CLINICAL STUDY

Early Vascular Healing Following Bioresorbable-Polymer Sirolimus-Eluting Stent Placement Compared to That with Durable-Polymer Everolimus-Eluting Stent Sequential Optical Coherence Tomography Study

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Summary

A recent thinner strut drug-eluting stent might facilitate early strut coverage after its placement. We aimed to investigate early vascular healing responses after the placement of an ultrathin-strut bioresorbable-polymer sirolimus-eluting stent (BP-SES) compared to those with a durable-polymer everolimus-eluting stent (DP-EES) using optical coherence tomography (OCT) imaging.

This study included 40 patients with chronic coronary syndrome (CCS) who underwent OCT-guided percutaneous coronary intervention (PCI). Twenty patients each received either BP-SES or DP-EES implantation. OCT was performed immediately after stent placement (baseline) and at 1-month follow-up.

At one month, the percentage of uncovered struts reduced significantly in both the BP-SES (80.9 ± 10.3% to 2.9 ± 1.7%; \( P < 0.001 \)) and DP-EES (81.9 ± 13.0% to 5.7 ± 1.8%; \( P < 0.001 \)) groups, and the percentage was lower in the BP-SES group than in the DP-EES group (\( P < 0.001 \)). In the BP-SES group, the percentage of malapposed struts also decreased significantly at 1 month (4.9 ± 3.7% to 2.6 ± 3.0%; \( P = 0.025 \)), which was comparable to that of the DP-EES group (2.5 ± 2.2%; \( P = 0.860 \)). The optimal cut-off value of the distance between the strut and vessel surface immediately after the placement to predict resolved malapposed struts was ≤ 160 μm for BP-SES and ≤ 190 μm for DP-EES.

Compared to DP-EES, ultrathin-strut BP-SES demonstrated favorable vascular responses at one month, with a lower rate of uncovered struts and a comparable rate of malapposed struts. (Int Heart J 2021; 62: 510-519)

Key words: Chronic coronary syndrome, Drug-eluting stent, Neointimal coverage, Intravascular imaging, Percutaneous coronary intervention

Placement of a drug-eluting stent (DES) is considered as the standard approach for patients with coronary artery disease undergoing percutaneous coronary intervention (PCI).31 Despite the low rates of restenosis, late stent thrombosis with serious, life-threatening consequences remains an ongoing concern for DESs.33 Pathologic findings have demonstrated the association between late stent thrombosis and uncovered or malapposed stent struts.32 Intravascular imaging studies have, therefore, focused on the vascular healing responses after DES implantation. Optical coherence tomography (OCT) with a high spatial resolution is ideal for assessing stent struts and neointimal coverage conditions.4,5

Recent technological developments in DESs have minimized the risk of stent thrombosis.30 Early vascular response (i.e., strut coverage) is considered a major factor responsible for reducing the risk of stent thrombosis.13 A bioresorbable-polymer sirolimus-eluting stent (BP-SES), with a novel stent platform consisting of ultrathin (60 μm) cobalt-chromium struts covered with an amorphous silicon carbide layer, has been shown to achieve favorable clinical outcomes.9,10 In theory, a thin strut facilitates early strut
coverage. An in vivo study in a porcine model demonstrated a lower rate of uncovered struts with a BP-SES at one week than those of everolimus-eluting stent (Promus) sirolimus-eluting stent (Cypher) with thicker struts. In humans, a few OCT studies have reported mid-term vascular responses three months after BP-SES placement; however, its healing response at an earlier time point has not been elucidated.

We hypothesized that the BP-SES with 60 μm strut thickness provides a better stent endothelial coverage early after its placement than the durable-polymer everolimus-eluting stent (DP-EES) with 81 μm strut thickness. The DP-EES is widely used in clinical practice and research studies. This study aimed to elucidate early vascular responses with the BP-SES compared to those with the DP-EES using OCT.

