SD [mm]                        | Minimum lumen diameter,        | 3.0 ±0.46                      |
| Diameter stenosis (%), mean ± SD      | 7 ±4                            |
| Stent-length to lesion-length ratio   | 1.55                            |
| Qualitative coronary angiography:     |                                |
| TIMI 3 flow                           | 36 (90%)                       |
| TIMI 2 flow                           | 4 (10%)                        |
| Angiographic presence of thrombus     | 1 (2.5%)                       |
| Residual dissection                   | 3 (7.5%)                       |
| Angiographic signs of spasm           | 0                               |
| Angiographic signs of distal embolisation | 1 (2.5%)                  |
| Angiographic complications after IVUS/OCT | 0                               |

IVUS – intravascular ultrasound, OCT – optical coherent tomography, SD – standard deviation, TIMI – thrombolysis in myocardial infarction.

Although IVUS consistently showed hypoechoic, thom-
bus-like structures moving in the lumen in the regions of CLs, which were observed consistently on VH-IVUS as yellow-greenish masses, there are no official criteria for the IVUS detection of thrombus. OCT is a tool that can not only identify thrombi, but also differentiate between the white and the red types [9]. Since OCT is capable of identifying and quantifying thrombus, it is a surprise that no proper thrombus scoring system has been established yet and cannot be found in the literature. In our study we analyzed in how many consecutive OCT frames and their quadrants the thrombus was identified. IVUS with its relatively low resolution is also not the best imaging modality for the detection of these phenomena as well as minor stent edge dissections or stent malappositions. Kubo et al. showed that OCT has a better potential for the detection of stent edge dissections (40% vs. 16%, $p = 0.005$), tissue protrusions (58% vs. 20%, $p < 0.001$) and stent malappositions (47% vs. 8%, $p < 0.001$) after stent implantation compared to IVUS [22]. Considering the fact that any kind of GM is associated with an increased risk for target vessel revascularization and myocardial infarction at 1 year as described earlier, stent

| Table III. Quantitative and qualitative ultrasound and optical coherence tomography characteristics |
|---------------------------------------------------------------|
| **Variable** | **IVUS data** | **OCT data** | **P-value** |
|----------------|---------------|--------------|-------------|
| Culprit lesion: | | | |
| Lesion length, mean ± SD [mm] | 24.2 ±10.28 | 22.52 ±9.18 | 0.53 |
| Minimum lumen diameter, mean ± SD [mm] | 1.61 ±0.25 | 1.14 ±0.55 | 0.21 |
| Minimum lumen area, mean ± SD [mm²] | 2.78 ±1.03 | 1.63 ±1.6 | 0.03 |
| Maximum plaque burden, mean ± SD [%] | 80.18 ±7.94 | NA | – |
| Vessel area at minimum lumen area, mean ± SD [mm²] | 14.05 ±5.61 | NA | – |
| Distal reference segment: | | | |
| Minimum lumen diameter, mean ± SD [mm] | 2.26 ±0.65 | 2.25 ±0.89 | 0.65 |
| Maximum lumen area, mean ± SD [mm²] | 8.29 ±3.8 | 7.52 ±4.06 | 0.72 |
| Minimum lumen area, mean ± SD [mm²] | 5.01 ±2.91 | 4.91 ±2.08 | 0.38 |
| Proximal reference segment: | | | |
| Minimum lumen diameter, mean ± SD [mm] | 2.58 ±0.58 | 2.74 ±0.76 | 0.45 |
| Maximum lumen area, mean ± SD [mm²] | 11.64 ±4.05 | 11.33 ±5.32 | 0.59 |
| Minimum lumen area, mean ± SD [mm²] | 6.94 ±2.81 | 7.58 ±3.92 | 0.72 |
| Qualitative assessment of culprit lesion: | | | |
| Presence of MLA | 38 (95%) | 39 (97.5%) | 0.82 |
| Presence of plaque rupture | 15 (37.5%) | 18 (45%) | 0.49 |
| Presence of thrombus | NA | 31 (77.5%) | – |
| Presence of thrombus at MLA | NA | 30 (75%) | – |
| Thrombus length, mean ± SD [mm] | NA | 6.9 ±4.02 | – |
| Plaque rupture proximal to MLA | 11 (27.5%) | 18 (45%) | 0.02 |
| Plaque rupture distal to MLA | 4 (10%) | 0 | 0.06 |
| Distance of plaque rupture from MLA, mean ± SD [mm] | 7.19 ±6.85 | 4.61 ±4.06 | 0.01 |
| Distance of maximal necrotic core from MLA, mean ± SD [mm] | 5.14 ±4.39 | NA | – |
| Maximal necrotic core proximal to MLA | 27 (67.5%) | NA | – |
| Maximal necrotic core distal to MLA | 11 (27.5%) | NA | – |
| Most unstable plaque type in the culprit lesion: | | | |
| Lipid | NA | 30 (75%) | – |
| Fibrous | NA | 6 (15%) | – |
| Calcific | NA | 2 (5%) | – |
| Minimum cap thickness, mean ± SD [µm] | NA | 121 ±47 | – |
| Plaque type at the plaque rupture: | | | |
| Lipid | NA | 11 (27.5%) | – |
| Empty cavity | NA | 9 (22.5%) | – |
| Fibrous | NA | 0 | – |
malappositions in AMI patients undergoing angiographically guided PPCI are a serious problem. Thrombus protrusions were identified by OCT in 92% of AMI patients. The clinical implications of thrombus protrusion, tissue prolapse, stent malappositions and stent edge dissections – usually small features – remain unclear [23]. However, the results of our study suggest another and a more important issue, which can be due to the superior resolution of OCT may be answered in the future and can impact the way we understood VH-TCFAs and their significance in guiding primary PCI. As mentioned earlier, different investigators have confirmed a positive correlation of VH-TCFA occurrence and later non-restenotic and total major adverse cardiac events [16, 18, 19].

