Serial optical coherence tomography-based observation of strut coverage on drug-eluting stent crossing side-branch vessels

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

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Serial changes in strut coverage of drug-eluting stent (DES), which are placed across side-branch vessels, remain unclear. The changes in strut coverage of DES crossing side-branch vessels (size ≥2.0 mm) were serially evaluated by optical coherence tomography (OCT) in 30 patients at 9 months and 2 years after the index DES implantation. DESs were paclitaxel-eluting stents (PESs), sirolimus-eluting stents (SESs), and zotarolimus-eluting stents (ZESs) each in 10 patients. Measured neointimal hyperplasia (NIH) thickness of 0 μm on OCT was defined as an uncovered strut. The percentage of uncovered side-branch struts significantly decreased from 55.7 ± 39.9% to 36.6 ± 32.0% ($p < 0.0001$) on serial follow-up: PESs, 93.4 ± 10.5% to 67.6 ± 24.2%, $p = 0.018$; SESs, 47.5 ± 34.4% to 29.6 ± 24.1%, $p = 0.036$; and ZESs, 26.2 ± 34.8% to 12.4 ± 19.0%, $p = 0.028$. Among covered side-branch struts, the overall percentage of struts with NIH thickness more than 30 μm significantly increased from 36.3 ± 37.4% to 51.0 ± 36.0% ($p < 0.0001$). However, compared to other DESs, a significant increase in relatively thin NIH (0 to 30 μm) was observed in PES (1.6 ± 3.4% to 17.4 ± 16.0%, $p = 0.018$). Serial follow-up OCT examination showed a significant decrease in the percentage of uncovered side-branch struts, and the coverage pattern differed with DES type.

Key words : optical coherence tomography, stent

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I. INTRODUCTION

The attachments of stent struts to vessel walls allow migration and proliferation of smooth muscle cells from the media. However, because stent struts positioned across side-branch vessels are not intrinsically attached to the vessel wall, neointimal coverage on these struts may be expected to be poor or absent. Although drug-eluting stents (DESs) have reduced the rate of restenosis compared to bare metal stents, safety concerns over the occurrence of late stent thrombosis have been raised[1-3]. Several pathological studies have suggested that late stent thrombosis may be predominantly associated with delayed arterial healing, characterized by incomplete or absent neointimal coverage over DES struts[4,5]. Therefore, DES struts positioned across side-branch vessels, which are theoretically typical examples of struts with poor neointimal coverage, may be a potential nidus for late stent thrombosis. Using optical coherence tomography (OCT), we previously showed that different patterns of strut coverage were observed on side-branch struts depending on the DES type[6]. However, to date, there are no published data about the natural course of uncovered side-branch DES struts in-vivo. We thus investigated serial changes in strut coverage over side-branch DESs using OCT.

II. MATERIALS AND METHODS

Study patients.

From the OCT registry database of our institute, we identified 250 patients who underwent follow-up OCT examination at 9 months (± 3 months) after DES implantation between November 2007 and August 2009. A second follow-up OCT examination was performed at 2 years (± 3 months) after stent implantation as planned follow-up angiography for other stented segments in 60 patients with 63 stented lesions. Thirty of the 60 patients who underwent DES implantation across side-branch vessels were selected using the following inclusion criteria: 1) de novo lesions with >50% diameter stenosis, 2) main vessel diameter ≥2.5 mm, 3) side-branch vessel diameter ≥2.0 mm, and 4) no target lesion revascularization procedure between 9-month and 2-year follow-up. An offline quantitative coronary angiography analysis system (CASS system; Pie Medical Instruments, Maastricht, The Netherlands) was used to determine the dimensions of the main and side-branch vessels for inclusion into the study. DESs used were sirolimus-eluting stent (SES, Cypher^{TM}, Cordis, Miami Lakes, FL) in 10 patients, paclitaxel-eluting stent (PES, Taxus^{TM}, Boston Scientific, Natick, MA) in 10 patients, and zotarolimus-eluting stent (ZES, Endeavor Sprint^{TM}, Medtronic, Santa Rosa, CA) in 10 patients. The selection of DES at the time of coronary intervention was at the physician's discretion. General inclusion and exclusion criteria for the follow-up OCT procedures have been previously reported[7]. Specifically, patients with in-stent restenotic lesions treated with repeat target lesion revascularization before 2-year follow-up were excluded from this study. The study protocol was approved by the institutional review board of our institutes, and informed written consent was obtained from all patients before the procedure. DES implantation was performed using conventional techniques, and most patients received dual (aspirin and clopidogrel) anti-platelet therapy

for at least 12 months.

