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Letter to the Editor

Impact of main-branch calcified plaque on side-branch stenosis in bifurcation stenting: An optical coherence tomography study

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Percutaneous coronary intervention (PCI) in bifurcations is routinely performed; however, this procedure is associated with higher rates of adverse events compared with non-bifurcation PCI [1,2]. While bifurcation PCI per se leads to progressively higher rates of periprocedural myocardial infarction as its complexity increases (i.e., 1- vs. 2-stent technique) [3], side-branch (SB) stenosis (SBS) after main-branch (MB) stenting may further contribute to myocardial ischemia and necrosis; in addition, it might require additional intervention and resource utilization. Due to its unprecedented high resolution (~10 μm axial) and sharp delineation of stent–lumen interface, optical coherence tomography (OCT) has been increasingly used for PCI guidance [4]; furthermore, OCT enables accurate characterization of plaque components [5,6]. We, therefore, hypothesized that we could take advantage of OCT's properties to better understand the complex relationship between underlying plaque components, particularly calcium, and SBS after MB stenting during bifurcation PCI.

We evaluated non-consecutive patients from a single center (New Tokyo Hospital, Chiba, Japan) with native de novo coronary artery bifurcation lesions with SB demonstrating ≤50% diameter stenosis (DS) deserving wire protection (SB length greater than 50 mm and/or reference vessel diameter greater than 1.5 mm) who underwent MB OCT before PCI. The study protocol was approved by the institutional review board of the institution and written informed consent was obtained from all the patients before any intervention was performed.

All patients were treated with aspirin (200 mg loading-dose) and clopidogrel (300 mg loading-dose). After stent implantation, aspirin was maintained indefinitely (200 mg/day), while clopidogrel (75 mg/day) was continued for at least one year. Stent type and procedure technique were left at the operator's discretion. The elevation of Tn-I or CK-MB above 3 times the 99% percentile URL was defined as periprocedural MI [7].

QCA of MB and SB were performed at pre- and post-MB stent implantation. Angiographic measurements were made in two matched orthogonal projections. Offline analyses of digital coronary angiograms (CASS, Pie Medical Imaging) were performed by independent investigators blinded to the clinical data and OCT findings. SBS after procedure was defined as % DS greater than 75% (AHA classification) within 5 mm distal from side branch ostium. Calcification and bifurcation angles were also evaluated.

A conventional angioplasty guide wire (0.014-inch) was advanced distal to the region of interest, and then the 2.7 French OCT catheter (Dragonfly™, St Jude Medical, St Paul, Minnesota, USA) was advanced over the guide wire at least 10-mm beyond the region of interest. Dedicated software with an automated contour-detection algorithm (Off-line Review Software, version C.0.2; St Jude Medical, St Paul, Minnesota, USA) was used for the analyses. All cross-sectional images were initially screened for quality assessment and excluded from analysis if any portion of the stent was out of the screen or if the image had poor quality caused by residual blood, artifact, or reverberation [4]. OCT assessments were performed pre-stent implantation in MB stent implantation in order to evaluate plaque type at bifurcation lesions. Bifurcation segments were determined as previously reported [8]. Qualitative assessments of plaque components by two highly experienced OCT analysts were performed at every frame