Several limitations in the present study should be appreciated. The main limitation was a relatively small number of patients enrolled. Second, the nature of enrollment was prospective. However, non-consecutive series

| Variable | IVUS data | OCT data | P-value |
|----------|-----------|----------|---------|
| Quantitative characteristics of the stented segment: | | | |
| Stent length, mean ± SD [mm] | 24.64 ±9.89 | 24.12 ±9.79 | 0.84 |
| Minimum lumen area, mean ± SD [mm²] | 6.94 ±6.59 | 6.57 ±6.65 | 0.79 |
| Maximum stent area, mean ± SD [mm²] | 10.93 ±4.07 | 11.71 ±3.99 | 0.62 |
| Minimum stent area, mean ± SD [mm²] | 7.02 ±2.42 | 6.9 ±2.14 | 0.87 |
| Malapposed struts, mean ± SD | 22.56 ±32.4 | 33.13 ±45.3 | 0.06 |
| Maximum malapposition distance, mean ± SD [mm] | – | 0.4 ±0.28 | – |
| Malapposition | 9 (22.5%) | 12 (30%) | 0.16 |
| Thrombus protrusion | 22 (55%) | 37 (92.5%) | 0.001 |
| Proximal edge dissection | 3 (7.5%) | 8 (20%) | 0.03 |
| Distal edge dissection | 2 (5%) | 10 (25%) | < 0.001 |
| Proximal reference segment plaque type: | | | |
| Healthy vessel | NA | 1 (2.5%) | – |
| Fibrous | NA | 9 (22.5%) | – |
| Calcific | NA | 3 (7.5%) | – |
| Lipidic | NA | 19 (47.5%) | – |
| Cap thickness if lipidic, mean ± SD [µm] | NA | 171 ±62 | – |
| Distal reference segment plaque type: | | | |
| Healthy vessel | NA | 3 (7.5%) | – |
| Fibrous | NA | 17 (42.5%) | – |
| Calcific | NA | 3 (7.5%) | – |
| Lipidic | NA | 13 (32.5%) | – |
| Cap thickness if lipidic, mean ± SD [µm] | NA | 143 ±65 | – |