OCT image protocol and analysis

OCT examination using a conventional OCT system (Model M2 Cardiology Imaging System, Light Lab Imaging, Westford, MA) with a motorized pull-back system at 1.0 mm/s was previously described[7]. OCT analysis was performed by an independent investigator blinded to patient and procedural information. OCT examination into side-branch vessels through the stent struts was not performed. OCT cross-sectional still frames were selected at 0.067-mm intervals in the limited segments with stent struts crossing a side-branch (Figure. 1). Because there might be a potential problem that proximal and distal end of side branch ostium are not well matched for serial comparison using the current OCT system, stented segments were chosen where the side branch vessel occupied more than 45° of the main vessel's circumference at the take-off[6]. Frames with image artifacts such as motion artifacts were excluded. For serial comparison, cross-sectional OCT images at 9 months and 2-year follow-up were manually and meticulously matched using the distance between the proximal and distal ends of the side-branch vessel for reference. Among 753 image sections, 716 image sections (95.1%) were analyzable in this study; 363/382 (95.0%) in initial follow-up and 353/371 (95.1%) in second follow-up.

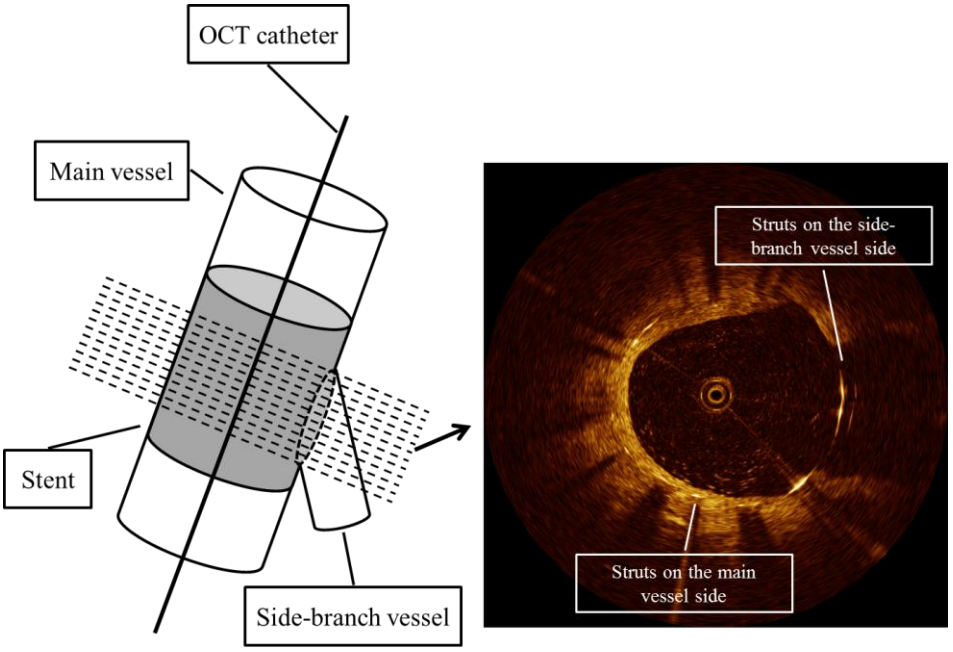

Figure 1. Frames at 0.067-mm intervals were chosen from each optical coherence tomographic (OCT) image having segments with stent struts over a branch vessel.

Stent and luminal cross-sectional areas (CSAs) were measured, and neointimal hyperplasia (NIH) CSA was calculated as the stent CSA minus the luminal CSA. Percent NIH CSA was calculated as NIH CSA × 100/stent CSA. The thickness of NIH was measured as the distance between the endoluminal surface of the neointima and the luminal surface of the strut[8,9]. An uncovered strut was defined as having a NIH thickness of 0 μm[8,9]. The percentage of uncovered struts were calculated as the (number of uncovered struts/total number of struts in the limited segments with stent struts crossing a side branch) × 100. In covered side-branch struts, NIH thickness pattern was divided into two groups: struts with relatively thin NIH thickness (0 to 30 μm); and those with NIH thickness more than 30 μm. One OCT study with 3-month follow-up after SES implantation showed that mean NIH thickness was 29 ± 41 μm[10].

