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Association of morphologic characteristics on optical coherence tomography and angiographic progression patterns of late restenosis after drug-eluting stent implantation☆

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ABSTRACT

Objectives: To gain insight into the pathophysiology of late drug-eluting stent (DES) restenosis.
Background: Restenosis of DES has a different time course from that of bare metal stents.
Methods: Patients who underwent follow-up coronary angiography (CAG) twice (six to nine months and 18 to 24 months) after DES implantation were examined using optical coherence tomography (OCT). All lesions with target lesion revascularization at first follow-up were excluded. Late catch-up was defined as lesions that progressed from less than 50% diameter stenosis (DS) at the first CAG to more than 50% DS at the second CAG. Lesions with the late catch-up were further divided into two groups; lesions with jump-up (less than 25% DS at the first CAG) and lesions with gradual progression (25–50% DS at the first CAG).
Results: Of the 25 patients who had late ISR, 23 patients (10 jump-up/13 gradual progression) were examined with OCT at late follow-up and enrolled in this study. In the qualitative OCT assessment, each ratio of homogeneous, layered, heterogeneous with or without attenuation tissue morphologies were in jump-up group, and gradual progression group were 0% and 15%, 0% and 23%, and 60% and 8%, and 40% and 54%, respectively. All of jump-up group showed heterogeneous restenotic tissue, while 62% of gradual progression group showed heterogeneous restenotic tissue ($P = .04$).
Conclusions: These findings suggest different pathophysiology of the late catch-up after DES implantation between the jump-up and gradual progression groups.

1. Introduction

Although drug-eluting stents (DES) are widely used for the treatment of coronary artery disease and significantly reduce restenosis, some studies have suggested that restenosis of DES may have a different time course from that of bare metal stents (BMS) and occasionally occurs more than 1 year after DES implantation (i.e., late catch-up phenomenon). In addition, a recent angiographic study demonstrated two patterns of late DES restenosis: 1) jump-up from mild restenosis on early follow-up coronary angiography (CAG); or 2) gradual progression from moderate restenosis on early follow-up CAG [1]. Moreover, recent optical coherence tomography (OCT) reports showed a variety of OCT image patterns of DES restenotic tissue [2–5], whereas homogeneous high-signal tissue intensity is dominant in BMS restenosis. To gain insight into the pathophysiology of late DES restenosis, we compared OCT morphologic characteristics between patients with jump-up and gradual progression restenotic lesions after DES implantation.

2. Methods

2.1. Study design and population

Patients with late (>1 year) in-stent restenosis (ISR) of 1st generation DES (sirolimus-eluting stent (SES), Cypher, Cordis Corp., Miami Lakes, FL, and paclitaxel-eluting stent (PES), Taxus, Boston Scientific, Natick, MA) were enrolled in this study. Patients with ST-segment elevation myocardial infarction, cardiogenic shock, or age more than 90 were excluded. In our hospital, first (early) follow-up angiography was scheduled at six to nine months after percutaneous coronary intervention (PCI) and the second (late) at 18 to 24 months after PCI, regardless of symptom. All lesions with target lesion revascularization at first

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follow-up were also excluded. ISR was defined as >50% of diameter stenosis. Late ISR was classified into 2 groups; 1) jump-up from mild restenosis (percent diameter stenosis (%DS) 0-24%) on early follow-up CAG; or 2) gradual progression from moderate restenosis (%DS 25–49%) on early follow-up CAG [1].

2.2. Quantitative coronary angiography (QCA)

Off-line quantitative coronary angiography (QCA) was conducted using the view that revealed the highest degree of stenosis. Severity of coronary stenosis was measured using the Cardiovascular Measurement System (CMS-MEDIS Medical Imaging System, Leiden, The Netherlands). Lesion length, reference diameter, minimal luminal diameter (MLD), and % diameter stenosis (DS) were calculated by a single technician who was blinded to clinical characteristics. Analysis of angiographic frames was performed in the end-diastolic stage.

2.3. Optical coherence tomography (OCT) imaging

After completion of coronary angiography, patients were evaluated with OCT. OCT imaging was performed using the OCT imaging system (M2 OCT system, LightLab Imaging, Westford, MA). The detailed specifications and the OCT procedure have been described elsewhere [2]. OCT analysis was performed using LightLab OCT imaging proprietary software (LightLab Imaging, Westford, MA). Qualitative analyses of OCT images were performed by experienced analysts who were blinded to clinical and angiographic lesion characteristics. To evaluate the morphologic appearance of restenotic tissue, the pattern of restenotic tissue structure in cross sectional images at minimal lumen area was categorized into 3 groups: 1) homogeneous intima: restenotic tissue has a uniform optical properties and does not show focal variations in backscattering pattern (Fig. 1A) [5]; 2) layered pattern: restenotic tissue consisting of concentric layers of a high-scattering endoluminal layer and a low-scattering abluminal layer delineated by a clear border