IVUS – intravascular ultrasound, OCT – optical coherent tomography.
Table V. Plaque types in stent reference segments as identified by VH-IVUS compared to OCT and the OCT cap thickness in lipidic plaques in patients with acute myocardial infarction

| No. | Distal reference segment | Proximal reference segment |
|-----|--------------------------|-----------------------------|
|     | VH-IVUS | OCT | Cap thickness [µm] | VH-IVUS | OCT | Cap thickness [µm] |
| 1   | CaTCFA | Lipidic | 130 | FCa | NA | / |
| 2   | AIT | Healthy vessel | / | PIT | Fibrous | / |
| 3   | AIT | Healthy vessel | / | TCFA | Lipidic | 200 |
| 4   | PIT | Fibrous | / | CaTCFA | Lipidic | 180 |
| 5   | AIT | NA | / | CaTCFA | Lipidic | 170 |
| 6   | TCFA | Lipidic | 120 | TCFA | Lipidic | 100 |
| 7   | NA | Fibrous | / | NA | Lipidic | 180 |
| 8   | FCa | Lipidic | 120 | TCFA | Lipidic | 80 |
| 9   | TCFA | Lipidic | 140 | PIT | Fibrous | / |
| 10  | PIT | Fibrous | / | CaTCFA | Lipidic | 450 |
| 11  | CaTCFA | Lipidic | 160 | CaTCFA | Lipidic | 320 |
| 12  | CaTCFA | Calcific | / | NA | NA | / |
| 13  | AIT | Fibrous | / | PIT | Fibrous | / |
| 14  | PIT | Fibrous | / | AIT | Healthy vessel | / |
| 15  | CaTCFA | Lipidic | 90 | TCFA | Lipidic | 180 |
| 16  | AIT | Fibrous | / | AIT | Fibrous | / |
| 17  | CaTCFA | Lipidic | 170 | NA | NA | / |
| 18  | FCa | Calcific | / | NA | Calcific | / |
| 19  | FA | Lipidic | 100 | TCFA | Lipidic | 100 |
| 20  | CaTCFA | Calcific | / | TCFA | Calcific | / |
| 21  | CaTCFA | Lipidic | 180 | CaTCFA | Lipidic (True TCFA) | 60 |
| 22  | PIT | NA | / | AIT | NA | / |
| 23  | AIT | NA | / | CaTCFA | Lipidic | 85 |
| 24  | AIT | Fibrous | / | NA | NA | / |
| 25  | NO PLAQUE | Fibrous | / | NA | Fibrous | / |
| 26  | PIT | Fibrous | / | PIT | Fibrous | / |
| 27  | NA | Fibrous | / | NA | Lipidic | 220 |
| 28  | FCa | Lipidic (True TCFA) | 30 | NA | Lipidic | 150 |
| 29  | PIT | Fibrous | / | PIT | Fibrous | / |
| 30  | TCFA | Lipidic | 300 | TCFA | Lipidic | 140 |
| 31  | CaTCFA | Lipidic | 190 | FCa | Calcific | / |
| 32  | NA | NA | / | NA | NA | / |
| 33  | PIT | Fibrous | / | NA | NA | / |
| 34  | FCa | Fibrous | / | CaTCFA | Lipidic | 130 |
| 35  | CaTCFA | Lipidic | 90 | CaTCFA | Lipidic | 190 |
| 36  | AIT | Fibrous | / | NA | NA | / |
| 37  | AIT | Healthy vessel | / | FA | Lipidic | 200 |
| 38  | PIT | Fibrous | / | PIT | Fibrous | / |
| 39  | AIT | Fibrous | / | TCFA | Lipidic | 150 |
| 40  | AIT | Fibrous | / | PIT | Fibrous | / |

AIT – adaptive intimal thickening, CaTCFA – calcified thin-cap fibroatheroma, FA – fibroatheroma, FCa – fibrocalcific plaque, PIT – pathological intimal thickening, NA – not applicable, OCT – optical coherence tomography, TCFA – thin-cap fibroatheroma, VH-IVUS – intravascular ultrasound with virtual histology.
of subjects who met eligibility criteria and consented to the study were enrolled. The third limitation was the limitation of the VH-IVUS as a method – its relatively low resolution, which does not allow, as discussed above, proper identification of only the true TCFAs as per the histology-derived definition. Fourth, IVUS and VH-IVUS could not identify thrombus. Finally, thrombus aspiration, if performed, could affect qualitative characteristics of the CL, especially regarding thrombus assessment. Follow-up clinical data were also not assessed.

Conclusions
Due to its superior resolution, OCT identifies TCFAs more precisely. OCT more often shows remaining problems related to stent implantation than IVUS after angiographically. OCT more often shows remaining problems related to stent implantation than IVUS after angiographically. OCT more often shows remaining problems related to stent implantation than IVUS after angiographically.

Conflict of interest
The authors declare no conflict of interest.

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