Another study reported that median NIH thickness was 52.5 μm, and the 25th percentile of NIH thickness was 28.0 μm on 6-month follow-up OCT after SES implantation[11]. Based on these studies[10,11], NIH thickness under 30 μm may represent early strut coverage. Mean values are reported in this study. The results of inter- and intra-observer variability for the measurement of OCT variables have been previously reported[12].

Statistical analysis

Statistical analysis was performed using Predictive Analytics SoftWare (PASW) for Windows, version 18.0.0 (SPSS, Inc., Chicago, Illinois). Data are expressed as number (%) or mean ± standard deviation. Comparisons of categorical data were made using χ-square statistics or Fisher's exact test. Student's *t*-test, paired *t*-test, or Wilcoxon signed-rank test was used to compare continuous variables. Comparisons among the three stent groups included were performed using one-way ANOVA or the Kruskal-Wallis test. A p-value <0.05 was considered statistically significant.

III. RESULTS

Baseline clinical and angiographic characteristics are listed in Table 1. All imaging procedures were performed without any complications or adverse events.

Table 1. Baseline clinical and angiographic characteristics

	PES (n = 10)	SES (n = 10)	ZES (n = 10)	P
Clinical variables				
Age (years)	59 ± 10	61 ± 10	61 ± 5	0.757
Men	6 (60%)	7 (70%)	8 (80%)	0.879

Diabetes mellitus	1 (10%)	3 (30%)	2 (20%)	0.847
Hypertension	4 (40%)	4 (40%)	5 (50%)	1.0
Hypercholesterolemia	3 (30%)	3 (30%)	4 (40%)	1.0
Current smoker	5 (50%)	3 (30%)	1 (10%)	0.204
Acute coronary syndrome	6 (60%)	4 (40%)	5 (50%)	0.897
Medications				
Aspirin	10 (100%)	10 (100%)	10 (100%)	1.0
β-blocker	10 (100%)	9 (90%)	8 (80%)	0.754
Angiotensin-converting enzyme inhibitors	3 (30%)	4 (40%)	3 (30%)	1.0
Angiotensin receptor blocker	6 (60%)	4 (40%)	6 (60%)	0.725
Calcium channel blocker	3 (30%)	2 (20%)	2 (20%)	1.0
Statin	10 (100%)	10 (100%)	8 (80%)	0.310
Angiographic variables				
Target vessel				0.309
Left anterior descending artery	7 (70%)	5 (50%)	6 (60%)	
Left circumflex artery	2 (20%)	3 (30%)	0 (0%)	
Right coronary artery	1 (10%)	2 (20%)	4 (40%)	
B2/C lesion morphology	10 (100%)	10 (100%)	9 (90%)	1.0
Lesion length (mm)	27.7 ± 6.9	25.6 ± 6.5	23.6 ± 3.6	0.337
Stent diameter (mm)	2.95 ± 0.23	2.93 ± 0.23	2.98 ± 0.34	0.886

Stent length (mm)	30.2 ± 6.5	28.3 ± 5.9	27.0 ± 3.2	0.499
Before stenting				
Reference vessel diameter (mm)	2.65 ± 0.33	2.69 ± 0.31	2.66 ± 0.37	0.864
Minimal lumen diameter (mm)	0.59 ± 0.41	0.69 ± 0.44	0.44 ± 0.42	0.427
After stenting				
Reference vessel diameter (mm)	2.72 ± 0.27	2.74 ± 0.27	2.70 ± 0.35	0.960
Minimal lumen diameter (mm)	2.69 ± 0.26	2.74 ± 0.20	2.74 ± 0.38	0.679

Data are presented as mean ± SD or n (%). PES indicates paclitaxel-eluting stent; SES, sirolimus-eluting stent; ZES, zotarolimus-eluting stent.