Methods

The institutional ethics committee approved the study protocol. All patients provided written informed consent before the procedures.

Study design and patient population: Between July 2018 and December 2019, patients with chronic coronary syndrome (CCS) and multivessel disease were considered eligible for the study if they underwent OCT-guided PCI and received either the BP-SES (Orsiro, BIOTRONIK, Buelach, Switzerland) or DP-EES (Xience Sierra, Abbott Vascular, Santa Clara, CA, USA) at Showa University Hospital (Tokyo, Japan), and were deemed to undergo another staged OCT-guided PCI for residual stenotic lesions at one month (details in Figure 1). All PCI procedures were clinically indicated. The choice of DES type was at the discretion of the treating physician. Once the number of patients implanted with either stent type reached 20, only the other stent was implanted until the other group also reached 20 patients.

The exclusion criteria were acute coronary syndrome, congestive heart failure, cardiogenic shock, culprit lesion of the left main coronary artery, in-stent restenosis, reference vessel diameter < 2.0 mm or ≥ 4.5 mm, chronic kidney disease with serum creatinine ≥ 2.0 mg/dL, hemodialysis or peritoneal dialysis, pregnancy, comorbid cancer with expected survival < 2 years, planned surgery within three months, contraindications for aspirin or P2Y12 inhibitor, and age < 20 or > 85 years.

OCT and PCI procedures: The OCT and PCI procedures followed the current practice guidelines. Dual antiplatelet therapy, consisting of aspirin and a P2Y12 inhibitor (either clopidogrel or prasugrel), was initiated before the procedure. Unfractionated heparin was administered during the procedure to maintain an activated clotting time of > 250 seconds. OCT imaging was performed throughout the stented segment with a margin of ≥ 5 mm from both proximal and distal stent edges using a commercially available system (Dragonfly OPTIS, Abbott Vascular, St. Paul, MN, USA). The first OCT evaluation was performed immediately after stent placement at the index PCI (baseline) to confirm optimal stent expansion. One month after the index PCI, the second OCT evaluation was performed at staged PCI for residual stenotic lesions.

OCT image analysis: Off-line OCT image analysis was performed using dedicated software (ILUMIEN, Abbott Vascular, St. Paul, MN, USA) by independent observers who were blinded to the clinical information of the patients, including the type of stents, as previously described. For quantitative analysis, cross-sectional OCT images
were analyzed at every 1 mm distance throughout the stented segment. The lumen and stent areas were measured manually. Struts were considered as covered if a layer of tissue covered all reflecting surfaces. If any part of the strut was visibly exposed, struts were considered as uncovered or malapposed. Malapposed strut was defined as the distance between the center reflection of strut and the adjacent vessel surface (S-V distance) greater than the strut thickness plus the polymer thickness and an OCT resolution limit of 20 μm. Using this definition, the thresholds of malapposed strut were ≥ 80 μm for stent diameters ≥ 3.0 mm, and ≥ 100 μm for stent diameters > 3.0 mm in the BP-SES, and ≥ 110 μm in the DP-EES. Malapposed struts immediately after the index PCI but disappeared at one month were considered resolved. In comparison, if they were also visible at one month, they were considered as persistent. Struts located at side branches and cross-sections with overlapping stents were excluded from the analysis. The rates of uncovered and malapposed struts were calculated as a percentage of the total struts analyzed for each patient.

Qualitative assessment was performed in all cross-sections within the stented segments. Underlying plaque morphology was characterized using previously validated criteria. Lipid core was identified as a diffusely bordered, signal-poor region. Fibrous-cap was defined as a signal-rich homogenous layer overlying the lipid core. Calcium was identified as a signal-poor or heterogeneous region with a sharply delineated border. Maximum plaque arc was determined as the largest plaque arc in the three candidate cross-sections selected by visual screening. Plaque length was calculated from the number of cross-sections. Intrastent thrombus was identified as a mass protruding beyond the stent strut into the lumen with a height ≥ 250 μm attached to the stent strut’s luminal surface and with an irregular surface signal attenuation. Irregular protrusion was defined as an intrastent tissue protruding beyond the stent strut with an irregular surface and a thickness of ≥ 250 μm. The percentages of the length of intrastent thrombus and irregular protrusion were calculated by dividing the sum of the longitudinal distance by the length of the stent.

