

WHAT IS KNOWN

- There are 3 types of stent malapposition: acute, late-persistent, and late-acquired stent malapposition.
- Late-acquired stent malapposition may constitute a potent substrate for late stent thrombosis after drug-eluting stent implantation.
- There are limited data on optical coherence tomography-detected acute and late stent malapposition in small sample sizes.

WHAT THE STUDY ADDS

- Acute, late-persistent, and late-acquired stent malapposition detected by optical coherence tomography had relatively high incidences but different predictors.
- The clinical outcome of optical coherence tomography-based stent malapposition was favorable.

who underwent drug-eluting stents implantation because of stenosis of de novo lesions and 52 patients (55 lesions) with postintervention OCT alone, excluding 351 study patients. DESs were selected by operators at the time of implantation and included sirolimus-eluting stents (Cypher, Cordis, Miami, FL), zotarolimus-eluting stents (Resolute or Integrity, Medtronic, Santa Rosa, CA), everolimus-eluting stents (Xience V, Abbott Vascular, Santa Clara, CA), or biolimus A9-eluting stents (Nobori, Terumo Corporation, Tokyo, Japan or Biomatrix, Biosensors International, Singapore). Each DES was implanted using conventional techniques. Unfractionated heparin was administered as an initial bolus of 100 IU/kg with additional boluses administered during the procedure to achieve an activated clotting time of 250 to 300 seconds. Dual antiplatelet therapy (aspirin and clopidogrel) was provided to each patient until the follow-up OCT was performed. The institutional review board of Yonsei University Severance Hospital approved this study, and written informed consent was obtained from each patient.

OCT Imaging and Analyses

OCT was performed using 2 OCT systems (Model M2 Imaging System and C7-XR Imaging System, LightLab Imaging, Inc, St Jude Medical, St. Paul, MN).^{7,8} All OCT images were analyzed at a core laboratory (Cardiovascular Research Center, Seoul, Korea) by analysts who were blinded to patient and procedural information. Cross-sectional OCT images were analyzed at 1-mm intervals. Stent and luminal cross-sectional areas were measured. The malapposition and neointimal hyperplasia (NIH) cross-sectional area was calculated as appropriate.⁹ Once a complete set of cross-sectional area measurements was obtained, intrastent volumes (stent, lumen, malapposition, and NIH volumes) were calculated by Simpson rule.¹⁰ NIH volume obstruction (%) was calculated as the NIH volume divided by stent volume. Mean values are reported. NIH thickness, the distance between the endoluminal surface of the neointima and the strut, was measured inside each strut with a line perpendicular to the neointima and strut.¹¹ The percentage of malapposed struts in each stented lesion was calculated as the (number of malapposed struts/total number of struts in all cross-sections of the lesion)×100.

A malapposed strut was defined as a strut that was detached from the vessel wall as follows: Cypher, ≥160 μm; Resolute or Integrity, ≥110 μm; Xience V, ≥100 μm; Nobori or Biomatrix, ≥130 μm.^{12–14} A coronary stent malapposition that is detected immediately after implantation of the stent is classified as an acute stent malapposition, whereas one that is detected later (during a follow-up examination) is classified as a late stent malapposition. Late stent malappositions can

be further classified as a late-persistent stent malappositions or late-acquired stent malappositions. A late-persistent stent malapposition is an acute stent malapposition that remains present at the follow-up examination. A late-acquired stent malapposition is a newly developed stent malapposition that is identified at the follow-up examination despite complete stent apposition during the initial procedure. If malapposed struts were detected by poststent OCT (ie, acute stent malapposition), each cross-section of the poststent OCT image was matched with corresponding cross-sectional images of the follow-up OCT image as accurately as possible based on the distance from fiducial landmarks (eg, stent edges, side branches, or calcification).⁸ The lesions were then appropriately classified as resolved acute stent malapposition lesions with or without late-acquired stent malapposition or late-persistent stent malapposition lesions with or without late-acquired stent malapposition (Figure 1). In addition, the longitudinal locations of malappositions were classified as stent edges (<5 mm from the proximal or distal edge of the stent) or stent body. If malapposed struts were detected within a stent edge and stent body simultaneously, the location with the larger malapposition volume was designated as the longitudinal location of malapposition.

Angiographic Analyses

Quantitative coronary angiography analyses were performed before and after stent implantation and at the follow-up using an off-line quantitative coronary angiographic system (CASS system, Pie Medical Instruments, Maastricht, The Netherlands) in an independent core laboratory (Cardiovascular Research Center, Seoul, Korea). Reference vessel diameters and minimal luminal diameters were measured with a guiding catheter for magnification-calibration from diastolic frames in a single, matched view that showed the smallest minimal luminal diameter.

Clinical Follow-up

All patients were advised to receive dual (aspirin and clopidogrel) antiplatelet therapy for ≥6 months after DES implantation. During the follow-up period, clinical events were investigated, including cardiovascular death, nonfatal myocardial infarction, stent thrombosis, and target lesion revascularization. Patients who experienced clinical events within the first year after DES implantation were included in this study.

Statistical Analyses

Categorical variables are presented as numbers (%). Continuous variables are presented as the mean±SD. Categorical variables were compared using χ^2 tests or Fisher exact tests. Continuous variables were compared using Student *t* tests, paired *t* tests, or 1-way ANOVA, as appropriate. If distributions were skewed, nonparametric tests were performed. Multivariate logistic regression analyses were performed to identify independent predictors of acute, late-persistent, and late-acquired stent malapposition. Variables with *P* values <0.2 from univariate analyses were included in multivariate analyses. Receiver-operating curve analyses were performed to identify the best cut-off value that separated late-persistent stent malapposition lesions from resolved acute stent malapposition lesions. The incidences of clinical events were presented as the proportions and compared using Fisher exact test because of the small number of clinical events. Statistical analyses were performed using the software program SPSS (version 20.0, Chicago, IL), and *P*<0.05 was considered statistically significant.

Results

Baseline clinical and procedural characteristics are summarized in Table 1. There were no statistically significant differences in baseline clinical and procedural characteristics among the 351 study patients, 52 patients with post-DES OCT alone, and the remaining 3235 patients with DES implantation during the same study period (Table 1). Figure 2 shows the incidences of acute, late-persistent, and late-acquired stent