Table 2 shows the initial and follow-up OCT findings of stent struts on the main vessel and branch vessel side. Percentage of uncovered side-branch struts was highest with PESs on initial follow-up OCT (93.4 ± 10.5% compared to 47.5 ± 34.4% and 26.2 ± 34.8% for SESs and ZESs, respectively; p = 0.0001). Similar results were seen on second follow-up OCT (67.6 ± 24.2% for PESs compared to 29.6 ± 24.1% and 12.4 ± 19.0% for SESs and ZESs, respectively; p < 0.0001).

Table 2. Optical coherence tomography findings

	PES (n = 10)	**SES (n = 10)**	**ZES (n = 10)**	**P**
Initial follow-up (months)	10.5 ± 2.1	9.7 ± 1.5	8.5 ± 1.4	0.085
Total no. of cross sections	109	143	111	
Main vessel side				
Total no. of struts	937	1026	1236	

Mean no. of struts	93.7 ± 35.7	102.6 ± 49.1	123.6 ± 68.4	
Stent CSA (mm^2)	7.72 ± 1.04	6.55 ± 1.34	7.18 ± 1.73	0.175
Lumen CSA (mm^2)	6.05 ± 1.33	6.11 ± 1.25	5.38 ± 1.92	0.468
Neointimal hyperplasia CSA (mm^2)	1.67 ± 0.64	0.44 ± 0.27	1.80 ± 1.21	0.002
Percentage of neointimal hyperplasia CSA (%)	22.3 ± 10.7	6.7 ± 3.7	26.4 ± 16.6	0.003
Percentage of uncovered struts (%)	4.7 ± 5.8	11.7 ± 6.8	0.4 ± 0.5	<0.0001
Branch vessel side				
Total no. of struts	148	173	197	
Mean no. of struts	14.8 ± 5.4	17.3 ± 12.1	19.7 ± 14.4	
No. of uncovered struts	13.8 ± 5.3	7.6 ± 5.3	4.9 ± 6.9	
Percentage of uncovered struts (%)	93.4 ± 10.5	47.5 ± 34.4	26.2 ± 34.8	0.001
Neointimal hyperplasia thickness (μm)	21.1 ± 29.3	53.5 ± 38.6	62.2 ± 59.6	0.047
Second follow-up (months)	25.1 ± 2.5	24.2 ± 3.1	23.2 ± 3.1	0.374
Total no. of cross sections	101	140	112	
Main vessel side				
Total no. of struts	915	1040	1247	
Mean no. of struts	91.5 ± 40.6	104.0 ± 57.4	124.7 ± 70.0	
Stent CSA (mm^2)	7.67 ± 0.98	6.64 ± 1.09	7.17 ± 1.73	0.116
Lumen CSA (mm^2)	5.88 ± 1.28	5.78 ± 1.05	4.30 ± 1.48	0.054
Neointimal hyperplasia CSA (mm^2)	1.72 ± 0.81	0.85 ± 0.54	2.87 ± 1.11	<0.0001
Percentage of neointimal hyperplasia CSA (%)	22.8 ± 10.8	12.8 ± 8.1	40.6 ± 12.6	<0.0001

Percentage of uncovered struts (%)	3.1 ± 3.5	6.2 ± 3.1	0.1 ± 0.2	<0.0001
Branch vessel side				
Total no. of struts	139	183	188	
Mean no. of struts	13.9 ± 6.2	18.3 ± 12.0	18.8 ± 18.6	
No. of uncovered struts	9.8 ± 7.1	5.2 ± 3.9	1.6 ± 2.1	
Percentage of uncovered struts (%)	67.6 ± 24.2	29.6 ± 24.1	12.4 ± 19.0	<0.0001
Neointimal hyperplasia thickness (μm)	25.6 ± 20.5	68.7 ± 37.5	78.3 ± 73.5	0.015

Data are presented as n or mean ± SD. PES indicates paclitaxel-eluting stent; SES, sirolimus-eluting stent; ZES, zotarolimus-eluting stent; CSA, cross-sectional area.

Serial changes in the percentage of uncovered struts in the main vessel and branch vessel side are shown in Table 3. The percentage of uncovered struts on the main vessel side decreased significantly from 5.6 ± 6.9% to 3.2 ± 3.6% ($p = 0.009$) at follow-up. It also decreased significantly from 55.7 ± 39.9% to 36.6 ± 32.0% ($p < 0.0001$) on the branch vessel side.