The primary endpoint was the percentage of uncovered struts at one month. The secondary endpoints included the improvement in malapposed and uncovered struts at one month.

Statistical analysis: The sample study size was predefined as 20 patients since we had tried to exploratorily assess vascular healing response to BP-SES because the previous study similarly compared the percentage of uncovered struts in sequential observation protocol. Continuous variables were presented as mean ± standard deviation or median [first quartile, third quartile], depending on the distribution. Categorical variables were expressed as the frequency with percentage. Between-group comparisons were performed using the unpaired-samples t-test or Mann-Whitney U test for quantitative variables and the chi-square test or Fisher’s exact test for categorical variables, as appropriate. OCT and quantitative coronary angiography findings at baseline and at one month were compared using the paired t-test or Wilcoxon signed-rank test for quantitative variables and McNemar test for categorical variables, where appropriate. The receiver-operating characteristic (ROC) analysis was performed to determine the optimal cut-off values of S-V distance for resolved malapposed struts at 1 month. Statistical analyses were performed using JMP software version 14.0 (SAS Institute Inc, Cary, NC, USA). A value of \( P < 0.05 \) was considered to indicate statistical significance.

Results

Baseline characteristics: A total of 40 patients underwent either BP-SES (20 patients with 21 lesions) or DP-EES (20 patients with 20 lesions) placement. As Table I shows, there was no difference in the patient, lesion, and procedural characteristics between the patients treated with the BP-SES and those with the DP-EES at baseline. Table II shows the baseline OCT characteristics. The underlying plaque morphology, such as calcium and lipid, was also not significantly different between the two groups. No patients had adverse clinical events during the 1-month observation period after the index PCI, and the study protocol was completed in all the patients. No procedure-related complications were observed.

Quantitative coronary angiography findings: The baseline angiographic characteristics were similar (Table III), with a percentage diameter stenosis of 76.2 ± 8.6% in the BP-SES group versus 75.7 ± 9.0% in the DP-EES group (\( P = 0.858 \)). In-stent diameter stenosis at post-procedure and 1-month follow-up was also similar in the two groups.

OCT findings: Baseline and 1-month follow-up Table IV summarize the OCT findings at baseline and 1-month follow-up. Comparing the BP-SES and DP-EES, groups, there were no significant differences in the OCT findings at baseline, including the percentage of the uncovered strut (80.9 ± 10.3% versus 81.9 ± 13.0%; \( P = 0.379 \)) and percentage of malapposed strut (4.9 ± 3.7% versus 3.1 ± 2.7%; \( P = 0.083 \)). At 1-month follow-up, the BP-SES group showed a significantly lower percentage of an uncovered strut than did the DP-EES group (2.9 ± 1.7% versus 5.7 ± 1.8%; \( P < 0.001 \)). Other OCT findings did not differ between the two groups.

Serial changes: When comparing the OCT findings at baseline and 1-month follow-up, the stent and lumen areas were not significantly different between both groups. Figure 2 displays individual changes in the percentages of uncovered strut and malapposed strut from baseline to the 1-month follow-up. The percentage of uncovered strut reduced significantly at 1 month both in the BP-SES (80.9 ± 10.3% to 2.9 ± 1.7%; \( P < 0.001 \)) and DP-EES (81.9 ± 13.0% to 5.7 ± 1.8%; \( P < 0.001 \)) groups. The rate of malapposed strut decreased significantly at the 1-month follow-up in the BP-SES group (4.9 ± 3.7% to 2.6 ± 3.0%; \( P = 0.025 \)), while no significant change was observed in the DP-EES group (3.1 ± 2.7% to 2.5 ± 2.2%; \( P = 0.467 \)). Representative serial OCT images of each stent are shown in Figure 3.