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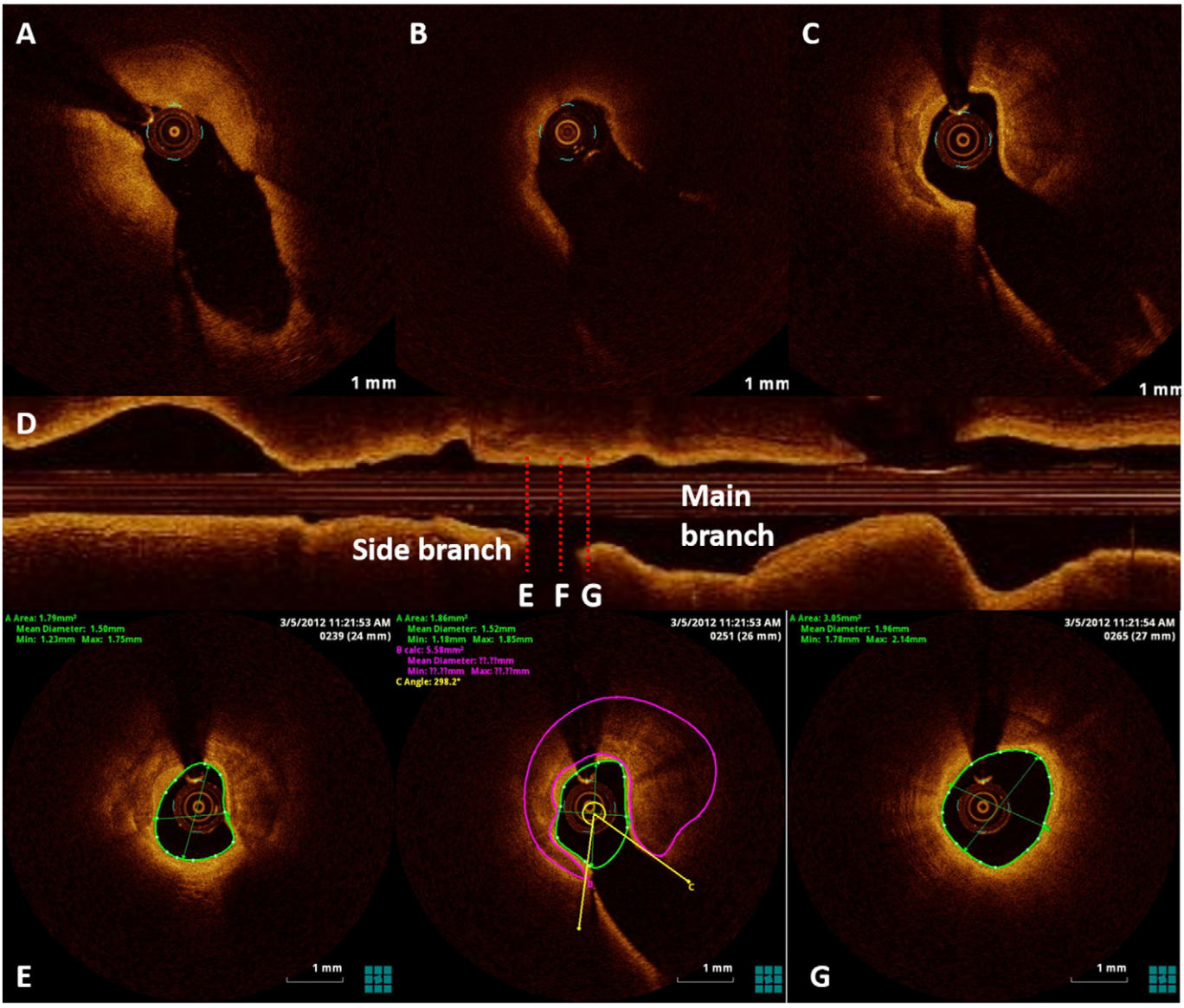

Fig. 1. Frequency-domain optical coherence tomography (FD-OCT) images of plaque type and calcified plaque analysis. (A) Fibrous, (B) lipid and (C) calcified plaques at bifurcation lesions. Panel D shows a longitudinal image of calcified plaque at bifurcation. Panels E and G show the distal part and Panel G shows the proximal part of calcified plaque. Panel F shows the real analysis of calcified plaque with calcified plaque (purple line) area and angle (yellow line).

(i.e., every 0.2 mm) in the bifurcation segment. We classified plaque type as fibrous, lipid and calcified (Fig. 1) as previously reported [9]. Calcium areas (max, mean and min/mm^2) and angles (max, mean and min/degree) were measured in every frame (0.2 mm/frame) (Fig. 1); in addition, calcium length (mm) was recorded (0.2 mm × number of cross-sections).

Seventy-five patients whom underwent BMS or DES implantation fulfilled the inclusion criteria. SBS occurred in 31 (41.3%) patients after MB stenting (Fig. 2.) Baseline clinical characteristics were comparable in the SBS and non-SBS groups (Table 1). Angiographic characteristics are shown in Table 2. All patients in both groups exhibited TIMI 3 flow before the procedure, while TIMI flow grade 2 post-procedure was more common in SBS patients (45.2% vs. 6.8%, respectively, $p < 0.001$). Smaller angles between MB and SB were identified in the SBS group compared with the non-SBS group (angle 48.55 ± 20.26° vs. 65.58 ± 33.98°, $p = 0.008$; and percentage of angle <70°: 93.6% vs. 61.4%, respectively, $p = 0.002$). Percentage DS of SB pre- and post-PCI were greater, while MLD post-PCI was significantly smaller in the SBS group than in the non-SBS group (Table 2).

OCT findings are demonstrated in Table 4. The presence of fibrous plaque in the MB was more common in the non-SBS group, whereas calcified plaque and greater magnitude of calcium distribution were more frequently demonstrated in the SBS group. (See Table 3.) (See Table 5.)

In multivariate analysis, bifurcation angle (<70°; odds ratio [OR]: 11.83; 95% confidence interval [CI]: 2.00 to 70.02; $p = 0.007$), % DS of SB pre-PCI (odds ratio [OR]: 1.07; 95% confidence interval [CI]: 1.02 to 1.13; $p = 0.012$), and the presence of calcified plaque determined by OCT in the bifurcation segment of MB (OR: 12.32; 95% CI: 2.58 to 58.83; $p = 0.002$) were independent predictors of SBS.