Table 3. Serial changes in uncovered struts grouped by stent type and OCT sequence

Uncovered struts (%)	**Initial follow-up**	**Second follow-up**	**P**
All drug-eluting stents			
Main vessel side	5.6 ±6.9	3.2 ± 3.6	0.009
Branch vessel side	55.7 ± 39.9	36.6 ± 32.0	<0.0001
Paclitaxel-eluting stent			

Main vessel side	4.7 ± 5.8	3.1 ± 3.5	0.208
Branch vessel side	93.4 ± 10.5	67.6 ± 24.2	0.018
Sirolimus-eluting stent			
Main vessel side	11.7 ± 6.8	6.2 ± 3.1	0.047
Branch vessel side	47.5 ± 34.4	29.6 ± 24.1	0.036
Zotarolimus-eluting stent			
Main vessel side	0.4 ± 0.5	0.1 ± 0.2	0.176
Branch vessel side	26.2 ± 34.8	12.4 ± 19.0	0.028

Data are presented as mean ± SD. OCT, optical coherence tomography

The percentage of side-branch struts with NIH thickness over 30 μm increased significantly from 36.3 ± 37.4% to 51.0 ± 36.0% ($p < 0.0001$; Figure. 2). However, a significant increase in relatively thin NIH (0 μm < NIH thickness < 30 μm) was seen in PES struts (1.6 ± 3.4% to 17.4 ± 16.0%, $p = 0.018$), but not in SES or ZES struts.

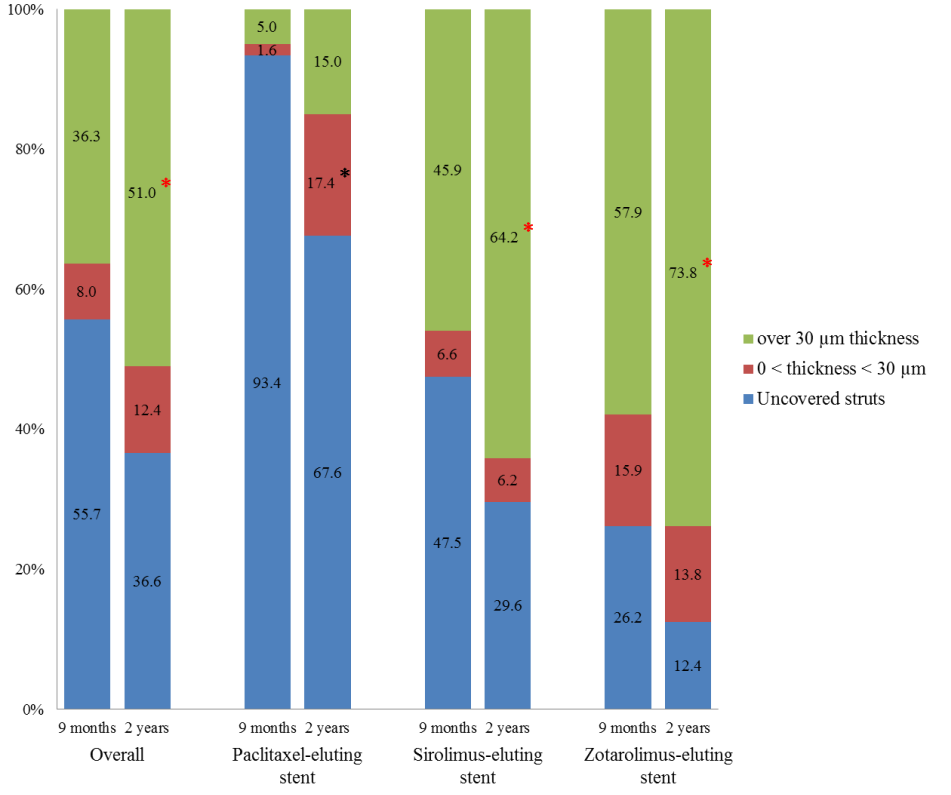

Figure 2. Optical coherence tomographic assessment of serial changes in strut coverage over the side-branch ostium. Green and red indicate neointimal hyperplasia thickness more than 30 μm and 0 to 30 μm, respectively.