The numbers and percentage length of intrastent thrombus decreased in the BP-SES (\( P = 0.014 \) and \( P =
Table I. Baseline Characteristics

|                          | BP-SES       | DP-EES       | P-value |
|--------------------------|--------------|--------------|---------|
| Age (years)              | 72.1 ± 8.1   | 69.1 ± 12.1  | 0.363   |
| Male (n, %)              | 17 (85.0)    | 17 (85.0)    | 1.000   |
| BMI (kg/m²)              | 25.0 ± 3.3   | 25.2 ± 2.4   | 0.365   |
| Risk factors             |              |              |         |
| Hypertension (n, %)      | 18 (90.0)    | 17 (85.0)    | 0.680   |
| Dyslipidemia (n, %)      | 17 (85.0)    | 15 (75.0)    | 0.469   |
| Diabetes mellitus (n, %) | 12 (60.0)    | 6 (30.0)     | 0.059   |
| Current smoking (n, %)   | 2 (10.0)     | 1 (5.0)      | 0.634   |
| Family history of CAD (n, %) | 6 (30.0)   | 3 (15.0)     | 0.290   |
| Medical history          |              |              |         |
| Previous MI (n, %)       | 3 (15.0)     | 2 (10.0)     | 0.680   |
| Previous PCI (n, %)      | 4 (20.0)     | 5 (25.0)     | 0.727   |
| Medication at the index procedure |          |              |         |
| Aspirin (n, %)           | 20 (100)     | 20 (100)     | 1.000   |
| Prasugrel (n, %)         | 16 (80.0)    | 17 (85.0)    | 0.708   |
| Clopidogrel (n, %)       | 4 (20.0)     | 3 (15.0)     | 0.708   |
| Statin (n, %)            | 19 (95.0)    | 20 (100)     | 0.548   |
| Clinical status          |              |              |         |
| Stable angina (n, %)     | 16 (80.0)    | 15 (75.0)    | 0.727   |
| Silent myocardial ischemia (n, %) | 4 (20.0)    | 5 (25.0)     | 0.727   |
| Procedural characteristics|              |              |         |
| Culprit vessel, LAD/RCA/LCx (n) | 6/10/4 | 13/4/3 | 0.071   |
| Implanted stent number (n) | 1.1 ± 0.2 | 1.1 ± 0.2 | 1.000   |
| Stent diameter (mm)      | 2.8 ± 0.4    | 2.9 ± 0.4    | 0.665   |
| Total stent length (mm)  | 26.1 ± 6.4   | 24.5 ± 10.6  | 0.220   |
| Post-dilatation (n, %)   | 13 (65.0)    | 14 (70.0)    | 0.750   |
| Maximum balloon diameter (mm) | 3.1 ± 0.5 | 3.1 ± 0.4   | 0.748   |
| Maximum inflation pressure (atm) | 14.1 ± 2.2 | 14.7 ± 2.2 | 0.348   |

Values are mean ± SD or number (percentage). BP-SES indicates bioresorbable-polymer sirolimus-eluting stent; DP-EES, durable-polymer everolimus-eluting stent; BMI, body mass index; CAD, coronary artery disease; MI, myocardial infarction; PCI, percutaneous coronary intervention; LAD, left anterior descending coronary artery; RCA, right coronary artery; and LCx, left circumflex coronary artery.