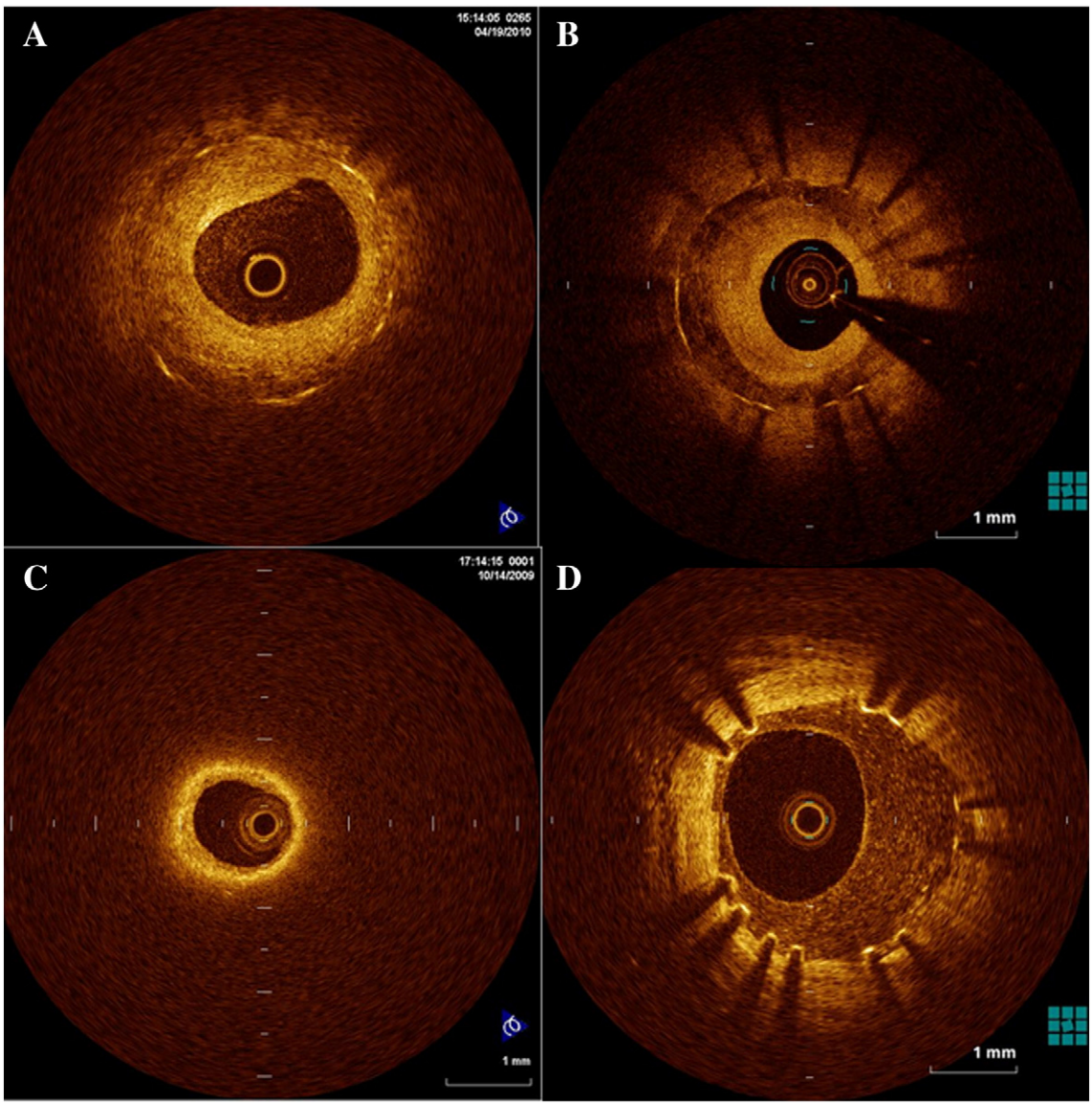

Fig. 1. A variety of optical coherence tomography image patterns of late restenotic tissue after drug-eluting stent implantation. A) homogeneous intima: restenotic tissue has uniform optical properties and does not show focal variations in backscattering pattern; B) layered pattern: restenotic tissue consisting of concentric layers with different optical properties (thick high scattering layer and a low scattering layer with stent strut); C/D) heterogeneous intima: restenotic tissue consisting of heterogeneous speckled band with (C) or without (D) area with marked signal attenuation with diffuse border.