*$p < 0.05$ for comparison between 9-month and 2-year follow-up.

The representative images about strut coverage were shown in Figure 3.

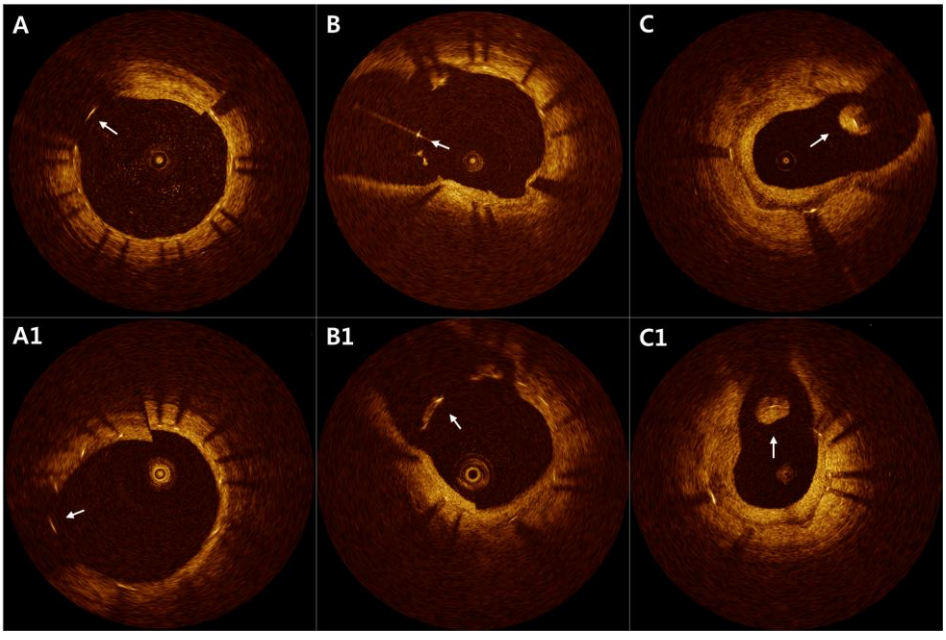

Figure 3. Optical coherence tomographic images about strut coverage over the side-branch ostium (arrow). (A) and (A1) paclitaxel-eluting stent, the uncovered strut (A) was persistent on follow up (A1). (B) and (B1) sirolimus-eluting stent, the uncovered strut (B) was changed with thin neointima (B1). (C) and (C1) zotarolimus-eluting stent, neointimal hyperplasia thickness increased from 250 μm to 310 μm.

IV. DISCUSSION

Compared to previous reports that showed that 21.9% of the side-branch struts were uncovered at 9 to 13 months follow-up[13], the percentage of uncovered side-branch struts at 9-month follow-up was relatively high (55.7%) in the present study. The difference may be attributable to different OCT analysis methods and the enrolled DES types. PESs were not included, and OCT analysis was performed at 1-mm intervals in the previous study[13]. In this study, the percentage of uncovered side-branch struts was highest in PESs

at 9-month follow-up OCT. This finding was consistent with a previous OCT study, which also showed the highest percentage of uncovered struts in side-branch ostium in lesions treated with PESs at 6-month follow-up OCT (60.1% for PESs compared to 17.0% and 13.2% for SESs and ZESs, respectively; $p < 0.0001$)[14].

To the best of our knowledge, this is the first study to evaluate the status of uncovered side-branch struts at 2 years follow-up and document the serial change between 9 months and 2-year follow-up. This serial follow-up study showed that there was significant improvement in overall DES strut coverage over side-branch ostium from 44.3% at 9 months to 63.4% at 2-year follow-up. Although the percentage of uncovered side-branch struts significantly decreased during serial follow-up, PESs still showed the highest percentage of uncovered side-branch struts at 2 years (67.6%) compared to other DESs. In addition, struts with relatively thin NIH thickness of 0 to 30 μm comprised about 50% of covered struts in PES even at 2-year follow-up. The proportion of side branch struts with relatively thin NIH was less than one fifth or one tenth in other DES covered struts. These findings suggested that strut coverage over the side-branch ostium may be insufficient or significantly delayed even at 2-year follow-up in PES compared to SES or ZES. These findings may be partially related to the different drug release kinetics or distribution of each DES[6]. The sirolimus in SESs is nearly completely released from the polymer within 30 days, and 95% of the zotarolimus in ZESs is eluted from the stent within 15 days after implantation[6,15,16]. In contrast, paclitaxel is released from PESs as an initial burst from the polymer, followed by a constant slow release lasting more than 180 days[6,17]. Thus, profound inhibition of the reparative response to arterial injury by the prolonged and inhomogeneous release of the antiproliferative drug paclitaxel[6,18] may be partly involved in the delayed coverage over the side-branch struts up to 2 years in this study.