Table II. Baseline Optical Coherence Tomography Characteristics

|                           | BP-SES       | DP-EES       | P-value |
|---------------------------|--------------|--------------|---------|
| Proximal reference lumen area (mm²) | 7.23 ± 2.14 | 6.81 ± 1.97 | 0.534   |
| Distal reference lumen area (mm²) | 5.60 ± 1.97 | 5.67 ± 2.02 | 0.914   |
| Minimal lumen area (mm²)   | 1.18 ± 0.39  | 1.22 ± 0.48  | 0.884   |
| Lesion length (mm)         | 22.1 ± 7.0   | 20.9 ± 9.0   | 0.380   |
| Lipid plaque               |              |              |         |
| Maximum lipid arc (degree) | 176.4 ± 71.3 | 163.8 ± 66.8 | 0.527   |
| Total lipid length (mm)    | 3.8 ± 2.3    | 3.4 ± 1.5    | 0.906   |
| Minimum fibrous-cap thickness (μm) | 95.3 ± 35.2 | 93.8 ± 32.0 | 0.984   |
| Calcified plaque           |              |              |         |
| Maximum calcium arc (degree) | 209.9 ± 103.4 | 188.6 ± 72.9 | 0.625   |
| Calcium length (mm)        | 11.9 ± 4.5   | 8.8 ± 3.0    | 0.114   |

Values are mean ± SD. OCT indicates optical coherence tomography; BP-SES indicates bioresorbable-polymer sirolimus-eluting stent; and DP-EES, durable-polymer everolimus-eluting stent.

Based on the ROC analyses (Figure 4), the optimal cut-off values of post-procedural S-V distance for predicting resolved malapposed strut were ≤ 160 μm for the BP-SES group and ≤ 190 μm for the DP-EES group. These cut-off values
provided an area under the curve (AUC) of 0.886 for the BP-SES, with a sensitivity of 85.7%, a specificity of 76.9%, and an AUC of 0.817 DP-EES, with a sensitivity of 85.7%, a specificity of 78.7%. The median post-procedural S-V distance struts for the BP-SES and DP-EES were 130 μm [110-160] and 140 μm [120-170] in resolved malapposed struts and 220 μm [190-325] in persistent malapposed struts, respectively.

### Table III. Quantitative Coronary Angiography Analysis

|                      | BP-SES 20 patients | DP-EES 20 patients | P-value |
|----------------------|-------------------|--------------------|---------|
| **Baseline**         |                   |                    |         |
| Reference vessel diameter (mm) | 2.7 ± 0.6 | 2.8 ± 0.5 | 0.428   |
| Minimum lumen diameter (mm) | 0.6 ± 0.2 | 0.7 ± 0.3 | 0.593   |
| Diameter stenosis (%) | 76.2 ± 8.6 | 75.7 ± 9.0 | 0.858   |
| Lesion length (mm)   | 20.7 ± 7.2 | 19.2 ± 9.4 | 0.310   |
| **Post procedure**   |                   |                    |         |
| In-stent minimum lumen diameter (%) | 2.5 ± 0.4 | 2.7 ± 0.4 | 0.465   |
| In-stent diameter stenosis (%) | 9.6 ± 6.3 | 7.2 ± 4.2 | 0.238   |
| In-stent acute gain (mm) | 1.9 ± 0.4 | 2.0 ± 0.4 | 0.518   |
| **1-month follow up**|                   |                    |         |
| Reference diameter (mm) | 2.8 ± 0.4 | 2.8 ± 0.4 | 0.807   |
| In-stent minimum lumen diameter (mm) | 2.4 ± 0.4 | 2.5 ± 0.4 | 0.507   |
| In-stent diameter stenosis (%) | 13.3 ± 6.4 | 10.2 ± 4.4 | 0.082   |
| In-stent late lumen loss (mm) | 0.1 ± 0.2 | 0.1 ± 0.2 | 0.407   |

Values are mean ± SD. QCA indicates quantitative coronary angiography; BP-SES, bioresorbable-polymer sirolimus-eluting stent; and DP-EES, durable-polymer everolimus-eluting stent.

