Images in Cardiovascular Medicine

Coronary Stent Fracture Complicated Multiple Aneurysms Confirmed by 3-Dimensional Reconstruction of Intravascular-Optical Coherence Tomography in a Patient Treated With Open-Cell Designed Drug-Eluting Stent

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A 55-year-old man with a previous history of cerebral infarct and hypertension presented to our cardiovascular center complaining of angina in November 2011. Chronic total occlusion in the proximal left anterior descending coronary artery was identified by coronary angiography (Figure 1A). The patient subsequently underwent percutaneous coronary intervention. Wiring was done successfully with a tapered stiff wire (Conquest Pro 20; ASAHI INTECC). After multiple predilation, a single drug-eluting stent (3.0 × 18 mm) of an open-cell design and bioabsorbable polymer (Nobori; Terumo, Tokyo, Japan) was implanted using a 3.5-mm noncompliant balloon (inflation pressure, 24 atm pressure; Quantum Maverick Balloon; Boston Scientific/Scimed, Maple Grove, MN) for application of final high-pressure postdilation (Figure 1B). The patient has been asymptomatic since percutaneous coronary intervention and on dual antiplatelet therapy. A 6-month scheduled angiographic follow-up demonstrated a structural misalignment at the stent implantation site with a change in focal aneurysm (Figure 1C). Digital subtraction imaging by StentBoost (Subtract; Philips Healthcare, Best, The Netherlands) was done under the suspicion of stent distortion, but the imaging was unclear to clarify the diagnosis (Figure 1D). To determine the precise configuration of the stent, we performed intravascular optical coherence tomography (OCT). Conventional 2-dimensional (2-D) OCT revealed a focal thrombus and 2 additional aneurysms near the suspicious area of stent fracture (SF) (Figure 2). However, considering uneven stent geometry of Nobori cross-sectional images, 2-D OCT was not conclusive for the final diagnosis (Figure 3). Therefore, we performed the color coding to each component in the segmented images by applying specific colors using the image processing software ImageJ (National Institutes of Health, Bethesda, MD) and the 3-D rendering on a stack of the color-coded 2-D images using a digital imaging and communications in medicine viewer (OsiriX; The OsiriX Foundation, Geneva, Switzerland). After 3-D reconstruction and strut segmentation, the presence of SF was finally verified (Figures 4 and 5). The patient was discharged on triple antiplatelet treatment without complications (aspirin, clopidogrel, and cilostazol).

Clinically relevant SF has been known to be a rare complication of the drug-eluting stent. However, recent autopsy data demonstrated that drug-eluting stent fracture occurred in 29% of lesions, suggesting that the actual incidence of subclinical SF is probably higher than reported clinically.1 Considering its potentially lethal complications, such as acute coronary syndrome, in-stent restenosis, stent thrombosis, and even cardiac tamponade, more accurate detection of SF is urgently needed. Various imaging modalities, including conventional coronary angiography, intravascular ultrasound, and digital subtraction radiograph imaging, have been tried to reveal SF, but the usefulness of such modalities is still questionable. Recently, intracoronary optical imaging, a viable method for imaging the microstructure of coronary stent struts with more than 10 times higher resolution compared with intravascular ultrasound, has been increasingly performed for the detection of SF. Previous reports suggested that 2-D OCT findings, such as lack of circumferential stent strut, destroyed transverse circular architecture, altered geometry of stent strut, and exaggerated neointimal hyperplasia in fracture sites, could be regarded as SF.2,3 However, these criteria should not be applied to all cases because the stent platforms of recently developed drug-eluting stents mostly have an open-cell design with minimal connecting links for the purpose of better conformability and flexibility. Accordingly, diverse, nonuniform patterns of struts are imaged on 2-D transverse OCT (Figure 3). Another limitation is that fractures occurring on one side of a stent could be easily misdiagnosed by 2-D OCT.

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(Figure 3). The present case highlights the potential role of 3-D OCT rendering and strut segmentation for the SF confirmation, which has not been used as a practical modality in clinical practice until now. In this context, this technology is expected to provide the valuable information regarding the clinical course of SF and will help determine the optimal therapeutic strategies. The spacing between current OCT images was 200 μm with a frame rate of 100 frames/s and a pullback speed of 20 mm/s. Although current OCT spatial resolution is sufficient to detect whether SF occurred within the modules of the stent, which was clearly visualized in 3-D rendering, the width of the stent strut is usually smaller than 200 μm. In future, automated 3-D OCT rendering with a better spatial resolution and a faster imaging rate under development would allow one to detect even smaller fractures, which could be more useful to determine whether or not the subclinical SF occurs and also for the development of future generations of stents.

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Figure 1. A stumpless chronic total occlusion lesion of the proximal left anterior descending artery. B, Immediate angiographic appearance after implantation of a 3.0 × 18 mm drug-eluting stent with final high-pressure postdilation using a 3.5 × 8 mm noncompliant balloon up to the burst pressure. C, Follow-up coronary angiography revealed increased tortuosity with focal aneurysmal change (black arrow). D, Digital subtraction imaging (StentBoost) showed deformed stent struts with doubtful loss of linkage (white arrow).

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Disclosures
None.

References
Figure 2. Findings from intravascular 2-dimensional optical coherence tomography. **A**, Intraluminal thrombus attached to the arterial wall (asterisk). **B**, Malapposed stent struts (small white arrows) and small peristrut ulcers were seen, which can be sequelae related to the positive arterial remodeling after the intervention. **C** and **D**, Aneurysmal changes corresponding with the finding observed in angiography at the site suspected of stent fracture (white arrows). **E** and **F**, Another small aneurysm at the opposite side of the aneurysm and multiple, small peristrut ulcers (white arrows). **G**, A cross-sectional image with circumferential stent struts. **H**, Coronary artery segment with lack of circumferential stent struts (only 3 stent struts was exhibited; arrowheads), which was reported previously as evidence of stent fracture.

Figure 3. Nobori stents having an open-cell design with 6 crowns and 2 connections between the cells. Various patterns of strut images could be observed in 2-dimensional optical coherence tomography attributable to different geometries of stent scaffold (**A** through **D**) compared with a closed-cell design stent, which produces circumferential strut images.
**Figure 4.** Three-dimensional reconstruction of optical coherence tomography demonstrating misaligned strut architecture, deformity of adjacent vascular wall, and 2 small aneurysms (yellow arrows). This 3-dimensional rendering technique allows direct configuration on the stent geometry with the adjacent arterial structure.

**Figure 5.** Three-dimensional strut mapping. This imaging technology confirmed the stent fracture by showing loss of stent strut integrity with apparent breakage of the connecting links (red arrowheads) compared with intact links (white arrowheads).
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