Our study had some limitations. Because it is a non-randomized,

retrospective study, it has the potential risk of selection bias. The number of study participants was relatively small. This study did not have OCT data for bare-metal stent struts across the side branch vessel and OCT analysis according to different rheological impacts on bifurcation lesions. Our study also lacked histopathological data to validate the OCT findings. Finally, with the current OCT techniques, a precise qualitative assessment of neointima remains challenging. For example, we could not differentiate fibrin deposition from neointimal formation on the stent struts.

V. CONCLUSION

This serial follow-up OCT study showed that strut coverage of side-branch DES, regardless of DES type, improved with time; however, PESs showed the highest percentage of uncovered side-branch struts on 2-year follow-up OCT. In addition, the NIH thickness pattern of covered struts in side-branch vessel side differed with each type of DES on serial follow-up.

REFERENCES

1. Iakovou I, Schmidt T, Bonizzoni E, Ge L, Sangiorgi GM, Stankovic G, et al. Incidence, predictors, and outcome of thrombosis after successful implantation of drug-eluting stents. JAMA 2005;293:2126-30.
2. Daemen J, Wenaweser P, Tsuchida K, Abrecht L, Vaina S, Morger C, et al. Early and late coronary stent thrombosis of sirolimus-eluting and paclitaxel-eluting stents in routine clinical practice: data from a large two-institutional cohort study. Lancet 2007;369:667-78.
3. Mauri L, Hsieh WH, Massaro JM, Ho KK, D'Agostino R, Cutlip DE. Stent thrombosis in randomized clinical trials of drug-eluting stents. N Engl J Med 2007;356:1020 –9.

4. Joner M, Finn AV, Farb A, Mont EK, Kolodgie FD, Ladich E, et al. Pathology of drug-eluting stents in humans: delayed healing and late thrombotic risk. J Am Coll Cardiol 2006;48:193–202.
5. Finn AV, Joner M, Nakazawa G, Kolodgie F, Newell J, John MC, et al. Pathological correlates of late drug-eluting stent thrombosis: strut coverage as a marker of endothelialization. Circulation 2007;115:2435–41.
6. Her A, Lee BK, Shim JM, Kim JS, Kim BK, Ko Y, et al. Neointimal coverage on the drug-eluting stent struts crossing the side-branch vessels using optical coherence tomography. Am J Cardiol 2010;105:1565-9.
7. Kim U, Kim JS, Kim JS, Lee JM, Son JW, Kim J, et al. The initial extent of malapposition in ST-elevation myocardial infarction treated with drug-eluting stent: the usefulness of optical coherence tomography. Yonsei Med J 2010;51;332-8.
8. Kim JS, Hong MK, Fan C, Kim TH, Shim JM, Park SM, et al. Intracoronary thrombus formation after drug-eluting stents implantation: optical coherence tomographic study. Am Heart J 2010;159:278-83.
9. Tearney GJ, Regar E, Akasaka T, Adriaenssens T, Barlis P, Bezerra HG, et al. Consensus standards for acquisition, measurement, and reporting of intravascular optical coherence tomography studies: A report from the international working group for intravascular optical coherence tomography standardization and validation. J Am Coll Cardiol 2012;59:1058-72.
10. Takano M, Inami S, Jang IK, Yamamoto M, Murakami D, Seimiya K, et al. Evaluation by optical coherence tomography of neointimal coverage of sirolimus-eluting stent three months after implantation. Am J Cardiol 2007;99:1033-8.
11. Matsumoto D, Shite J, Shinke T, Otake H, Tanino Y, Ogasawara D, et al. Neointimal coverage of sirolimus-eluting stents at 6-month follow-up: evaluated by optical coherence tomography. Eur Heart J 2007;28:961-7.
12. Kim JS, Jang IK, Kim TH, Takano M, Kume T, Hur NW, et al. Optical

coherence tomography evaluation of zotarolimus-eluting stents at 9-month follow-up: comparison with sirolimus-eluting stents. Heart 2009;95:1907–12.