### Table IV. Serial Quantitative and Qualitative Optical Coherence Tomography Analysis

|                | BP-SES (n = 20) | DP-EES (n = 20) | P-value |
|----------------|----------------|----------------|---------|
| Struts analyzed (n) | 303 ± 70 | 298 ± 70 | 0.833   |
| Stent area (mm²)    | 6.6 ± 1.9 | 6.9 ± 2.0 | 0.657   |
| Lumen area (mm²)    | 6.6 ± 1.9 | 6.7 ± 2.0 | 0.926   |
| Neointimal thickness (μm) | 41.5 ± 18.2 | 43.6 ± 19.3 | 0.903   |
| Uncovered struts (n) | 247.5 ± 73.6 | 8.8 ± 5.6 | <0.001  |
| % Uncovered strut (%) | 80.9 ± 10.3 | 2.9 ± 1.7 | <0.001  |
| Malapposed struts (n) | 15.3 ± 12.8 | 8.9 ± 12.4 | 0.029   |
| % Malapposed strut (%) | 4.9 ± 3.7 | 2.6 ± 3.0 | 0.025   |
| Incidence of thrombus (n, %) | 13 (65.0) | 7 (35.0) | 0.058   |
| Number of thrombi (n) | 1.5 ± 1.5 | 0.4 ± 0.6 | 0.014   |
| % Length of thrombus (%) | 7.3 ± 7.5 | 1.0 ± 1.5 | 0.005   |
| Incidence of irregular protrusion (n, %) | 6 (30.0) | 0 (0) | 0.008   |
| Number of irregular protrusion (n) | 0.4 ± 0.7 | 0.0 ± 0.0 | 0.010   |
| % Length of irregular protrusion (%) | 2.4 ± 4.3 | 0.0 ± 0.0 | 0.010   |

Values are mean ± SD or number (percentage). OCT indicates optical coherence tomography; BP-SES, bioresorbable-polymer sirolimus-eluting stent; and DP-EES, durable-polymer everolimus-eluting stent.

### Discussion

The present study evaluating the vascular healing response one month after placement of the BP-SES and DP-EES, demonstrated that the BP-SES was associated with a lower rate of uncovered struts and a comparable rate of malapposed struts than was the DP-EES. This is the first human study to demonstrate a favorable very early vascular response in the BP-SES with the ultrathin strut.

**Early strut coverage:** Given the increasing lesion complexity referred to recent PCI procedure, stent thrombosis is still a major concern, even in this era of modern stents. Lack of neointimal coverage of the stent struts is a predominant cause of stent thrombosis. Before being covered with the neo-intima, uncovered struts affect the coronary blood flow and trigger activation of platelets and leukocytes. Delayed vascular response—Incomplete endo-thelialization with uncovered struts—leads to a risk of persistent stent thrombosis. Although the progression of stent strut coverage and re-endothelialization after placement of the DES is multifactorial, strut thickness could be a potentially major influencing factor for early strut coverage.

The DP-EES with a strut thickness of 81 μm significantly reduced stent thrombosis as well as target lesion re-
vascularization than did the earlier-generation DESs. Because of its safety and a vast amount of evidence, the DP-EES is currently considered the standard DES. The BP-SES with the thinnest strut thickness of 60 μm among the currently available DESs has shown favorable clinical outcomes. A meta-analysis, in which the results were largely driven by comparisons between BP-SES and DP-EES, ultrathin strut (< 70 μm) DESs showed lower rates of stent thrombosis at any stage, irrespective of the type of DES. A randomized trial, BIOFLOW-II, showed comparable uncovered struts and lumen loss at nine months between the BP-SES and DP-EES (2.0% versus 2.7%). Another randomized trial comparing the BP-SES and durable-polymer zotarolimus-eluting stent reported a better mid-term stent coverage in the BP-SES at three months (3.9% versus 8.9%). The present study is the first to evaluate the very early vascular response of the BP-SES in humans. We found a lower rate of uncovered struts at one month in the BP-SES than in the DP-EES. The rates of uncovered struts in DP-EES at one month in patients with chronic coronary syndrome seen in our study were similar to our previous report (5.7% versus 6.4%).