13. Gutirrez-Chico JL, Regar E, Nesch E, Okamura T, Wykrzykowska J, di Mario C, et al. Delayed coverage in malapposed and side-branch struts with respect to well-apposed struts in drug-eluting stents: in vivo assessment with optical coherence tomography. Circulation 2011;124:612-23.
14. Kyono H, Guagliumi G, Sirbu V, Rosenthal N, Tahara S, Musumeci G, et al. Optical coherence tomography (OCT) strut-level analysis of drug-eluting stents (DES) in human coronary bifurcations. EuroIntervention 2010;6:69-77.
15. Klugherz BD, Llanos G, Lieuallen W. Twenty-eight-day efficacy and pharmacokinetics of the sirolimus-eluting stent. Coron Artery Dis 2002;13:183–8.
16. Nakazawa G, Finn AV, John MC, Kolodgie FD, Virmani R. The significance of preclinical evaluation of sirolimus-, paclitaxel-, and zotarolimus-eluting stents. Am J Cardiol 2007;100:36M–44M.
17. Finn AV, Kododgie FD, Harnek J, Guerrere LJ, Acampado E, Tefera K, et al. Differential response of delayed healing and persistent inflammation at sites of overlapping sirolimus- or paclitaxel-eluting stents. Circulation 2005;112:270 –8.
18. Nakazawa G, Ladich E, Finn AV, Virmani R. Pathophysiology of vascular healing and stent mediated arterial injury. EuroIntervention 2008;4:C7–10.

ABSTRACT(IN KOREAN)

순차적 광 간섭 단층 촬영을 통한 분지 혈관 측 약물 방출 스텐트 스트럿 피복의 관찰

<지도교수 홍명기>

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분지 혈관 (side-branch vessel)에 위치한 약물 방출 스텐트 (drug-eluting stent) 스트럿 (strut)의 순차적인 피복 (coverage) 변화에 관해서는 아직까지 알려지지 않았다. 직경 2.0 mm 이상의 분지 혈관 측 스트럿의 변화를 광 간섭 단층촬영 (optical coherence tomography)을 이용하여 약물 방출 스텐트 시술 9 개월 및 2 년 후, 총 30 명의 환자에서 관찰하였다. 각각 10명의 환자에서 약물 방출 스텐트는 paclitaxel-eluting stents (PESs), sirolimus-eluting stents (SESs) 및 zotarolimus-eluting stents (ZESs) 였다. 광 간섭 단층 촬영 상 신생 내막의 두께 0 μm 를 노출된 스트럿 (uncovered strut)으로 정의하였다. 분지 혈관 측 노출된 스트럿의 비율은 55.7 ± 39.9% 에서 36.6 ± 32.0% 으로 유의하게 감소하였다 ($p < 0.0001$). 각 스텐트 별로 PES는 93.4 ± 10.5% 에서 67.6 ± 24.2% ($p = 0.018$), SES는 47.5 ± 34.4% 에서 29.6 ± 24.1% ($p = 0.036$), ZESs는 26.2 ± 34.8% 에서 12.4 ± 19.0% ($p = 0.028$)로 감소하였다. 노출된 분지 혈관 측 스트럿 중 30 μm 이상의 신생 내막 두께 (neointimal thickness)를 보인 스트럿은 36.3 ± 37.4% 에서 51.0 ± 36.0% 으로

증가하였다 ($p < 0.0001$). 하지만 다른 약물 방출 스텐트와 비교해 PES는 1.6 ± 3.4% 에서 17.4 ± 16.0% ($p = 0.018$) 로, 30um 미만의 비교적 얇은 신생 내막을 가진 스트럿의 비율이 증가하였다. 결론으로 순차적 광 간섭 단층촬영을 통하여 분지 혈관 측 스트럿의 피복은 유의하게 향상되나, 스트럿 피복의 패턴은 약물 방출 스텐트의 종류에 따라 다르다.

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