In addition to strut thickness, strut width also affects early stent coverage. On the abluminal side, a narrower strut (i.e., small contact area) generates a higher pressure on the vessel wall, resulting in deeper penetration of the strut into the vessel wall. Assuming similar endothelialization between the BP-SES and DP-EES, the BP-SES with thinner and narrower struts are likely to be embedded deeper into the vessel wall, leading to earlier strut coverage by endothelial cells. These might, in part, explain the results in this study.

Another explanation for the favorable outcomes of the BP-SES might be seen in the hybrid coating of the stent surface. The BP-SES has a circumferential stent coating consisting of biodegradable poly-L lactic acid (PLLA) polymer and amorphous silicon carbide. In the early phase after biodegradable-polymer DES placement, there are concerns about immunogenicity and vascular inflammation caused by byproducts of polymer dissolution. However, a previous study demonstrated that the biodegradable PLLA polymer-based SES showed milder pathologic inflammatory responses compared to other biodegradable or durable polymer-based SESs at short and mid-term follow-up after stent placement in a porcine model. In addition to PLLA polymer, the amorphous silicon carbide

Figure 2. Individual plots of serial changes in the percentages of uncovered struts and percentages of malapposed struts at one month. A, C: Biodegradable-polymer sirolimus-eluting stent. B, D: Durable-polymer everolimus-eluting stent.
Malapposed struts: Understanding the natural course of malapposed struts is clinically important. Stent malapposition immediately after placement depends on the lesion and procedural characteristics. Early malapposition does not closely correlate with stent thrombosis, and a majority of malapposed struts resolve over time. However, persistent malapposition following DES placement is considered a major factor associated with stent thrombosis. In the present study and the BIOFLOW-II trial, the rate of malapposed struts did not differ between the BP-SES and DP-EES immediately after placement, at one month, and at 9 months. In our study, the decrease in the percentage of malapposed strut at one month was statistically significant only in the BP-SES group. This difference would have been partly caused by the rate of malapposed strut at baseline. Although the difference in the percentage of malapposed strut at baseline was not statistically significant, the percentage was numerically higher in the BP-SES group.

Prediction of resolved malapposed struts can avoid unnecessary additional high-pressure post-dilatation to optimize stent apposition, which might result in edge dissection of coronary perforation. Previous studies have revealed the feasibility of the OCT-derived S-V distance for predicting resolved malapposed struts. The present study found that the optimal cut-off value of S-V distance for resolved malapposed struts at 1 month was ≤ 190 μm for the DP-EES, which is in line with a previous study (≤ 185 μm), and ≤ 160 μm for the BP-SES. The difference in the cut-off S-V distance between the two stents seems to be minimal. Given the comparable early endothelialization, the cut-off S-V distance might depend on strut thickness, stent conformability, the potency of anti-proliferative drugs, and vascular reaction to biodegradation of the polymer.

Abnormal intrastent findings: OCT allows detailed evaluation of abnormal intrastent findings, such as thrombus and tissue protrusion, as well as neointimal coverage. A previous OCT study showed that irregular protrusion is an independent OCT predictor of 1-year device-oriented clinical endpoints, mainly target lesion revascularization. In the present study, the frequency of intrastent thrombus and irregular protrusion in the BP-SES group was comparable to those in the DP-EES group. Thrombus was markedly similarly decreased, and irregular protrusion had completely resolved at one month in both groups. Resolution of thrombus may lead to the increase in the incidence of late acquired malapposition and uncovered struts, which might be compensated by promoted
Clinical implications: With increasing frailty in patients treated with DES, bleeding risks during the mandatory period of dual antiplatelet therapy after DES placement are a major concern. The latest guideline recommends dual antiplatelet therapy after contemporary DESs placement is shortened to 3 months in patients at high risk of bleeding. More recently, a large randomized trial revealed that after DP-EES placement, 1-month dual antiplatelet therapy reduces the risk of bleeding without an increase in cardiac ischemic events than does the standard 12-month dual antiplatelet therapy. Our finding suggests that the ultrathin-strut BP-SES has the potential to shorten the duration of dual antiplatelet therapy in a wider range of patients. The cut-off value of S-V distance immediately after DES deployment could be a useful index for determining the feasibility of early de-escalation of antiplatelet therapy.

Study limitations: We acknowledge several limitations. First, this study was a single-center study conducted on a small number of patients. Second, the choice of DES type was at the discretion of treating physicians. Therefore, selection bias cannot be excluded. Third, all the patients had multivessel disease because the second OCT evaluation was performed at the time of staged PCI for residual stenotic lesions. Fourth, we did not assess patients with acute coronary syndrome. Early vascular responses might

Figure 4. ROC analysis and distribution of S-V distance of malapposed struts at baseline. A: Bioresorbable-polymer sirolimus-eluting stent: the optimal cut-off value for resolved malapposed struts was S-V distance ≤ 160 μm with a sensitivity of 85.7% and specificity of 72.9% (AUC: 0.886). B: Durable-polymer everolimus-eluting stent: the optimal cut-off value for resolved malapposed struts was S-V distance ≤ 190 μm with a sensitivity of 77.3% and specificity of 78.7% (AUC: 0.817).

neointimal coverage. Thinner strut thickness and antithrombotic amorphous silicon carbide coating of BP-SES might have a small advantage for early strut coverage. Clinical implications: With increasing frailty in patients treated with DES, bleeding risks during the mandatory period of dual antiplatelet therapy after DES placement are a major concern. The latest guideline recommends dual antiplatelet therapy after contemporary DESs placement is shortened to 3 months in patients at high risk of bleeding. More recently, a large randomized trial revealed that after DP-EES placement, 1-month dual antiplatelet therapy reduces the risk of bleeding without an increase in cardiac ischemic events than does the standard 12-month dual antiplatelet therapy. Our finding suggests that the ultrathin-strut BP-SES has the potential to shorten the duration of dual antiplatelet therapy in a wider range of patients. The cut-off value of S-V distance immediately after DES deployment could be a useful index for determining the feasibility of early de-escalation of antiplatelet therapy. Study limitations: We acknowledge several limitations. First, this study was a single-center study conducted on a small number of patients. Second, the choice of DES type was at the discretion of treating physicians. Therefore, selection bias cannot be excluded. Third, all the patients had multivessel disease because the second OCT evaluation was performed at the time of staged PCI for residual stenotic lesions. Fourth, we did not assess patients with acute coronary syndrome. Early vascular responses might
differ between acute and chronic coronary syndromes. Lastly, all stent implantations were guided by OCT, which is not routinely used in the United States and Europe. Further investigation is necessary with a larger cohort of patients to validate whether our findings can be applicable for a wider range of patients or angiography-guided PCI.

Conclusion

In patients with CCS with multivessel disease, the ultrathin-strut BP-SES demonstrated favorable vascular responses at one month with a lower rate of uncovered struts and a comparable rate of malapposed struts, compared to that with the current generation DP-EES. BP-SES may allow us to shorten dual antiplatelet therapy duration as has been clinically applied for DP-EES.

Conflicts of interest: No conflict of interest.

Acknowledgments

The authors are deeply grateful to the following members of 1) Showa University: Katsuki Nagata and Noriko Iwaki, 2) Kobe Cardiovascular Core Laboratory and Micron Inc. Osaka, Japan: Hiromasa Otake, M.D. and Keiji Noutomi.

Disclosure

Conflicts of interest: All authors declare that they have no conflict of interest.

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